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Framework Model to Enhance the Effectiveness of Blockchain Technology through the Knowledge Management Processes

Hamad AlBadri

Abstract: This study topic is essential since it highlights the challenges facing the effective integration of blockchain technology and the necessary measures to improve their performance through knowledge management processes. The primary aim of this study was to develop a framework model for advancing the effectiveness of blockchain technology in the Middle East and the Gulf region. For this study, the researchers collected secondary data by conducting a deep systematic review of all the information found online on the topic. The researchers selected essential studies by integrating an inclusion and exclusion criteria. This research exclusively included articles released post-2019 to guarantee that they contained relevant information. In addition, studies had to be in English to ensure clarity for all the researchers involved. The authors collected the secondary data through the GovInfo.gov database as well as the Google Scholar search engine. After the comprehensive reviewing of all the relevant articles that fit the inclusion and exclusion criteria, fifteen articles were included in the research. Out of the fifteen, eight focused on the Middle East and the rest on the Gulf. **Conclusion:** The development of blockchain technology in the Middle East and the Gulf region has witnessed tremendous improvements over the years. Many sectors like healthcare and banking industries have dedicated efforts to applying the technology in their processes. However, the technology has faced numerous challenges that need immediate address to ensure the ultimate success of this technology. The concerned policymakers should research on the topic and develop appropriate policies that guarantee the effectiveness of the technology.

Keywords: blockchain technology; framework model; knowledge management processes; the Gulf region; the Middle East

1 INTRODUCTION
1.1 Operational Definition

Blockchain technology reflects a shared and indisputable ledge that spearheads the transaction recording procedures and asset tracking within a business system. In such a network, assets can be either tangible or intangible. The primary features of blockchain technologies consist of distributed ledger machinery, immutable records, and smart contracts. This technology is essential in a business environment as most companies work best if they receive accurate information quickly. Weking et al. (2019) [25] insist that blockchain technology guarantees that enterprises incorporate new methods of shaping financial activities, thereby minimizing costs, and enhancing trust in the business ecosystem. On the other hand, knowledge management is the acquisition, conversion, storage, and application of a firm's intellectual knowledge [7]. The processes involved in knowledge management comprise the obtaining, creation, collection, and dissemination of knowledge in companies. These procedures often aim to save staff knowledge and experiences in an enterprise, after which they distribute and utilize it effectively and efficiently. The main goal of this study is to establish a framework model that can improve the effectiveness of blockchain technology by using the knowledge management process. The focus of the research is the Middle East and the Gulf region.

1.2 Research Problem and Questions

The main problem that has triggered this study is the presence of various inefficiencies with blockchain technology. For instance, the technology encounters the shortcoming of having updating challenges and preventing the ultimate elimination of errors. Attaran's (2020) [8] study highlights the primary disadvantage of blockchain technology as its infancy since the concept is still new and

may face numerous obstacles before its ultimate successful implementation. This challenge makes it necessary to establish a method of enhancing the effectiveness of blockchain technology. It is essential to develop the most sustainable approach that companies can use in the long run with many ways available. Thus, creating a framework model for understanding how the knowledge management processes can enhance the effectiveness of blockchain technology remains critical.

At that juncture, the main aim of the study is to establish a framework model for ensuring the efficiency of blockchain technology via knowledge management processes in the Middle East and the Gulf by conducting a deep systematic literature review. The following research questions will help in fulfilling this aim:
- What is the current state of blockchain technology in business in the Middle East and the Gulf?
- How effective is blockchain technology in business in the Middle East and the Gulf?
- Which framework model will ensure that knowledge management processes enhance the effectiveness of blockchain technology in the Middle East and the Gulf?

1.3 Significance of the Study

This study is essential, as it will facilitate the public learning about blockchain technology, its performance, and ways of enhancing its effectiveness. The answers to this study will benefit the public by translating the knowledge to their work environment to improve the associated blockchain technology. The study will also contribute to existing research by presenting a framework-based model for improving blockchain technology. Currently, not many research papers address this issue. The central institutions that will benefit from this study are the Middle East and the Gulf companies that integrate blockchain technology. The information provided via this research will enable them to

deal with any inefficiency challenges they encounter appropriately. In addition, the manufacturers of blockchain technology will benefit from this research since it will equip them with the necessary knowledge to improve the technology and make it more efficient. Moreover, this study will help future researchers by providing them with the relevant information on the topic, whereby they can use it to inform their independent studies. In addition, this research offers an avenue for future researchers to support or criticize the study.

1.4 Previous Studies

Previous studies on this topic focused on the Middle East have highlighted the limitations of blockchain technologies in the region. For instance, Papadaki and Karamitsos (2021) insist that since the technology is still in its infant stages, it has led to various disadvantages like few use cases, lack of collaborative governance, and limited employee skills. Other challenges include difficulties in cross-country collaboration and the lack of a regulatory model [20]. These factors could ultimately contribute to the inefficiency of this technology. In a similar perspective, Alsubaei (2019) [6] argues that the majority of the blockchain technology available in the Gulf region is still at its establishment phase, but efforts to test and implement the technology. For example, in 2018, the UAE launched a strategy titled Emirates Blockchain, whose goal was to transfer fifty percent of the country's government transactions to the blockchain by 2021. The application of blockchain technology in institutions in the Gulf is likely to increase in the future.

1.5 Limitation of the Study

The main limitation of this study is that it exclusively relies on secondary data to form conclusions. As a result, it lacks the originality researchers attain through conducting primary research. Another shortcoming is the absence of sufficient literature concentrating on the study topic, revealing a literature gap that is necessary to fill through more research. The study adopted a cross-sectional design, implying that the data collected only reflects the current situation in January 2022. This information may not be relevant in future studies, especially if there are significant changes in blockchain technology, such as developing more efficient methods of improving the technology. The final limitation of this research is that the researcher exclusively included journal articles in English. This situation is disadvantageous as the researcher could have missed out on other arguments in non-English journals.

2 RESEARCH METHOD AND PROCEDURES
2.1 Methodology of the Study

The authors decided to use a secondary data collection method during this research. This approach involves using information collected by someone else other than the primary user. Secondary data can also be defined as data collected for other research purposes but relevant to the current research. The information used in secondary data collection might come from internet journals, books, information collected by the government, libraries, and many other sources [13]. The benefit of the approach is that it saves the researcher a lot of time that would be spent gathering information on the ground. The secondary data collection method is easy to conduct since accessing secondary information is easy as the internet provides vast information. Furthermore, the secondary data collection technique usually is cost-effective [2] since most of the sources of information are free, which allows the researcher to gain knowledge without having to put any money on the table. On the other hand, the shortcoming of the approach is that it might not be specific to the researcher's requirements since the information was collected in the past for another reason making it unreliable for the researcher's current needs. In addition, the information might be outdated since it was acquired in a different error [26].

The collection of secondary information involved integrating a deep systematic literature review approach. The approach produces scientific evidence to answer particular research questions in a precise and reproducible manner while looking forward to incorporating all issued proof on the research topic and promoting the quality of the evidence. A systematic literature review follows clearly defined procedures that outline the criteria before the analysis [23]. Furthermore, a comprehensive, clear search conducted on various databases and grey literature that can be photocopied and reproduced by other researchers, which requires organizing a research strategy that is well thought out and mainly answers a defined question. The advantage of using systematic reviews in research is that it is comprehensive when appropriately conducted [18] since all relevant research is acknowledged and assessed. The other benefit of systematic literature reviews allows individuals who want to know the overall answer to a question to get a quick solution, thus saving the readers a lot of time [24]. However, the disadvantage of using a systematic literature review is that it might take time to conduct it thoroughly and publish it.

The researcher used the inclusion and exclusion criteria, which included the features that prospective research subjects should have to participate in the research. On the other hand, the exclusion criteria are the characteristics that disqualify future subjects from participating in the study. Thus, the inclusion and exclusion criteria might incorporate age, gender, and ethnicity (Martinic et al., 2019). Using the inclusion end exclusion criteria assists the researcher in developing eligibility criteria that rule in and out the participants in a study. The inclusion and exclusion criteria follow the scientific objectives of the research and contain vital implications for the scientific rigor of a research and the assurance of ethical principles. The exclusion criteria are essential as it is used to eliminate the subjects that do not comply with follow-up visits, those who cannot provide biological specimens or information, and those whose safety and ethical protection cannot be assured [21].

The criteria are only included in papers published from 2019 onwards since most of the information found in those articles is recent. Furthermore, the researcher considered the papers published in 2019 and beyond since most of the data

is accurate compared to the current situation in the Middle East. Additionally, the researcher dealt with documents written in English since English is linear and contains one central point, with each part contributing to the main point of argument without digressions or reputations. In addition, English is the standard written form of the language used in many countries. Furthermore, most individuals find articles written in English easy to read and understand. Papers relevant to the study were vital since they offered information that matched what the investigation entailed, making it possible for the researcher to gather relevant information. Nonetheless, papers addressing the Gulf region or those that refer to the Gulf region and represent the area were helpful to the researcher since they offered specific information that focused mainly on the Middle East.

The researchers used the best match 5-years filters in the GovInfo.gov catalogue to collect appropriate data. On the contrary, when looking for sources in the Google Scholar search engine, the authors used the 2019-2022 filters to ensure that the data collected was the hottest in the field. Readings met the inclusion criteria if they focused on either region of the Gulf and involved information on how to upgrade the effectiveness of blockchain technology through implementing a knowledge management process. The researchers were responsible for developing the search strategy, and they analyzed the method through the press checklist. This technique allowed the researchers to investigate whether the design implemented by prospective studies matched the study topic. Further, the list permitted the researcher to generally evaluate the sources of the cases and ensure the correct spelling and filters suitability. Nonetheless, when a conflict arose during this process, the researchers controlled it via agreement.

2.2 Procedure for Drawing Conclusions

For this research, all the people involved reviewed all the data acquired from the articles concerning the effectiveness of blockchain technology in the Middle East and the Gulf. The next step entailed critically evaluating the arguments presented to establish what they meant and their implication for the study. Finally, the researchers derived conclusions based on their understanding of the information reviewed.

3 RESULTS AND DISCUSSION
3.1 Results

Two of the researchers involved in the drafting of this manuscript worked side by side to review all the potential publications f inclusion in the study. They surveyed whether they were available as abstracts or full texts and exclusively integrated only the full-text articles to conceptualize the study methodology and outcomes. Out of all the studies reviewed, only fifteen qualified for incorporation into the study. Out of the fifteen articles, eight of them (53.3 %) contained information concentrating on the Middle East, while seven (46.7 %) focused on the Gulf region. The pie chart below highlights this information (Fig. 1).
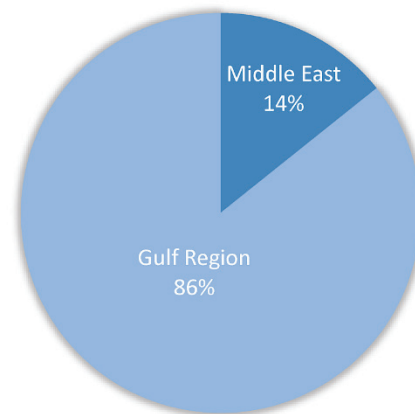
Figure 1 Primary focus of the included publications

3.2 Discussion
3.2.1 Blockchain Technology in the Middle East

The integration of blockchain technology in the Middle East has witnessed significant improvement over the years. For instance, numerous opportunities in Egypt can ensure the successful adoption of blockchain technology in the food sector, such as improving trust, advancing food traceability, and minimizing counterfeiting [12]. Nonetheless, many people in Egypt lack awareness about the technology, its success is uncertain, and there is insufficient collaboration. In Israel, there is a high potential for blockchain technology [27], given the success in Fintech and cybersecurity. The country also has a blockchain ecosystem with eleven start-up enterprises.

In another study focusing on the Middle East, Ozturan, Atasu, and Soydan (2019) [19] highlighted that Turkish banks' readiness to adopt the blockchain technology was at a mean of 3.30. In a similar perspective, Bulut, Kantarcı, Keskin, and Bahtiyar (2019) [10] examined the efficiency of blockchain technology by testing the time it takes to conduct an election. The results revealed that the technology significantly minimized waiting time for results. However, this experiment depends on theory, and more practical evidence is necessary. In Afghanistan, the integration of blockchain technology is most evident in the land administration sector. For instance, a study by Konashevych (2021) [17] showcased that adopting this technology in the industry has failed to yield positive outcomes due to the bureaucracy and failure to prove that it guarantees the system's security. A synonymous study by Hedayati, Baktash, and Mohmand (2019) [15] claims that incorporating blockchain technology in Afghanistan's voting system encounters numerous challenges, such as low literacy levels, cybersecurity risks, and website accessibility requirements.

Another study concerning Syria reveals that the blockchain system integrated into the education sector faces multiple shortcomings. Since Syria is a low-income country, the cost of setting up blockchain technology is significantly lower. Nevertheless, the system encounters trust and credibility issues that make its success uncertain in the region [4]. More importantly, Barbino (2021) [9] evaluates the potential of blockchain technology to solve the refugee

identification crisis prevalent in Syria. These arguments imply that there is a high potential for integrating blockchain technology. However, the successful incorporation of the concept requires handling all the limitations of the technology. Establishing a framework for reducing inefficiencies is vital if the technology should survive in the Middle East.

3.2.2 Blockchain Technology in the Gulf

In the Gulf, the adoption of blockchain technology has been significant, particularly in the United Arab Emirates. A study by Alabbasi and Sandhu (2021) [1] points out that the integration of blockchain technology in the region presents a chance to maximize these countries' growth by eradicating the monetary threats in the banking sector. Moreover, in Saudi Arabia, integrating blockchain technology in the country's healthcare sector in managing diabetes patients has yielded significant corroborative [16]. Nevertheless, the technology is in its nascent stage and more research in the topic is necessary to solve the current problem the technology faces. In Iran, the application of the blockchain technology in the healthcare domain has faced numerous shortcomings inclusive of expertise absence, cost, and security issues, in addition to uncertain state policies [14]. In a similar viewpoint, studies such as that by Sahebi, Mosayebi,

Masoomi, and Marandi (2022) [22] showcase that Iran policymakers must establish policies that ensure the development of blockchain technology-driven renewable energy supply chains.

Most importantly, in Kuwait, the application of blockchain technology remains evident via the Ripples blockchain technology applied at Kuwait Finanche House [5]. In Oman, studies concerning the application of the technology in various sectors are limited [3] and more research is appropriate. In a synonymous viewpoint, Dora and Srinivasan (2019) [11] identify the primary challenges impeding the successful integration of blockchain technology in Oman banking sector include insufficient tools, high training costs, privacy leaks, and the sensitivity of data sharing. Based on these arguments, it remains evident that despite the adoption of blockchain technology by various countries in the Gulf, its successful implementation encounters many shortcomings that may negatively affect its ultimate success. Therefore, it remains essential for all the relevant policymakers to invest in the development of knowledge management processes that can ultimately improve the efficiency of blockchain technology and guarantee ultimate success.

At that juncture, after a deep systematic review of literature, the researchers developed the following framework model (Fig. 2) for advancing the effectiveness of blockchain technology in the Middle East and the Gulf.
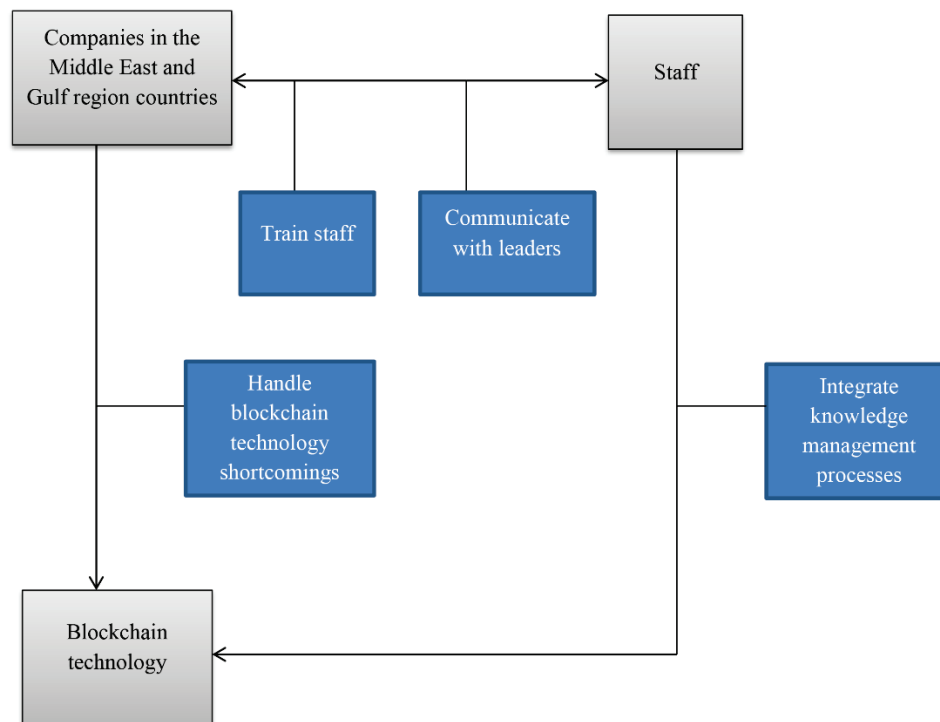
Figure 2 Suggested Framework

4 CONCLUSIONS

The main objective of this research was to establish a framework model for improving the efficiency of blockchain technology in the Middle East and the Gulf region. The researchers conducted a deep systematic review of all the

information found online on the topic. The review led to the identification of fifteen essential articles focusing on the target region. Eight concentrated on the Middle East and seven on the Gulf region. The information presented in the documents reveals that in the two regions, the integration of blockchain technology is in its infancy phases. Nonetheless,

some sectors like healthcare and banking have integrated the technology in their practice. Based on the analysis, it remains evident that Gulf region countries have achieved more success from incorporating the technology. However, the challenges experienced when integrating the technology are numerous. The technology encounters security, implementation, and employee training challenges. The solution of these problems is vital to ensure the success of blockchain technology in both regions. Thus, all the concerned people should establish collaborations to develop frameworks for dealing with the shortcomings brought about by the technology to guarantee that they reap maximum benefits once they incorporate it into their different sectors.

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Effects of Non-Wood Fibres in Printed Paper Substrate on Barrier and Migration Properties

Mia Kurek*, Irena Bates, Ivana Plazonić, Maja Rudolf, Valentina Radić Seleš, Kata Galić, Katja Petric Maretić

Abstract: Nowadays, there is a strong initiative to use recycled or biodegradable materials in all aspects of production including the graphic industry. In this study, paper was used as a material fulfilling the two of mentioned properties. Under laboratory conditions, papers were made of 70% pulp from recycled wood fibres with an addition of 30% straw pulp (wheat, barley or triticale). Considering the importance of the possibility of printing such media based on their end use, the influence of fibre type on vapour barrier properties was studied and overall migration to hydrophilic and fatty food simulants was measured. Analyses were performed on digital, flexographic, and offset prints obtained by printing laboratory papers with UV-curable black ink. It was found that prints produced using the offset technique, in which the ink remains on the surface of the paper, had lower overall levels of migration compared to other printing techniques. The paper produced appears to have the potential to be used as a secondary food packaging material.

Keywords: non-wood fibres; overall migration; printing techniques, recycled fibres; water vapour permeability

1 INTRODUCTION

Over the past decade, there have been significant initiatives to reduce the negative environmental impact of synthetic materials and related products in the packaging industry. As a result, there is a strong demand for greener, sustainable, renewable and bio-based packaging materials. In this context, paper is considered as one of the environmentally friendly and sustainable packaging materials used for both food and non-food products [1]. The interest in paper-based packaging materials dates back centuries and accounts for 31% of the global packaging market segment in 2017 [2]. Its eco-friendly label makes paper the first choice for the food industry [3], where it is mainly used as primary or secondary packaging. While primary packaging implies direct contact with food, secondary packaging aims not to come into direct contact with food, but to serve for transportation and storage of the primary packaging. Worldwide, half of all paper produced is used as packaging material. About 420 million tonnes of paper-based packaging were produced, including nearly 90 million tonnes in Europe in 2018 [4, 5]. Paper is mostly made from a network of cellulose fibres derived from wood and non-wood plants, forming a compact material. As public interest in the conservation of natural resources has increased in recent years, emphasis has been placed on the use of alternative fibre sources by recycling used paper as a source of secondary fibres and using virgin non-wood fibres (including bamboo, bagasse, hemp, wheat straw, flax) in the paper industry [6,7]. The use of alternative sources of cellulose fibre reduces pressure on forest resources, which has recently become attractive not only because of limited wood supply but also because of environmental concerns in countries with acceptable wood sources. The reuse of agricultural waste for fibre production also contributes to sustainability. This raw material is interesting because it is available worldwide on an annual basis and its chemical composition makes it suitable for processing into pulp. Unlike wood materials, it is important to know that straw contains less lignin and more hemicellulose with an extremely high content of extractives at the same cellulose

content [6]. The principle of pulping is the separation of the fibres from the plant tissue by chemical cooking to remove the lignin, or by mechanical separation combined with chemical softening, which is much easier and shorter for such raw materials than for wood raw materials [8]. However, it should be emphasised that straw cannot have an advantage over wood raw materials because the quality of straw is naturally very heterogeneous, and depends on the type of grain, the time of sowing and harvesting, and vegetation conditions. Therefore, this type of raw material provides fibres that are mixed with wood fibre pulp in varying proportions during paper production. The quality of prints on papers with pulp from agricultural residues has not been thoroughly investigated. In recent research [9], the possibility of using mixed pulp from wood and triticale straw up to 30% was shown on a laboratory scale. The use of paper with pulp from agricultural residues (wheat, barley and triticale straw) in the printing industry has been confirmed in several studies [10-13]. The main advantages of using wood-based papers for commercial packaging include: excellent print quality for most boards, very good mechanical protection for the products, relatively low production and processing costs, and easy recyclability [4]. The selection of a suitable substrate is very important, as the interaction of the substrate with the printing inks should not affect the packaged product and should not change the appearance of the packaging. Information on printed food packaging plays an important role in presentation, promotion and consumer information [14]. However, mixing wood fibre pulp with non-wood fibres can change the appearance of the packaging. In fact, the choice of raw material for pulp and paper production can affect the papermaking process and paper quality in terms of its physicochemical, barrier, mechanical, and printing properties [4].

Paper is an extremely porous medium that has small open spaces in the form of pores or voids that affect the interaction between inks and paper, as well as permeability properties [1]. The water vapour barrier properties of the substrate play an important role in mechanical resistance and maintaining the quality and safety of packaged food [15]. Paper contains cellulose or other fibres whose hydrophilic nature results in

poor water vapour barrier properties [16]. Characterization of permeability is of great importance in predicting the barrier and printing properties of paper [17].

Another mass transfer, migration, is described as the transfer of low molecular weight compounds from a material to a packaged item. Paper and board are porous materials from which various compounds can migrate by diffusion from the packaging into the food. Other interactions include those from outside through the packaging, through a gas phase, or the set-off during material storage on rolls or in stacks. Excessive migration can occur due to various factors such as the duration of contact, the rising temperature, and expansion of the contact area, the composition of the ink and the composition of the packaged food rich in aggressive substances. When used as food packaging, the migration of ink can seriously affect food safety, consumer health, and consequently affect the acceptance (withdrawal) of such a product on the global market. Recycled paper must meet a number of basic safety criteria regarding possible migration. In the paper recycling process, many chemicals are used for bleaching and strengthening. It makes a big difference whether the material is used as primary or secondary packaging, with less impact and risk when used as secondary packaging. However, even if it is used as secondary packaging, which could be the case with papers used in this study, it is important to know the risks of the potential migration values. A recent review article [18] discussed approaches to reduce chemical migration from recycled paperboard. Inks have been shown to migrate through paper into dry and liquid food simulants [19]. The use of recycled materials such as fibres from recovered paper may also result in direct contact between ink components and food, or the pathway through the material could be shorter or altered if alternative fibres are used. Print stability is another extremely important parameter for reproduction quality, especially in the packaging industry. Castle has published a comprehensive review of potential contaminants in food contact materials made from recycled paper and cardboard [20] and there is a wide range of different ink and overprint varnish formulations available to meet the requirements of printing processes, substrate types and specifications for food packaging [14]. A number of specially formulated low-migration inks and overprint varnishes are available for the production of paper packaging for food. Variations can occur depending on the printing technique (offset, gravure, flexographic, digital) and ink type (solvent-based, water-based, cationic UV-curable, low-migration UV-curable, electron beam-cured) [14].

The aim of this study was to analyse the different properties of recycled paper enriched with non-wood fibres that can be used as secondary food packaging. Three printing techniques commonly used for packaging (digital, flexographic and offset) were selected for printing these innovative paper substrates with black UV-curable ink. All printing techniques used printing conditions that ensure high print quality at full tone. All printed substrates were tested for water vapour barrier, and print quality parameters (optical ink density and undertone) were determined. The stability of

the prints was also tested by comparing the overall migration in two food simulants with unprinted paper samples.

2 MATERIALS AND METHODS
2.1 Papers with Straw Pulp

Laboratory papers weighing approximately 42.5 g/m^2, formed by Rapid-Köthen sheet former (FRANK-PTI) according to the standard EN ISO 5269-2:2004 [21], were made entirely from recycled wood pulp or from a blend of 70% recycled wood pulp and 30% unbleached wheat, barley, or triticale pulp (Tab. 1).

Table 1 Labeling of laboratory-produced papers used as printing substrates

Paper type	Composition	
	Straw pulp, %	Recycled pulp, %
N	0	100
NT	30	70
NB	30	70
NW	30	70
* straw type: N = only recycled wood; T = triticale; B = barley; W = wheat		

Semi-chemical straw pulp was obtained from crop residues left in the fields after harvest. These were collected, purified, manually cut and processed by the soda pulping method [22].

2.2 Printing Techniques

In this study, the three most common printing techniques were used: digital, flexographic and offset printing, in which black, UV-curable ink was applied to laboratory papers to achieve a full tone.

2.2.1 Digital Technique

All laboratory papers were printed using a digital EFI Rastek H652 UV-curable inkjet printer. Variable piezoelectric drop-on-demand printing technology ensures that full tone areas are printed with black ink on each laboratory-made paper at a resolution of 600×600 dpi (with high-quality mode in eight passes), at a printing speed of 12.10 m^2/h. In this technique, the printing process is performed based on ink droplets sprayed from the print head nozzles. The data from the digital print job is transferred directly to the inkjet system, which transfers the ink to the printing substrate via the nozzles [23].

2.2.2 Flexographic Technique

Printing on laboratory papers with black UV-curable ink Solarflex Integra (Sun Chemical) in fulltone pattern was performed with flexographic laboratory device F1-basic Printability Tester. It was performed at a speed of 0.5 m/s, a printing force of 300 N and an anilox roller force of 200 N. An anilox roller with 90 lines cm^{-1} (60° raster angle) and a cell volume of 18 cm^3/m^2 was used for printing at a temperature of 23 °C and a relative humidity of 50%. The prints were additionally dried using the Technigraf Aktiprint

L 10-1 UV dryer (UV-C tube, with a light source power of 120 W/cm and an intensity of 60%).

2.2.3 Offset Technique

All laboratory-produced papers were printed in full tone by laboratory device Prüfbau multipurpose printability testing machine with SunCure Starluxe low migration black ink (manufacturer Sun Chemicals) at a temperature of 23 °C and relative humidity of 50%. It was printed at a speed of 0.5 m/s and a pressure of 600 N. The prints were then additionally dried using a Technigraf Aktiprint L 10-1 UV dryer [24].

2.3 Analysis
2.3.1 Material Thickness

Material thickness (x) was measured using a digital gauge with an accuracy of 0.001 mm (Digimet, HP, Helios Preisser, Germany). For all calculations, the average value of ten thickness measurements at different positions per paper type was used.

2.3.2 Water Vapour Permeability

The water vapour permeability (WVP) of the paper and print samples was determined gravimetrically according to the modified ASTM E96-80 standard method [25, 26]. The surface area (A; dm^2) of the sample and the sample thickness (x; m) was measured before experiments. The relative humidity difference was set up to 100% > 30%, and the measurement temperature was 25±1 °C. The glass cells were filled with distilled water and placed in a ventilated climatic chamber (Memmert HPP110, Germany) and difference in pressure on both sides of the sample (Δp; Pa) and slope on the graph ($G\ t^{-1}$; g/s) were monitored. The water vapour permeability (WVP, g/(m·s·Pa)) and the water vapour transmission rate ($WVTR$, g/(m^2·s)) were calculated from the change in cell weight over time at steady state according to Eqs. (1) and (2), respectively.

$$WVP = \frac{WVTR \cdot x}{\Delta p} \qquad (1)$$

$$WVTR = \frac{G}{t \cdot A} \qquad (2)$$

2.3.3 Overall migration

Determination of the overall migration values (OM) was performed to verify the maximum amount of low molecular weight compounds that migrated from paper or printed samples into selected food simulants. Aqueous acetic acid (CH$_3$COOH) 3% [w/v] and ethanol (CH$_3$CH$_2$OH, EtOH) 95% [v/v, used as simulants for hydrophilic foods with pH < 4.5 like infusions, coffee, tea, beers (Commission Regulation EU No 10/2011 [27-29]) and were used as simulants for all measurements. Measurements were performed using the

migration cell (MigraCell®; FABES Forschungs-GmbH, Munich, Germany) and the immersion method (EN 1186-1 Standard) [30]. The surface area (A; dm^2) of the sample was measured before experiments. The migration cells were stored at 40 °C for 10 days, corresponding to the peer case scenario or potentially prolonged contact. Subsequently, the food simulant solution was evaporated at high temperatures (> 300 °C) in a previously weighed glass cell (m_1; mg). After all the solution was evaporated, the glass cell was dried at 105 °C to constant weight (m_2; mg). All measurements were performed in triplicate. The overall migration (OM, (mg/dm^2)) was calculated using the Eq. (3).

$$OM = \frac{m_2 - m_1}{A} \qquad (3)$$

2.3.4 Optical Ink Density

To observe the thickness of the black ink film on laboratory paper substrates (N, NT, NB, NW), the optical ink density parameter was used. The optical ink density (D_i) on all prints obtained with different printing techniques (digital, flexographic, offset) was determined using a densitometer eXact, X-Rite (D50/2º). Since the ink layer is opaque, the optical ink density was calculated from the values of the light intensity (I) reflected by the ink layer in relation to the light intensity (I_0) and the values of the light intensity (I_0) reflected by unprinted paper substrates according to Eq. (4) [31].

$$D_i = \log \frac{I_0}{I} \qquad (4)$$

Thus, a higher optical ink density means a higher ink layer or a higher concentration of ink and a higher optical contrast [32].

2.3.5 Undertone

The undertone describes the colour of a thin layer of ink on paper that can be seen through its white background. The determination of undertone in this study was done using the Euclidean colour difference based on the colorimetric values of CIE L^*, a^*, b^* from a white background of the printed laboratory paper and a white background of the unprinted laboratory paper. The undertone values are calculated based on ΔE_{00}^*. The colorimetric values were measured by a spectrophotometer eXact, X-Rite under an illuminant D50 and 2° standard observer. The following Eq. (5) was used to calculate the Euclidean colour difference (ΔE_{00}^*) [33] from the measured values of the transformed lightness difference between samples ($\Delta L'$), the transformed chroma difference between samples ($\Delta C'$), the transformed hue difference between print samples ($\Delta H'$), the rotation function (RT), the parametric factors for the variation in the experimental conditions (k_L, k_C, k_H) and the weighting functions (S_L, S_C, S_H):

$$\Delta E_{00}^* = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)} \quad (5)$$

2.3.6 Data Analysis

Statistical analysis was performed in XLStat using analysis of variance (ANOVA). All experiments were carried out at least in triplicate, and the results were reported as the means and the standard errors of differences of the means of these measurements.

3 RESULTS AND DISCUSSION
3.1 Water Vapour Permeability and Optical Ink Density of Prints

Like other paper properties, air permeability is an indicator of end-use performance and can be used to estimate how inks will penetrate and spread. One of the goals of this research was to measure the permeability to gases (O_2 and CO_2) to see if the presence of inks on papers with straw pulp would have a positive effect on lowering the gas permeability values. Unfortunately, all of the printed samples were extremely permeable which limited the ability to obtain accurate results before the test was finished, so they were not included in this study. The water barrier properties of the paper are important in extending the life cycle of the material. The comparison was made for UV-curable inks applied to a laboratory-produced paper substrate using three different printing techniques: digital (marked "d"), flexographic (marked "f") and offset (marked "off"). The measured *WVP* values were similar for all paper types and were within a range of 10^{-10} g/(m·s·Pa) (Tab. 2). This was attributed to the pore structure and hydrophilic nature of fibre-based paper samples. In [22], it was found that the water absorption of laboratory-produced papers with recycled fibre pulp increased by about 50% with the addition of 30% pulp from triticale, barley, or wheat pulp. Similar *WVP* values were also reported for uncoated commercial paper or for paper coated with a thin layer of biopolymers to reduce the sensitivity of the destructive paper matrix to water vapour [34]. Otherwise, the high permeability values were not surprising, since paper and cardboard are known for their relatively low resistance to moisture and gases [35]. Although the application of polymer ink coatings could improve barrier performance and compensate for the above disadvantage, this was not the case in the present study.

WVTR values ranged from 1.08 to 11.45×10^{-3} g/(m²·s), with significantly lower values for offset prints (Tab. 2). It is possible that the ink fills the pores, which reduces the permeation of water vapour molecules and decreases the size of voids between fibres [36]. This is attributed to the composition of the ink. The offset inks used in this study were low migration-inks, which have lower optical ink density values [24]. The results were somewhat lower than the values found in the literature (33.29×10^{-3} g/(m²·s) for the copy paper grade [37].

Table 2 Thickness (x), water vapour permeability (*WVP*) and water vapour transmission rate (*WVTR*) values of unprinted and printed laboratory-produced papers by different printing techniques

Paper type	x (μm)	*WVP* ($\times 10^{-10}$ g/(m·s·Pa))	*WVTR* ($\times 10^{-3}$ g/(m²·s))
N unp	90.10±2.13[b]	3.39±0.05[c,d]	8.28±0.12[d,e]
N d	87.20±2.57[b]	4.53±0.13[b]	11.45±0.33[a,b]
N f	85.60±2.23[b]	3.33±0.16[c,d]	8.55±0.41[d,e]
N off	92.14±13.83[a,b]	5.49±2.30[b]	1.31±0.55[a,b]
NT unp	101.67±14.72[a,b]	3.84±0.23[b,c,d]	8.06±0.47[d,e]
NT d	100.01±1.05[a,b]	3.18±0.14[d]	7.25±0.33[e]
NT f	94.80±9.65[a,b]	3.96±0.15[b,c,d]	9.21±0.34[c,d,e]
NT off	96.86±20.64[a,b]	4.33±1.11[b,c]	0.99±0.25[a,b,c,d]
NB unp	91.67±4.08[a,b]	3.41±0.12[c,d]	8.34±0.29[d,e]
NB d	91.70±3.75[a,b]	3.19±0.17[d]	7.65±0.41[d,e]
NB f	92.60±8.58[a,b]	3.93±0.12[b,c,d]	9.34±0.29[b,c,d]
NB off	97.71±12.98[a,b]	4.77±0.17[a,b]	1.08±0.04[a,b,c]
NW unp	101.67±17.22[a,b]	3.33±0.15[c,d]	8.30±0.38[d,e]
NW d	101.05±2.27[a,b]	3.04±0.12[d]	7.30±0.29[e]
NW f	91.43±5.26[a,b]	3.72±0.13[b,c,d]	8.96±0.30[c,d,e]
NW off	107.43±9.68[a]	5.73±0.55[a]	1.17±0.11[a]

* N = laboratory-produced paper from pulp of 100% recycled wood fibres; NT = laboratory-produced paper with addition of 30% triticale pulp; NB = laboratory-produced paper with addition of 30% barley pulp; NW = laboratory-produced paper with addition of 30% wheat pulp; unp = unprinted; d = digital printing technique; f = flexographic printing technique; off =offset printing technique.
[a-e] Different superscripts within the column indicate significant differences between samples at $p < 0.05$.

The thickness of laboratory-made papers with straw pulp was significantly higher than that of the control sample (N), with no significant differences depending on the type of straw fibre. There were also no significant differences between prints on the same type of paper with respect to the printing technique used.

Table 3 Optical ink density of printed black ink with variuos printing techniques

Paper type	Optical ink density		
	digital prints	flexographic prints	offset prints
N	0.96 ± 0.01[a B]	1.15 ± 0.01[a A]	0.96 ± 0.01[b B]
NT	0.91 ± 0.02[c C]	1.10 ± 0.01[c A]	1.01 ± 0.02[a B]
NB	0.90 ± 0.01[c C]	1.13 ± 0.01[b A]	1.02 ± 0.02[a B]
NW	0.93 ± 0.02[b C]	1.13 ± 0.01[b A]	0.98 ± 0.03[b B]

Different superscripts within the column ([a-c]) and in the row ([A-C]) indicate significant differences between samples at $p < 0.05$.

The values of optical ink density in Tab. 3 show that the highest values are contained on all laboratory papers produced by the flexographic printing technique, while the values on offset and digital prints were very close to each other.

3.2 Overall Migration

The overall migration was measured to verify the migration of all substances from the paper and print samples in 3% aqueous acetic acid and 95% ethanol [38, 39]. Although these papers are not primarily intended for primary food packaging, it was interesting to investigate how papers with a novel type of incorporated fibres would behave if they came into contact with food. Potentially, they could be used as disposable takeaway food materials or as secondary packaging.

The results of overall migration values (OM) for unprinted paper samples are shown in Fig. 1, and for printed samples in Fig. 2, where the red line indicates the legal overall migration limit of 10 mg/dm^2 [29].
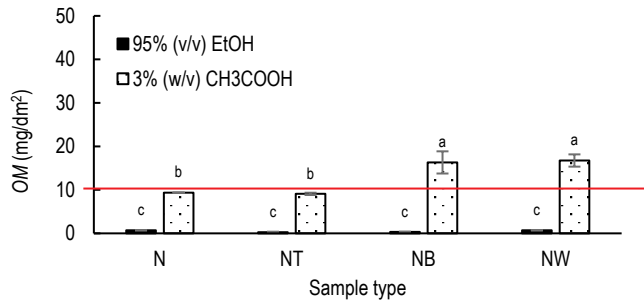
Figure 1 Overall migration values (OM) from unprinted paper sample types. [a-c] Different superscripts indicate significant differences between samples at $p < 0.05$.
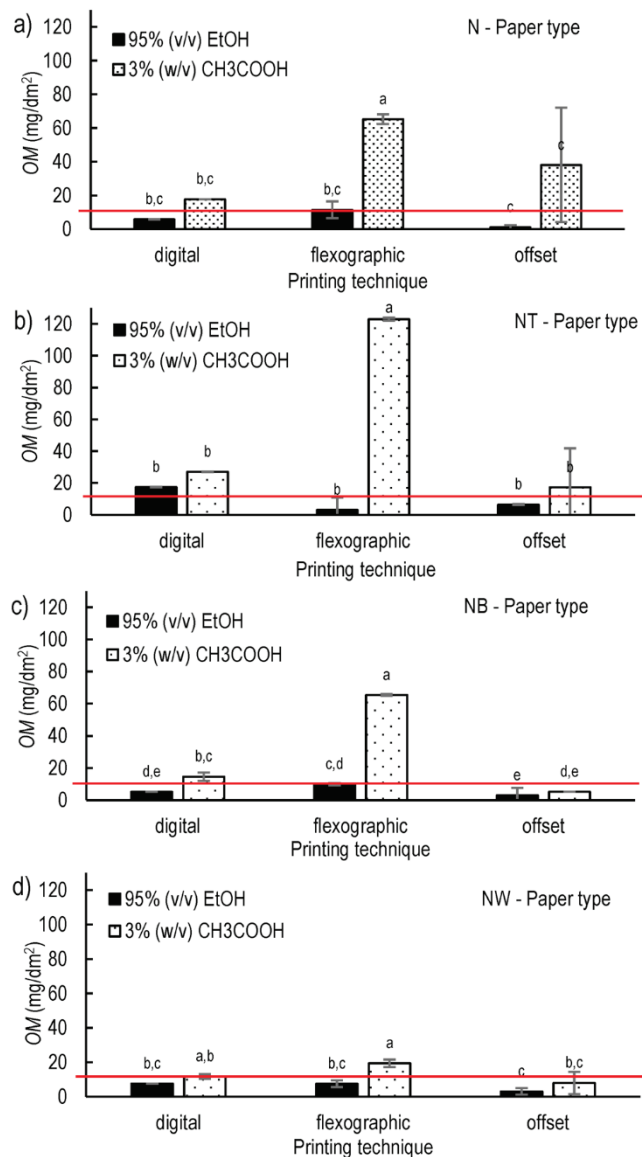
Figure 2 Overall migration values from prints on: a) N - paper type, b) NT - paper type, c) NB - paper type and d) NW - paper type. [a-c] Different superscripts indicate significant differences between samples at $p < 0.05$.

In general, all samples had higher migrations in acetic acid than in ethanol. This can be explained by the composition of paper. Indeed, paper can be defined as a sheet-like material consisting mainly of cellulose fibres and other organic and inorganic components. In terms of quantities used, fillers are the second most important constituent of paper after the fibres themselves [40]. Fillers are water-insoluble substances in the form of particles with a size of about 0.1 μm to 10 μm, which are added to the pulp before paper formation. Calcium carbonate ($CaCO_3$) is the most commonly used in the paper industry. In addition to the numerous advantages of this type of filler, which fills voids in the cellulose fiber network, it is also characterized by its solubility when the pH of medium drops below 6.5 (acidic medium). Therefore, the papers showed significant migration to acetic acid, as this food simulant lowers the pH value of the paper, affecting the solubility of the filler between the fibers and making it more permeable. For the unprinted samples, the overall migration values of N and NT were below the OM limit, while the overall migration values for NB and NW papers in acetic acid were slightly above the limit (Fig. 1). When comparing printing techniques, it appears that the lowest OM values were measured for offset printing, probably due to the use of low-migration inks, followed by digital prints and papers printed with flexographic inks with the highest OM values, especially for the acetic acid. However, no trends could be derived from the results and the samples studied. Recently, it was found in [23] that the ink penetrates less in paper samples containing non-wood fibers than in papers made exclusively from recycled wood fibres, which shows taht the surface ink from paper migrates more easily.

Table 4 Undertone of printed black ink with variuos printing techniques (digital, flexographic and offset) on laboratory-made papers

Paper type	Undertone of prints		
	Digital prints	Flexographic prints	Offset prints
N	8.37±0.92[c B]	19.89±2.64[a A]	5.13±0.44[c C]
NT	18.68±2.44[a A]	19.45±2.26[a A]	6.37±0.54[a,b B]
NB	13.01±1.26[b B]	19.34±3.15[a A]	6.61±0.68[a C]
NW	11.77±0.59[b B]	16.22±1.73[b A]	5.93±0.32[b C]

Different superscripts within the column ([a-c]) and in the row ([A-C]) indicate significant differences between samples at $p < 0.05$.

Tab. 4 shows that the undertone values are extremely low in prints produced by the offset printing technique, while the highest values were obtained in flexographic prints, which means that the ink was retained on the printed surface in offset prints. From the different ink properties, it can be concluded that the ink that did not penetrate deeply into the printing substrate had a positive effect on migration, i.e. lower migration in 3% aqueous acetic acid and 95% ethanol.

4 CONCLUSION

This study defined that the addition of non-wood fibers derived from cereal straw to recycled fiber pulp results in paper substrates that have approximately the same water vapor permeability as 100% recycled paper. The study also confirms that substrates with non-wood fibers can be used for

packaging, which is preferably printed by offset printing due to the extremely low *WVTR* value. It is also concluded that in addition to the different ink properties, the ink printed by offset printing remains on the surface of the paper, resulting in lower overall migration values. Water vapour permeability values for digital prints were similar to flexographic one, while the overall migration values were higher than that measured in offset prints and lower than flexographic prints. The main limitation of this study was not uniformity of laboratory-scale produced paper as well as sample sizing. Further work will be focused on scaling-up to commercial production line and, if possible, case-study on real products.

Acknowledgements

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An Enhanced AdaBoost Classifier for Smart City Big Data Analytics

Fahd S. Alotaibi

Abstract: The targeted goal regarding the smart cities is improving the goodness of their people and to raise the economic improvement in maintaining certain rate or level. Smart cities would increase all set of utilities, which involves healthcare, education, transportation and agriculture among other utilities. Smart cities are depended on the ICT framework, which includes the Internet of Things methodology. These methodologies make bulk of diverse in data, which referred to as big data. Moreover, these data have no purpose by themselves. Modules needed to improve as new to explain the large amount of data collected and one of the good methods to solve is to use the methods of big data analytics. It shall be maintained and designed through the methods of analytics to get good understanding and in order to increase the utilities of smart city.

Keywords: AdaBoost; Big Data; Internet of Things; Linear Regression; Smart Cities

1 INTRODUCTION

Cities all over the world are trying to change themselves into smart cities. Most recent research shows that the main factor in this change is urban big data use from the things, which are physical in city areas. The usage of data in smart cities constantly remains Strange by framework and knowledge. This research paper results in finding an analysis on cases, which are different types among big data in cities of all over the world and government organizations projects toward smart cities development. [1] The data use for smart cities can form a framework by collecting the models for reference, problems to be faced, and thoughts. Generating huge amount of data in different format and takes from more parts like traffic sector, energy sector, education sector, healthcare and producing various parts is the main application in the smart city. [2] The produced data is gathered in huge amounts and on general it offers a view on what and how was happening in real-time of the city at any time. To confirm the correction and needful using these data in applications of smart city, which are perfectly suit and powerful tools among big data management must be present. [3]

2 IMPACTS OF BIG DATA

Impacts of Big Data includes different departments such as transport, cost, safety etc. [4] (Fig. 1).
1) **Public Safety.** Identity the prone area for the purpose of public safety to predict the exact crime location.
2) **Transportation.** Traffic jam and roadblock can be decreased and road optimization can be done by data driven.
3) **Cost Minimization.** Used to identify the required area transformation and identity what kind of transformation.
4) **Supportable Growth.** Growth drivers of suitability is by Continuous growth. The outcome in development of a smart city is determined by the major playing role of data.
5) **Smart Network Infrastructure.** It contains the capacity of connecting components easily. The real-time smart cities applications in big data must have the support of quality of service (QoS).
6) **Smart Filtering and Aggregating.** It helps to decrease the traffic of network and fastest data preprocessing.

Figure 1 Big Data Impacts

3 ADABOOST CLASSIFICATION ALGORITHM

Methods for classification must have developed for decades. There are two types of classification methods commonly termed as: supervised classification and unsupervised classification. The analyst chooses the training samples land cover class first for each and it makes guidance for the system to find same areas in each class is known as Supervised Classification. From The selection of given trained samples which is depended on collection of field data. The best and recent classification methods of supervised machine learning includes large likelihood method, parallelepiped method, small distance, decision tree method, random forest method, and support vector machine method, among other methods. [5] The classification, which does not start with training samples, is known as unsupervised classification. However, the analyst particularly choose the desired count of classes, and hence the system automatically groups the pixels, which are closely same as the clustering algorithms. [6]

The cluster algorithms, which are commonly used, are K-Means, Iterative Self-Organizing Technique for Data Analyzing. The Repetitive process of cluster produces in a preset count of "spectral classes", which then declared as labels of class and changes to "information classes". Unsupervised is the method of classification, which is especially efficient when, came to know early knowledge about the research area, which was unavailable? Sometimes hybrid approach is used which merges the unsupervised and supervised classification methods. [7]

To classify remote images supervised and unsupervised methods are used. They are the classification methods, which are pixel-based, which is only depended on information of spectral. [8]

3.1 AdaBoost

Adaptive Boosting is shortly known as AdaBoost Algorithm, which is a technique for boosting used in Machine Learning. It is called Adaptive Boosting Algorithm as the weights were assigned again for each instance, with heavier weights assigned with incorrectly categorized instances. Decreasing as well as growing difference in supervised machine learning is done boosting. It does something on learners growing principle Back-to-Back. Each ensuring learner is grown from previously grown learners Except the first. Shortly, weak learners were changed as strong learners. The algorithm of AdaBoost tries as similar as the rule for boosting it with a little variance. [9]

During the period or hour of data training [10], it makes n count of decision trees. As the first decision tree or sample demo is made, the first model priority is given to incorrect records, which are classified. As input for the second model priority, only these records are sent. Until we denote a number of base learners, the process goes on and we need to make creation. Point to remember, with all boosting techniques repetition of records are allowed.

Model 1,2,…, N are individual models (e.g. decision tree)
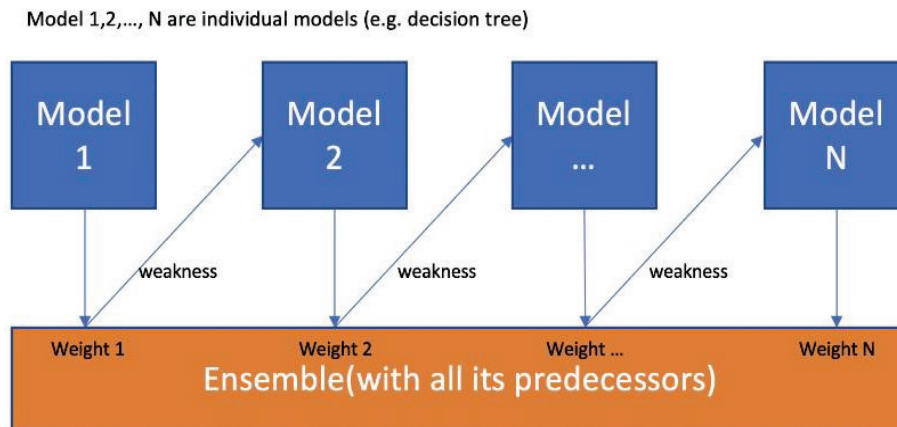
Source: Google

Figure 2 Work Structure of AdaBoost Classifier

4 IMPLEMENTATION OF ADABOOST CLASSIFIER ALGORITHM WITH PYTHON

In AdaBoost Classification [14] To the data points, higher points are allotted which are not classified properly or predicted wrongly by the previous model. This determines that a weighted input will be got through each successive model.

The AdaBoost model consists of weak classifiers, weight update and classify.

Weak Classifiers. AdaBoost combines weak classifiers with certain strategies to get a strong classifier, as shown below. At each iteration, the weights of samples, which are wrongly classified, will increase to catch the classifier "attention". For example, in Fig. 3a, the dotted line is the classifier-plane and there are two blue samples and one red sample, which are wrong, classified. Then, in Fig. 3b, the weights of two blue samples and one red sample are increased. After adjusting the weights at each iteration, we can combine all the weak classifiers to get the final strong classifier.

Weight Update. There are two types of weight to update at each iteration, namely, the weight of each sample and the weight of each weak classifiers. At the beginning, there are initialized as follows:

$$w_i = \frac{1}{n} \tag{1}$$

$$\alpha_m = \frac{1}{m} \tag{2}$$

where n and m are the number of samples and the number of weak classifiers respectively.

AdaBoost trains a weak classifier at each iteration denoted as whose training error is calculated as:

$$e_m = \sum_{i=1}^{n} w_{mi} I(G_m(x_i)) \neq y_i \tag{3}$$

Then, update the weight of weak classifier by:

$$\alpha_m = \frac{1}{2}\ln\left(\frac{1-e_m}{e_m}\right) \tag{4}$$

From the above equations, we can conclude that:
1) The training error is the sum of weights of the wrong classified samples.
2) When e_m is less than 0.5, α_m is greater than 0, which means the lower training error the weak classifiers has, the more important role that weak classifier plays in the final classifier.
3) The code of training process [11-14] of AdaBoost is shown below:

```
def train (self, train_data, train_label):
    if self.norm_type == "Standardization":
train_data = preprocess.Standardization(train_data)
```
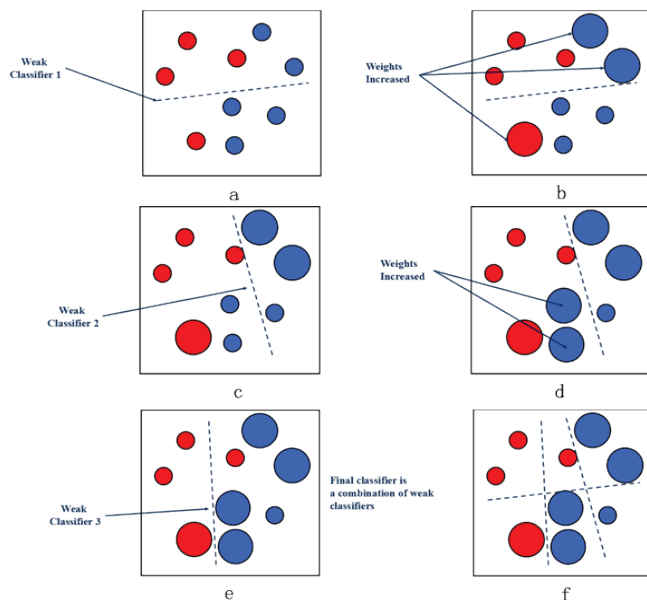

Figure 3 Week and Strong Learners of AdaBoost Classifier AdaBoost Model

Conclusion and Analysis of AdaBoost Implementation. AdaBoost can be regarded as additive model with exponent loss function using forward step algorithm. In AdaBoost, the type of weak classifiers can be different or the same [15]. In this article, we use 5 SVM classifiers as the weak classifiers, and the detection performance is shown below:
Output:
Accuracy of AdaBoost: 0.850000
Runtime of AdaBoost: 3. 4339-06546173096

AdaBoost Algorithm:
Step 1: Assign Entire observations with its own weight
Step 2: With the support of stump the observation samples are classified randomly
Step 3: Sum of weights of misclassified record is calculated in the form of total error.
Total Error = weight of misclassified records Total error will among 1 and 0.

1 represents misclassification which is also known as weak stump.
0 represents correct classification which is also termed as perfect stump.
Step 4: calculate stump performance

$$SP = \frac{1}{2}\ln\left(\frac{1-TE}{TE}\right) \tag{5}$$

(Where *SP* is stump performance as well as *TE* is total error)
Step 5: Update weight based on the performance of stump,the weights are updated

$$NW = W * E^P > MR$$
$$NW = W * E^{-P} > CCR \tag{6}$$

Where *NW* is new weight, *W* is weight, *P* is performance, *MR* is misclassified records, and *CCR* is correctly classified records.
Step 6: Update weights in Iteration.
Step 7: Discover Final Predictions

$$\frac{FP}{SIGN(WS)} = \sum(\alpha_i * EIWPV) \tag{7}$$

Where *FP* is final prediction, *WS* is weighted sum and EIWPV is each iteration with predicted value.

Linear Regression. While we have a single input in Linear Regression, to show the coefficients efficiently statistics can be used.
Calculating statistical properties is essential from the data that are:
• means,
• standard deviations,
• correlations and
• covariance.

To cross and calculate the method of statistics, all data must available.

5 RESULT ANALYSIS

Smart city index is the dataset from kaggle.com
Utilizing different types of IoT (Internet of Things) sensors to collect and manage data - combined with many other technical integrations into our city hubs - defines the future of data & automation being embedded in our urban-living. Think of Smart Cities as a customer experience - for residents of a city.
The Leap Data team utilized globally recognized indices (formalized for the evaluation of Smart City initiatives), and developed a data model to interpret how Calgary & Edmonton stand in relation to Global Leaders of Smart City activities.

6 ATTRIBUTES

Table 1 Smart City Index

ID	City	Country	Smart Mobility	Smart Mobility	Smart City Index
1	Oslo	Norway	6480	6512	7138
2	Bergen	Norway	7097	6876	7296
3	Amsterdam	Netherlands	7540	5558	7311
4	Copenhagen	Denmark	7490	7920	7171
5	Stockholm	Sweden	6122	7692	6812
6	Montreal	Canada	7490	4848	7353
7	Vienna	Austria	5683	7608	6771
8	Odense	Denmark	6160	8404	6886
9	Singapore	Singapore	5790	4344	6813
10	Boston	United States	7870	5224	6852
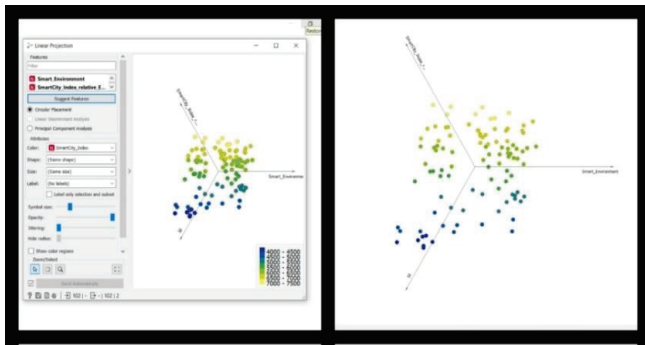
Figure 4 Outcome of AdaBoost

ID: Column identifier

City: List of smart cities across the world

Country: List of countries where smart cities across the world are located

Smart Mobility: Index calculated from assessment of citywide Public Transportation System, ICT, and accessibility infrastructure.

Smart Environment: Index calculated from environmental sustainability impact, monitoring pollution and energy management.

Smart Government: Index calculated from comparative study of transparent governance & open data initiatives of smart cities across the Government of each States.

Smart Economy: index calculated through global comparison of citywide productivity, economic vitality, and support for Finance.

Smart People: Index calculated by comparing social and cultural plurality, education systems and its supporting ancillary facilities across the world.

Smart Living: Index calculated by measuring metric around healthcare services, social security and housing quality.

Smart City Index: Aggregate score for smart city model based on smart city super groups.

7 CHALLENGES AND OVERCOMING TECHNIQUES

Smart city planning is the combination of various sectors that adds peoples, public welfare organizations, local and state government and private enterprises, healthcare, etc. hence after these combinations are gathered, it develops various large chances for business, sustainability, disaster prevention, public safety. However, many difficulties and problems can be shown by the combination of methodological collaboration and innovation among the private enterprises and public organizations.

Figure 5 Methods to overcome Challenges

8 CONCLUSION

Two important concepts are Big Data and Smart City; Hence, Applications in developing Smart Cities will help reaching the comfortability, good recovery than previous, Powerful manner of governance, Increased Life's Quality, and brilliant Organization of resources in smart city Development. Our work of research explained either the terms or their various short Explanation and then we were gone to know that some attributes which are common for everything. In spite of differing the short explanation, each category has a count of characteristics and functions that particularly means it. Based upon the above functionalities, which are common, hence now we are capable of choosing the most similar gain of big data usage to make design and support the improvement of applications in smart city.

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Design of a Single-Core Digital-to-Analog Converter with Ultra-Wideband and Low Power Consumption for CUWB-IR Applications

Seyed Mohammad Hashemifar

Abstract: Data converters are intermediate circuits used to connect between two analog and digital ranges. Data converters are not only used for converting audio into a microphone or speaker, but also for converting audio into a camera or display, transferring information to a computer or digital signal processor. At these times, the need for data converters is not invested in every aspect of life. Digital to analog converters is a leading part of these converters, which are widely used in most audio and video circuits. In this thesis, we have proposed a 4-bit 1GS/s DAC for CUWB-IR usage. To enhance the above performance with superior speed and the need for linearity, every significant block containing the convenient sources, current switches, and deglitcher were designed optimally and a new DAC converter circuit was developed which improves the linearity. The designed DAC was performed using a commercial 130 nm CMOS process. DAC INL/DNL≤0.22LSB features more than high Nyquist bandwidth at extremely low power losses of 0.45 mW. The proposed DAC achieves the best FoMs at the right time for advanced DACs.

Keywords: Cognitive Ultra-Wide Band; CUWB-IR; differential non-linearity; digital-to-analog converter

1 INTRODUCTION

Analog-to-digital converters are one of the most important blocks in software radio and other signal processing systems [1]. With the advancement of technology, the design of analog circuits has become more complex due to the reduction of the inherent gain of the transistor and the voltage of the power supply [2, 3]. Therefore, it is extremely challenging to design a converter with high speed and accuracy [4]. Analog-to-digital tube converters have absorbed a great deal of attention among other analog-to-digital converters due to their relatively incredible speed, low power consumption, and medium to high accuracy, and are widely used in Nyquist sampling. Maybe [5]. In these converters, by reducing the channel length of the transistors in SIMAS technology, it becomes extremely challenging to design an amplifier with significant gain and speed. Recent methods have been proposed to solve the problems of analog-to-digital converters. In some of these methods, by reducing the voltage of the power supply, the converters are designed and as a result, the power consumption is reduced. Broadband (CUWB) comprises a combination of broadband (UWB) and radiography, which represent an emerging approach that allows the use of a highly efficient, low-interference spectrum (as opposed to non-cognitive types that require Has a spectrum band allocation) [6]. Typically, the CUWB system negotiates with nearby radio systems to find available spectrum bands, searches for the spectral range of the negotiations, and then repeats the process in real-time. Given the mentioned fact, it is mostly achievable that the CUWB transmit system could produce compatible UWB waves that are in reach by spectral bands.

The alternative method is a digital-to-analog converter (DAC) generator that can reduce these weaknesses by combining a UWB compatible waveform with the corresponding digital inputs. In the non-cognitive UWB radio waves (UWB-IR), the UWB wave formed is typically produced via a pulse producer using a delay regenerator, oscillator circular, and phase modification diode method. However, the mentioned methods are unsuitable for Cognitive UWB-IR, mainly since the pulse producers are usually restricted to a single UWB form. When multiple pulse producers can be multiplied to form various pulse shapes, there are problems with excessive hardware shortages, complex pulse producers, or poor compatibility of the on-chip (SoC) CMOS system. [14]

An alternative method is a digital-to-analog converter (DAC) generator that can reduce these weaknesses by combining a UWB compatible waveform with the corresponding digital inputs [7]. It should be noted that the DAC-based pulse producer has three profits. At the first, using the previous signal of the digital signal processor, the UWB signal can be generated with adjustable pulse shapes. Secondly, this feature shows a reduction in the diameter of the pulse waveform ring [8], thus improving power efficiency and noise safety. Ultimately, the system is CMOS compatible with the chip (SoC). Because of these features, the high-speed Nyquist DAC is significantly better for CUWB-IR transmitter pulse generators. Despite these advantages, current DACs are unsuitable for the most advanced CUWB-IR systems for low power consumption. Some high-speed DACs [9, 10] employing exotic fabrication procedures (eg SiGe, BiCMOS, III-V, and HBT) by high-frequency transistors have been proposed. On the other hand, the reported ultra-fast CMOS DACs require soaring cost, excessive complexity, and hardware such as a phase-locking loop (PLL) frequency divider to achieve high conversion rates. In addition, losses lead to more power [11, 12]. For this purpose, in this paper, a high-speed single-core CMOS DAC with low hardware cost is required to build a low-power CUWB-IR system.

2 METHOD
2.1 1GS/S 4-bit Analog-to-Analog Digital Converter

Fig. 1 depicts the schematic of a digital converter designed for 4-bit analog 1GS/s. The input signal is followed by the deglitched providing digital signals. After that, the conditional digital signals are fed to the current switch at the

outer level. Essential blocks structures - current sources, current switches, and deglitches - are identified in turn.
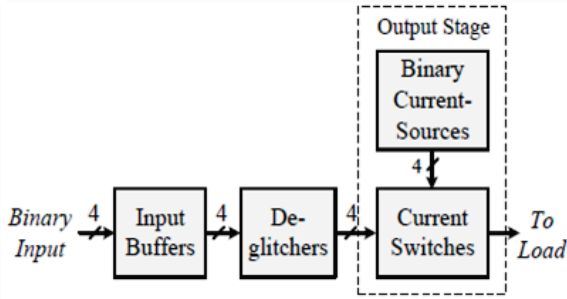
Figure 1 Block diagram of the digital converter to 4-bit analog 1GS/s

A transistor with complex output impedance is critical for low output distortion, and this is achieved by a small transistor for the low noise capacitor. Vice versa, small-sized transistors can degrade the transistor's fit across the array of current sources, leading to high nonlinearity and reduced efficiency [8]. Up and matching a good transistor is essential. Fig. 2 shows a diagram of a cascade current source with current switches. According to the below equations, firstly the impedance resistor is determined, which is sufficient to achieve the 4-bit requirement, and then determine the transistor matching. The optimum output impedance of a completely different DAC is deducted by the *INL* and *SFDR* specifications.
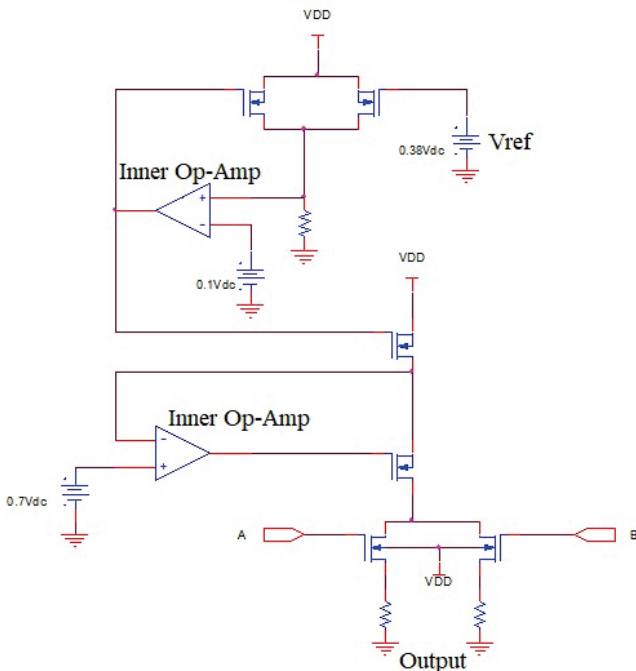
Figure 2 Outline of a source and DAC current switch

As shown in Fig. 3, the link between the apparent input resistance and the *INL* for the unit current control topology can be determined. The common binary flow topology is effectively parallel to the multiple units of flow sources. According to the end-of-line *INL* calculation [7], the INL_k for the input code k is obtained as follows:

$$INL_k = \frac{v_{\text{out}, k} - v_{\text{out}, 0}}{v_{\text{out}, LSB}} - k = \frac{k(M-k)(M-2k)}{2(k+s)(M-k+s)}. \tag{1}$$

The *INL* peak value is expressed as follows:

$$|INL| = \frac{(3s^2 + 3Ms - p)\sqrt{6s^2 + 6Ms + M^2 - 2p}}{2(s^2 + Ms - p)}, \tag{2}$$

in this case:

$$r_0 = R_L \left(-\frac{M}{2} + \frac{\sqrt{3}}{18} \sqrt{9M^2 + 8INL^2 + \frac{(3M^2 + 4INL^2)^{3/2}}{|INL|}} \right). \tag{3}$$

Then, assuming that intermodulation proves the third-largest stimulus, the link between apparent output resistance and *SFDR* (dB) is obtained in part from the analysis in [9], as follows:

$$r_0 = \frac{R_L M}{4} \left(-2 + \sqrt{3 \times 10^{|SFDR|/20} - 9} \right). \tag{4}$$

Based on the previous equations, the R_L must obtain 50 ohms and the required r_0 more than one kW ohm to meet the condition < 0.25LSB *INL* and > 24dBc *SFDR*.

2.2 Current Switches

Fig. 2 illustrates the outline of the flow switches in which a simple differential pair topology is tuned to satisfy the conversion rate requirement of 10 GS/s. The current switch model here includes amplifying the dynamic linearization of the DAC reduction in the output errors caused by the capacitive power supply. The effect of capacitive power supply is deduced by minimizing intermittent capacitance between currents and using low voltage fluctuation (excitation) control signals in current switches.

2.3 Deglitches

The inverter [8] can reduce the discharge mechanism: by adjusting its output transfer point so that the current switches are never "off" at the same time. To more significantly modify the discharge mechanism, the deglitches (based on inverter M1-M6) are proposed by increasing the high-speed source (M7-M8) and are illustrated in Fig. 4. The amplified source reduces the glitch mechanism by specifying low voltage fluctuations (0.5 VDD) and short transmission times (10 T clock%). In addition, the interference between the two algorithms is reduced by two methods. First, resistive loads, instead of three-dimensional transistors, are used for rapid change, as well as interference and internal interference. Second, the apparent resistance of the output is designed to reduce intersymbol interference due to undesirable overload [10].

3   SIMULATION RESULT

The proposed DAC test is rigid, especially because of the digital algorithms, 4×10 Gb/s input is required. For Gb/s speeds, the time interference method [11-13] is typically used to reduce I/O requirements. However, this method increases several other challenges, including much larger auxiliary circuits, complex auxiliary circuits (e.g. RF PLLs, frequency dividers), and so on.

Our proposed model maintains three advantages. Initially, it offers dual performance mode (READ) and a fast 25 Mb/s WRITE speed (1 Gb/s). It should be noted that the purpose of the test is incredible speed, and the second makes it attractive for simplicity and low-speed planning. In addition, the proposed tester is relatively easy to implement.

Fig. 3 illustrates a proposed tester designed to produce high-speed digital patterns at 1 Gbp/s. The required rate of one Gb/s is obtained using four devices built into testers with data pattern lengths of up to 4 bits. Fig. 3 shows the execution state data streams:
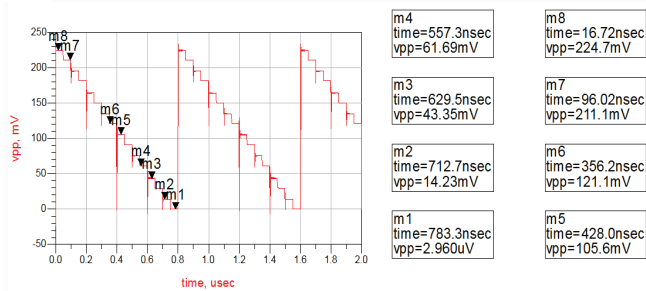
Figure 3 Shows the performance of the proposed circuit
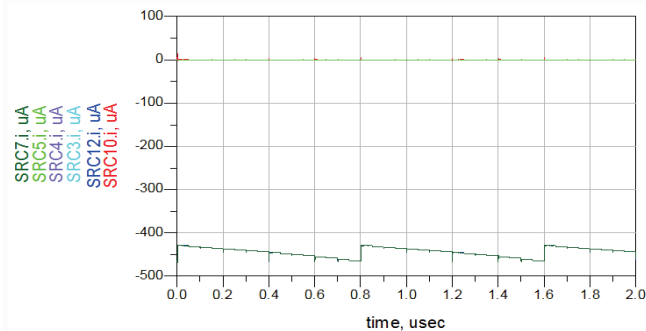
Figure 4 Displays the system consumption current over time
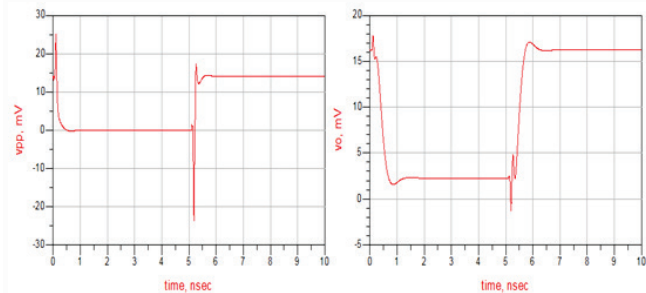
Figure 5 Displays single-bit input change

Generate data loops at speeds above one gigabyte per second. In this section, the output results of the designed

circuit are reported in Fig. 4. Based on the circuit diagram, it is designed for an output range of zero to 240 mV, which for a 4-bit resolution is equal to 15 mV for each phase change (LSB). There is very good linearity in the system. Figs. 4-6 also shows the transient response speed of the converter to change one bit in the input. Finally, Fig. 6 shows the performance of auxiliary operational amplifiers.
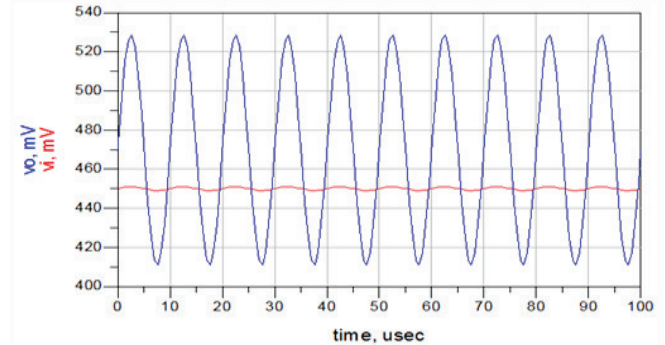
Figure 6 Shows the performance of an auxiliary operational amplifier as a buffer and amplifier

To evaluate the proposed DAC against advanced CMOS-based and non-CMOS-based DACs, we have implemented various schemes in Tab. 1. In this benchmark, the CMOS DAC in [13] has a higher conversion ratio than the proposed one in this research. Chiefly since it uses a 16:1 period. However, it is slower based on a single-core DAC. Multiple approaches to the CUWB-IR application are not considered scheduled to the complex hardware overload for synchronization.

Table 1 Evaluation of the proposed DAC against high-speed super-fast DACs

	This work	[7]	[8]	[9]	[6]
System	CMOS	CMOS	CMOS	Bi- CMOS	InP HBT
Size (mm)	130	28	65	250	500
Resolution (bit)	4	6	6	4	6
V_{DD} (V)	1	2.5/1.4	2.5/1.1	3.5	-4
$f_{conv-1-core}$ (GS/s)	2.1	7	3.5	30	60
$V_{out-swing}$ ($V_{pp-diff}$)	0.24	0.5	0.6	0.05	1
P_d(mW)	0.45	145	46.87	455	1800
INL (LSB)	0.16	-	-	0.49	0.31
DNL (LSB)	0.22	-	-	0.57	0.43
FoM$_1$ (pJ)	0.028	0.32	0.21	0.95	0.47
FoM$_2$ (pJ^{-1})	--	1.11	2.30	-	-

4   CONCLUSION

Analog-to-digital tube converters are widely used in telecommunication receivers due to their relatively high speed and medium to absolute accuracy. For this reason, currently, many efforts have been produced to reduce its power consumption in various ways. In this paper, we propose a 4-bit 1GS/s DAC for CUWB-IR applications. To achieve the above high-speed performance and the need for linearity, every critical block containing existing sources, current switches, and deglitcher were optimally designed, and a new deglitcher circuit was developed that improves linearity. In addition, a new tester has been developed that provides low-speed programming and high-speed digital pattern generation. The DAC is designed using a commercial

130 nm CMOS processor. DAC INL/DNL≤0.22LSB features more than high Nyquist bandwidth at extremely low power losses of 0.45 mW. The proposed DAC obtains the best FoMs at the right time for advanced DACs.

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Influence of Infill Pattern on 3D-Printed Parts Compression Strength

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Abstract: Article presents analysis of the influence of infill pattern on 3D printed parts compression properties. Most of the researches from this field covered tensile 3D-printed parts properties, but for some applications compression mechanical properties are far more important. For the analysis of compression strength, 3D-printed specimens were produced by Fused Filament Fabrication (FFF) process from acrylonitrile butadiene styrene (ABS) with different shapes of infill pattern. Testing results showed that honeycomb infill pattern results with the highest compression strength. Unexpected result was the lowest compression strength of gyroid infill pattern, which must be more deeply investigated.

Keywords: Acrylonitrile Butadiene Styrene (ABS); additive manufacturing; compression strength; Fused Filament Fabrication (FFF); infill pattern

1 INTRODUCTION

Fused Filament Fabrication (FFF) is a 3D printing technology that is based on material extrusion (MEX) and it is one of the most common Additive Manufacturing (AM) technologies used today [1]. When printing, various parameters can be changed such as model orientation, printing temperature and layer thickness, but in this paper the focus is on the infill structure. Most mechanical properties of the 3D printed parts, such as the tensile strength, have been thoroughly studied in the literature, but this paper analyses the compressive strength that is largely based upon the infill structure. The experimental part of this paper compares the compressive strength of samples manufactured from acrylonitrile butadiene styrene (ABS) with various infill patterns produced by FFF 3D printing. Within experiments, infill patterns such are rectilinear, triangle, cubic, honeycomb, as well as 3D honeycomb and gyroid are analysed.

2 MATERIAL AND METHODS
2.1 Acrylonitrile Butadiene Styrene (ABS)

Compression specimens were produced from acrylonitrile butadiene styrene (ABS) thermoplastic filament. It is amorphous thermoplastic which is used when higher thermal resistance and higher toughness are expected. Temperature range of ABS filament processing with FFF process is 230 - 260 °C, which is at relatively higher level compared to most common thermoplastic materials used for FFF. In case of ABS filament, printing bed also has to be heated to higher temperatures in order to reduce warpage of the first 3D-printed layers and their peel of the bed (most often in the corners of the 3D-printed part) (Fig. 1 - left). ABS also shows tendency to cracking between the layers during 3D printing because of cold air flow against the printed part (Fig. 1 - right), and this is the reason why it is recommended to have closed chamber when printing ABS. One of advantages of the ABS 3D printed parts is possibility to smooth 3D-printed part surface with acetone. [2, 3]
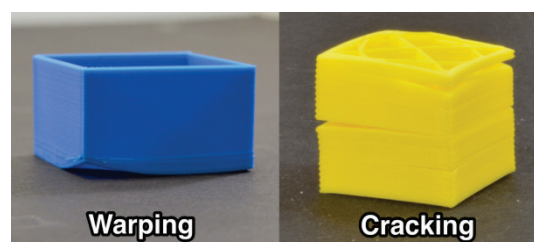
Figure 1 Common problems in 3D printing ABS parts [4]

2.2 Fused Filament Fabrication (FFF)

FFF is currently one of the most popular additive manufacturing processes due to its simplicity and low running and material costs. FFF works on a principle of material extrusion through numerically controlled nozzle on printing bed (Fig. 2) [5].
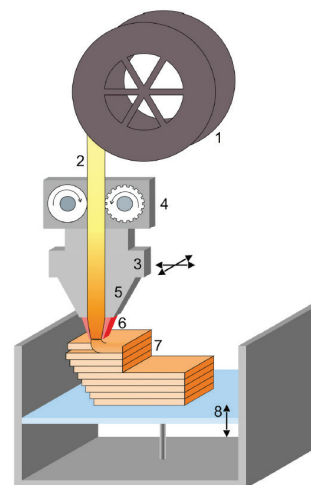
Figure 2 Schematic illustration of the material extrusion process: (1) spooled material, (2) filament, (3) heated deposition unit consisting of (4) counter-rotating driving wheels, (5) a liquefier, (6) a nozzle, (7) element fabricated in a layer-by-layer manner, (8) vertically movable build platform [5]

For research in this article, ABS filament was extruded on a modified Creality Ender 3 fused filament printer (Creality 3D Technology Co. Ltd, Shenzen, China) with installed nozzle diameter of 0,4 mm, shown in Fig. 3 [6].
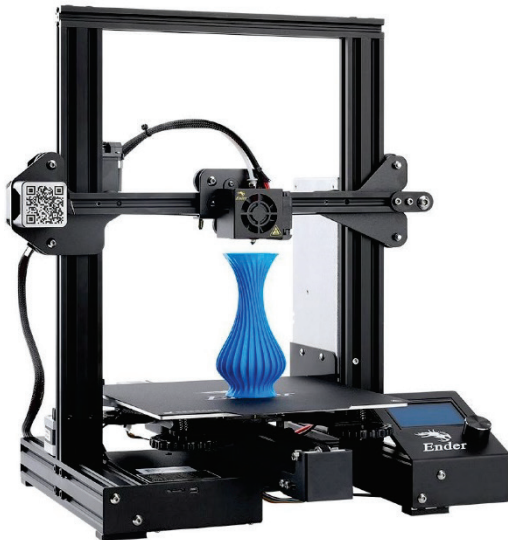
Figure 3 FFF printer Creality Ender 3 [6]

The software PrusaSlicer (Prusa Research, Prague, Czech Republic) was used to prepare the G-code for dog-bone specimens' production with the following parameters which were kept constant through all trial runs:

- Layer thickness 0,2 mm
- Infill density 30 %
- Printing speed 40 mm/s
- Extruder temperature 260 °C
- Bed temperature 110 °C.

2.3 Specimens Geometry and Infill Patterns

Specimen geometry for the compression properties testing is determined with standard HRN EN ISO 604 [7]. Standard specimen dimensions for compression strength testing are $10 \times 10 \times 4$ mm.
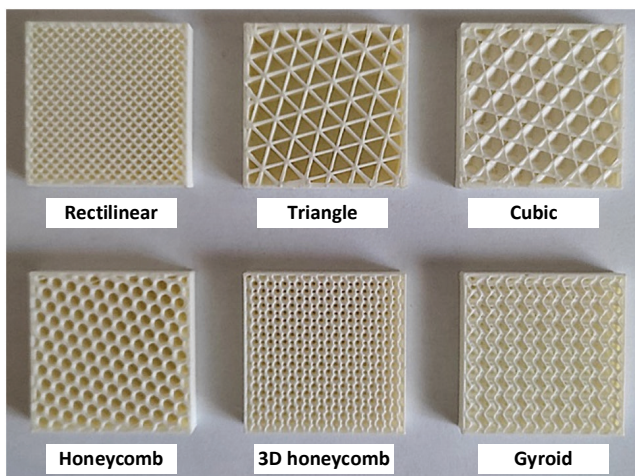
Figure 4 Tested infill patterns

For FFF manufacturing it was determined to create 1 outline for side specimen walls, and 3 layers on the bottom and top of the specimens. This resulted with wall thickness of 0,6 mm at the bottom as well as on the top of the specimen,

and only 2,8 mm of specimen was left for infill structure. As the main aim of this research was not to determine nominal compression strength of specimens according to standard, but to compare different shapes of infill patterns, standard specimens were enlarged by scale of 3 to dimension $30 \times 30 \times 12$ mm

For the infill, six different pattern shapes were selected. Four of them were 2D-infills: rectilinear, triangle, cubic, honeycomb; and two of them 3D-infills: 3D honeycomb and gyroid (Fig. 4).

For the analysis of the influence of infill pattern shape on compression strength, 5 specimens were printed with each type of the infill pattern (total of 30 specimens).

2.4 Compression Testing

Tensile testing of 3D printed compression specimens was performed on a universal static testing machine Messphysik Beta 50-5 (Messphysik Materials Testing GmbH, today ZwickRoell, Fürstenfeld, Austria), shown on Fig. 5.
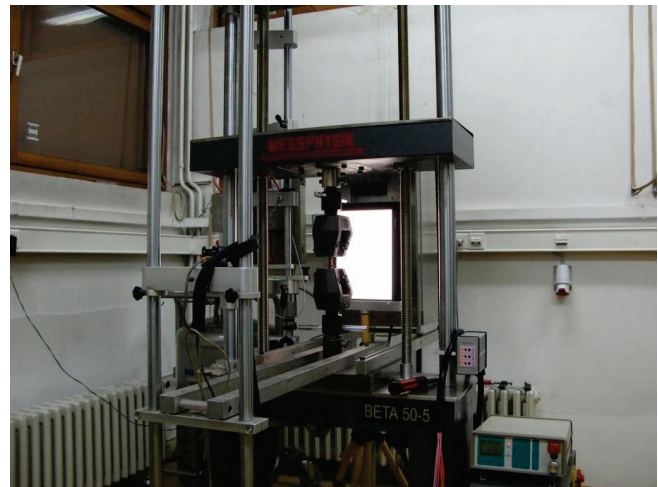
Figure 5 Messphysik Beta 50-5 compression testing machine

Maximum testing force on this machine is 50 kN. Specimens from ABS were tested at deformation speed of 2 mm/min at the temperature of 20 °C. Specimen after the testing is shown on Fig. 6.

Figure 6 Compression specimen after the testing

3 RESULTS AND DISCUSSION

Time necessary for 3D printing each type of the specimens is presented in Fig. 7.

3D printing time (minutes)
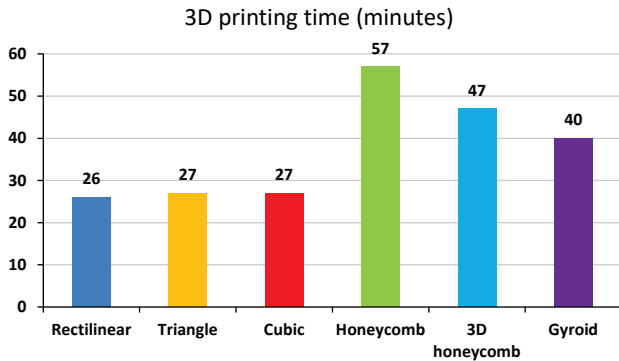
Figure 7 3D printed time for specimens (5 specimens for each infill type)

In case of infill pattern types that require frequent changing in print direction, printing times are increased. Therefore, it can be concluded that infill pattern selection can significantly influence on 3D printing time.

Obtained masses of the specimens with included standard deviation (SD) are presented in Tab. 1.

From specimen's mass point of view, they can be divided into two groups: with simple infill shapes (rectilinear, triangle and cubic) and with more complex infill patterns (honeycomb, 3D honeycomb and gyroid). The trend is: increasing specimen mass with increasing infill complexity, with exception of gyroid, where the most complex infill

pattern results with the lowest specimen mass. In this case variations are not so significant and the difference between the specimen with lowest mass, and with highest mass is 24 %, but the research was performed on specimens with relatively small dimensions. For larger 3D printed parts, shape of infill patterns will have more significant influence on their mass.

Table 1 Specimens mass

	Infill pattern	Specimen (average) mass (g)
1	Rectilinear	4,84 ± 0,01
2	Triangle	5,10 ± 0,01
3	Cubic	5,10 ± 0,02
4	Honeycomb	5,50 ± 0,01
5	3D honeycomb	5,64 ± 0,01
6	Gyroid	4,54 ± 0,01

Compression strength testing results with included standard deviation (SD) of each type of infill pattern are shown in Tab. 2.

Table 2 Compression testing results

	Infill pattern	Compression strength (MPa)
1	Rectilinear	11,79 ± 0,66
2	Triangle	21,10 ± 0,45
3	Cubic	12,57 ± 0,23
4	Honeycomb	23,73 ± 0,11
5	3D honeycomb	22,03 ± 0,96
6	Gyroid	9,71 ± 0,10

Fig. 8 presents compression stress – strain diagram for one representative specimen from each infill type group.
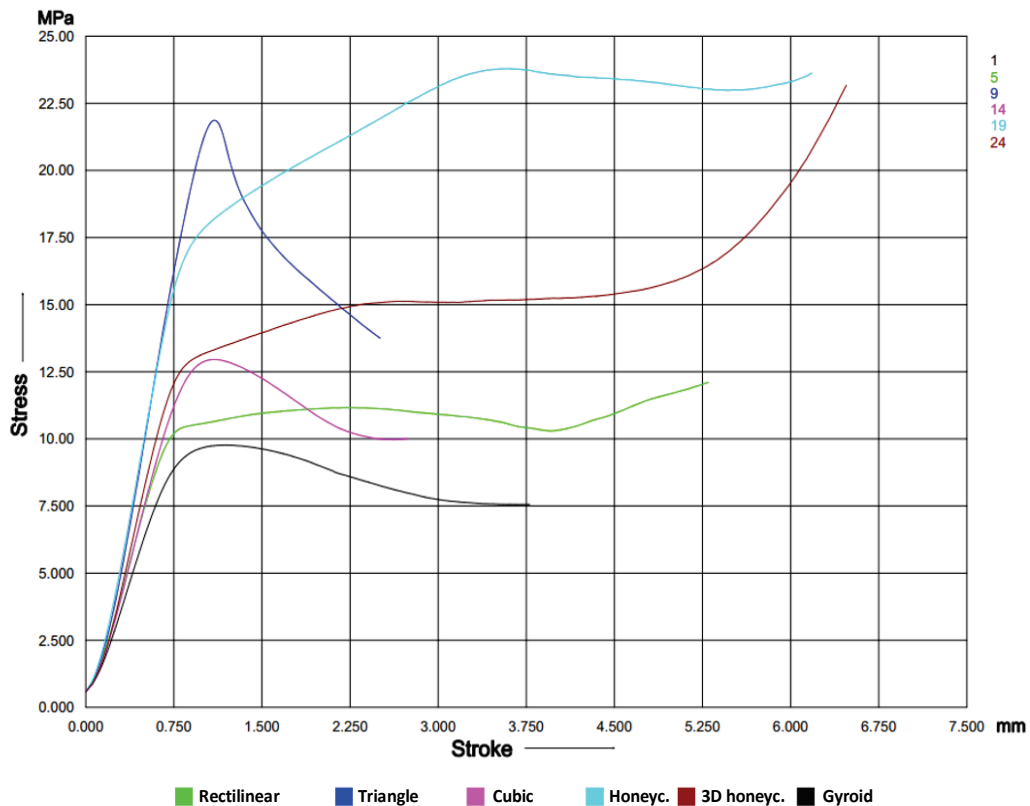
Figure 8 Compression stress – strain diagram

The highest results of compression strength obtained for specimens with honeycomb and 3D honeycomb infill patterns were expected, as they are more complex. Compression strength of specimens with triangle infill patters was unexpectedly high. The specimens with gyroid infill pattern showed the lowest compression strength. Gyroid infill pattern generally shows equal strength in all directions, and although it is not the strongest infill pattern, it offers obtaining the smallest 3D printed part mass (more that 20 % compared to the honeycomb patterns).

Rectilinear infill pattern as well as all complex types of infill pattern (honeycomb, 3D honeycomb and gyroid) shown higher elasticity compared to triangle and cubic infill patterns.

If we are comparing all analysed infill patterns through two criteria: compression strength and time (Fig. 9), it can be concluded that triangle infill pattern can be in some cases favourable, because with almost the shortest 3D printing time, this type of infill pattern results with compression strength comparable with honeycomb infill patterns. Here it should be taken into account that compression testing was performed in direction of specimen's layer deposition, where 2D infill patterns in general have higher strength due to their anisotropy.
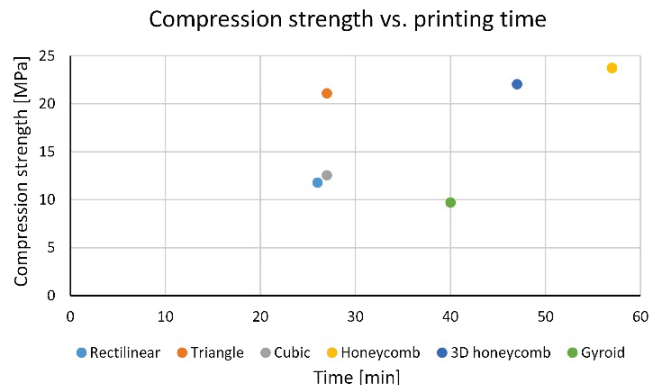
Figure 9 Compression stress vs. printing time for different infill patterns

4 CONCLUSION

The goal of the presented research was determination of the influence of different infill pattern on the compressive strength of 3D printed specimens from ABS material. Specimen masses and 3D printed times were also compared. In case of masses, the difference between specimen with highest (3D honeycomb) and the lowest mass (gyroid) is 24 % which for smaller 3D printed parts is not so large, but in case of larger parts it can present significant difference.

In case of 3D printed time, all three simple infill patterns require considerable shorter printing time (up to 55 % shorter time), compared with both honeycomb infill patterns. Gyroid infill pattern requires longer 3D printing time compared to simple infill patterns, but 15-30 % shorter time compared to the honeycomb infill patterns.

Both honeycomb infill patterns achieved the highest compression strength. Gyroid infill pattern showed the lowest compression strength, around 60 % lower compared

to honeycomb infill pattern. Surprising result was obtained with triangle infill pattern which shown compressive strength similar to the strength of honeycomb patterns but requires significant shorter 3D printing time.

Compression testing in presented research was performed on specimens in direction of 3D printing. For the future research, specimens will be tested in direction orthogonal of 3D printing, where 3D infill patterns – 3D honeycomb and gyroid – should maintain their compressive properties due to their isotropy, and 2D infill patterns, due to their anisotropy should show significantly lower strength.

Another way to improve infill pattern strength, for example in cases where 3D printed part mass is crucial (transportation sector), is development of hybrid gyroid and 2D infill patterns. [8, 9]

Notice

The paper was presented at MOTSP 2022 – 13th International Conference Management of Technology – Step to Sustainable Production, which took place in Primošten/Dalmatia (Croatia) on June 8–10, 2022. The paper will not be published anywhere else.

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Context-Driven Method in Realization of Optimized Human-Robot Interaction

Leon Koren*, Tomislav Stipančić, Andrija Ričko, Juraj Benić

Abstract: Perceptual uncertainty and environmental volatility are among the most enduring challenges in robotic research today. Contemporary robotic systems are usually designed to work in specific and controlled domains where a total number of variables is defined. Traditional solutions therefore often result in over-constrained interaction spaces or rigid system architectures where any unexpected change can result in system failure. The focus of this work is set on achieving a constant adaptation of the system to changes through interaction. A computational mechanism based on the entropy reduction method is integrated along with the three-component control model. This model is seen as a context-to-data interpreter used to provide context-aware reasoning to the technical system. The mechanism is using a decrease in interaction uncertainties when proofs are provided to the system. In this way, the robot can choose the right interaction strategy that resolves reasoning ambiguities most efficiently.

Keywords: affective; cognitive informatics; context; emotions; human-robot interaction; knowledge representation; probabilistic reasoning; robotics; ubiquitous computing

1 INTRODUCTION

The problems associated with smart system control are recognized as being the most important open problems in the field of robotics. The paradigm shift in the development of smart systems is moving toward a realization of adaptive system skills. The relationship and role the system has within its environment are slightly becoming the focus of research today [1].

Human-robot interaction (HRI) is a very prominent and widespread research activity in which the focus is set on processes of interaction [2]. In contemporary robotics, the focus is usually set on participants where the robot control routines should cover all possible outcomes that the environment could produce. But the nature of the environment is chaotic and undefined in terms of degrees of freedom in temporal or spatial dimensions. Some researchers, therefore, tried to decrease the level of uncertainty by constraining the environment [3]. Such approaches often lead to complex, expensive, or inefficient systems that are not adaptable to the current changes occurring within the environment. In this vision, industrial robots are often placed behind the safety fences or boxes to ensure safe and efficient work. These systems are not suitable to work efficiently in an open and unconstrained world. On the other hand, living beings found the path in constant interaction and adaptation to the environment where they are placed. For example, a human brain to ensure existence is using and shaping the current thoughts, feelings, and decisions by using memories, imagination, predictions, guessed facts, etc. It seems that it is impossible to achieve such tremendous capabilities in any artificial existence today [4].

Interaction is slightly becoming the mandatory skill that every cognitive system should have to adapt to the current changes. Besides the reasoning mechanism, such systems use different sensors to track the significant changes. These sensors are used as a part of sensing modalities to analyze different information spaces including vision, sound, touch, etc. Based on the number of used sensing modalities these inputs are then fused in a multimodal approach [5].

The probabilistic nature of interaction requires control mechanisms that can work under conditions of uncertainties. Artificial Intelligence is the scientific field that provides a plethora of possibilities for the design of such systems, including many different techniques from Deep Learning or Probabilistic Computing. For example, Deep Neural Networks are efficiently used in many areas of data mining and reasoning, such as Natural Language Processing – NLP [6] or Machine Vision [7] tasks. On the other hand, some other AI techniques are very efficient in probabilistic reasoning, like Bayesian Networks [8] or Markov Hidden Models which are very suitable for reasoning in the temporal domain [9].

Interaction, in essence, is the natural process through which living beings are acquiring new information by use of senses to detect significant and meaningful changes. Some authors, especially in the field of cognitive psychology, connected this process with the creation of mental reasoning maps associated with the representation of the current thoughts or occurrences within the physical environment [10]. Within this vision, the interaction is used to decrease the reasoning error through the continuous process in the loop. For example, within the Theory of Constructed Emotions proposed by the same author, *"variations and not uniformity is the norm"* and similar occasions within the same individual can result in different responses. The partial information currently concluded or acquired by senses can instantly change the reasoning output. In this way, a single piece of information can result in recognition, or it can result in a change in perspective [11].

In this work, the authors developed a model based on the semantic representation of the environment and probabilistic reasoning. This computation model is realized as a three-component computation mechanism, containing: (i) the part for analyzing the environment based on principles of Ubiquitous Computing, (ii) the semantic representation part, and (iii) the probabilistic reasoning part. In (i), the model uses a couple of inputs to constantly collect the significant information based on a multimodal approach. In (ii), a semantic representation of the environment is developed in a form of ontology. In (iii), the probabilistic reasoning part is

realized in a form of a Bayesian Network (BN). BN is used to provide a single solution for the robot. Even though it is very rare, BN can become undecidable about the most appropriate solution. Therefore, as a special part of interaction strategy, a reasoning mechanism is developed. This mechanism is based on the entropy reduction method to resolve ambiguities derived within BN by suggesting the most appropriate subroutine for execution.

This solution is implemented on an affective robot PLEA, as shown in Fig. 1.

Figure 1 PLEA affective robot head at the Art & AI Festival in Leicester, UK, 2022.

PLEA is an interactive biomimicking robot head [12]. PLEA samples its environment to reason about the feelings of the person in the interaction. PLEA then demonstrates its affection using its visual expressions.

The rest of this paper is organized as follows. Section 2 rationale about the theoretical concept of the proposed model for the robot interaction control in which the more detailed insights are provided about all components of the model. Section 3 introduces the interaction reasoning concept in which the interaction is analyzed, and the new interaction strategy is proposed. Based on the acquisition of new information during the interaction the virtual agent can resolve the reasoning ambiguities.

The physical model implementation containing all model components is discussed in Section 4. At the end of the paper, a conclusion, summarizing the main concepts and the potential future research directions is provided in Section 5.

2 MODEL FOR THE ROBOT INTERACTION CONTROL

Within the working scenario, the robot is observing two people in communication and guessing about the quality of their interaction. A reaction of the robot is expressed by appropriate facial expressions shown on the robot's face. For the information visualization part, it is used a small light projector placed within the neck part of the robot, as shown in Fig. 1. When the robot detects a break in communication between those two observed people, according to a determined occasion, the robot will use the appropriate facial response.

2.1 Information Acquisition Sensing Modalities

The model for the robot action control is made of three main parts, as shown in Fig. 2.
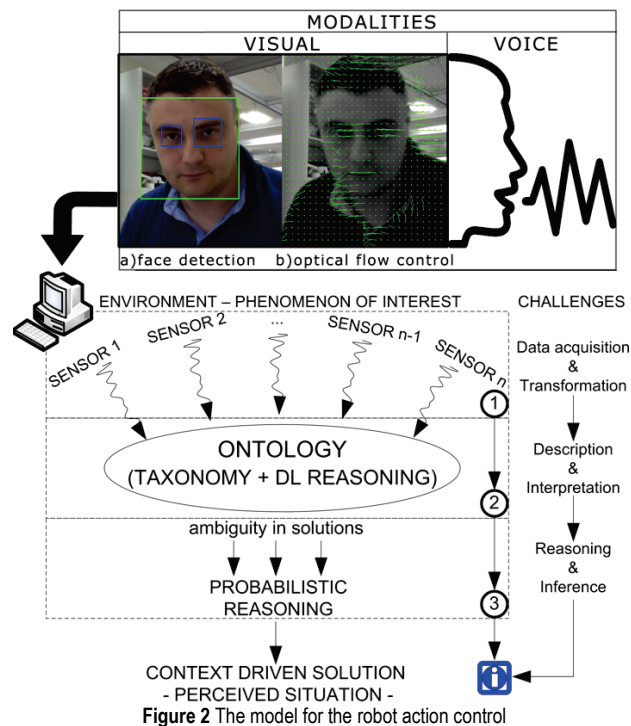
Figure 2 The model for the robot action control

The first part of the model is used for information acquisition based on the principles of Ubiquitous Computing [13]. Ubiquitous Computing is a paradigm of embedded computational capability in which smart sensors and devices are placed within some environment of interest to track significant occurrences. These occurrences are in a close relationship to the activities of the robot which are defined by control algorithms. In this way, program subroutines that control the robot's responses are intertwined with the acquired information in a meaningful way. The robot is then capable of reacting in accordance with environmental changes.

Under the visual modality, the model uses two submodalities. The first one is used for detecting the person's face. For this purpose, the model relies on ResNet neural network architecture [14]. Detection of one or two faces indicates a break in communication because people stopped communicating and started to pay attention to the robot. Combining those two submodalities indicates the level of distraction. The second submodality is used to measure the level of body movements of the person in the interaction. This information also provides insights into the inner psychophysical status of the person, including the level of excitement or nervousness. This submodality relies on the Optical Flow algorithm which is defined as the pattern of apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an observer and scene [15, 16]. The level of body movements is represented numerically. If the value of the sensor output is over a

predefined threshold, the contextual meaning behind that value indicates the excitement or nervousness of the person.

The second sensing modality is the voice modality, which is defined similarly to the body movement submodality. When the numerical value of the sensor output reaches a predefined threshold value, the sensor will return the value 1 instead of 0. This value indicates a very loud conversation describing its nature (quarrel or great excitement of the person).

In both cases, threshold values are determined through empirical measurements with human subjects in an uncontrolled environment.

2.2 Formal Knowledge Representation

The formal knowledge about the application is stored in a form of ontology.

Table 1 Knowledge representation in a form of ontology

ID	V	$F1$	$F2$	$B1$	$B2$	Emotion Classes	Robot Response (R)
01	0	0	0	0	0	Support	01, 02
02	0	0	0	1	0	Support	01, 02
03	0	0	0	0	1	Support	01, 02
04	0	0	0	1	1	Neutral	03, 04
05	1	0	0	1	1	Neutral, Condemn	03, 04, 05
06	0	0	1	0	0	Support	01, 02
07	0	0	1	0	1	Neutral	03, 04
08	0	0	1	1	0	Neutral	03, 04
09	1	0	1	1	0	Neutral, Condemn	03, 04, 05
10	0	0	1	1	1	Neutral, Condemn	04, 05
11	1	0	1	1	1	Condemn	05, 06
12	0	1	0	0	0	Support	01, 02
13	0	1	0	0	1	Neutral	03, 04
14	1	1	0	1	0	Neutral, Condemn	03, 04, 05
15	0	1	0	0	1	Neutral	03, 04
16	0	1	0	1	0	Neutral, Condemn	03, 04, 05
17	0	1	0	1	1	Neutral, Condemn	04, 05
18	1	1	0	1	1	Condemn	05, 06
19	0	1	1	0	0	Neutral	03, 04
20	1	1	1	0	0	Neutral, Condemn	03, 04, 05
21	0	1	1	0	1	Neutral, Condemn	04, 05
22	1	1	1	0	1	Condemn	05, 06
23	0	1	1	1	0	Neutral, Condemn	04, 05
24	1	1	1	1	0	Condemn	05, 06
25	0	1	1	1	1	Condemn	05, 06
26	1	1	1	1	1	Condemn	05, 06
27	Other sensor combinations					Support	01, 02

From the Artificial Intelligence point of view, an ontology is a set of concepts and categories related to some domain of interest showing their properties and relations between them. Ontologies denote a formal representation of entities (classes) along with associated attributes (objects) and their mutual relations [17]. Ontology is written in Ontology Web Language – OWL [18], as is the case in this work, it is made of taxonomy and Descriptive Logic - DL [19]. Taxonomy is made of classes, attributes, and individuals within classes. Employing DL, taxonomy can be developed into an ontology in which different classes, attributes, or individuals are connected in meaningful ways by DL conjunctions to form DL sentences that represent knowledge. Some authors stated that certain types of contexts are important while characterizing a situation of a particular

entity [13]. In this way, these sentences become contextual and can provide different results by changing the query input parameters. Ontology written in OWL is following so-called Open World Assumptions (OWA), meaning the fact that all generated responses have the same level of importance [20]. In that case, for the same combination of the input sensor values, the knowledge base will propose more than one possible solution resulting in ambiguities in reasoning, as defined in Tab. 1. The table abbreviations are as follows: V – voice detected, $F1$ – Face 1 detected, $F2$ – Face 2 detected, $B1$ – intense Body 1 movements detected, $B2$ – intense Body 2 movements detected.

Table 2 Information Visualisation

Emotion Classes	Robot Responses	Goodness	Facial Expressions
Support	$R01$		
Support	$R02$	⇑ Reactions to perceived ⇓	
Neutral	$R03$		
Neutral	$R04$		
Condemn	$R05$		
Condemn	$R06$	Badness	

Facial expressions are separated into three defined classes: *Support*, *Neutral*, and *Condemn*. Each of these classes contains two facial expressions, as shown in Tab. 2. When a certain sensor combination occurs (for example, Tab. 1, ID17), the ontology will suggest the list of the most possible solutions respecting the emotion class (for ID17 the ontology suggests 04 or 05). In the provided example the robot will remain unsure about what is the most suitable solution because both suggested solutions have the same importance. Therefore, the reasoning mechanism is updated

with probabilistic reasoning in a form of a Bayesian Network (BN).

2.3 Probabilistic Reasoning

The ontology can suggest more than one solution having the same priority and significance based on the principles of Open World Assumptions. That causes ambiguities in which the robot cannot decide on the most suitable solution for the current context. Therefore, to resolve ambiguities the initial reasoning model is updated with the probabilistic reasoning part in a form of a Bayesian Network – BN [21, 22]. BNs are directed acyclic graphs containing nodes (variables) and links that connect them. Links indicate a direction of influences that parent nodes have on their children through the structure of BN. Each network variable has a Conditional Probability Table – CPT, in which the influences of ancestors are expressed. BN also has query nodes at the end of the structure, which contain beliefs or percent of certainty of the network about the most probable solutions, as shown in Fig. 3.
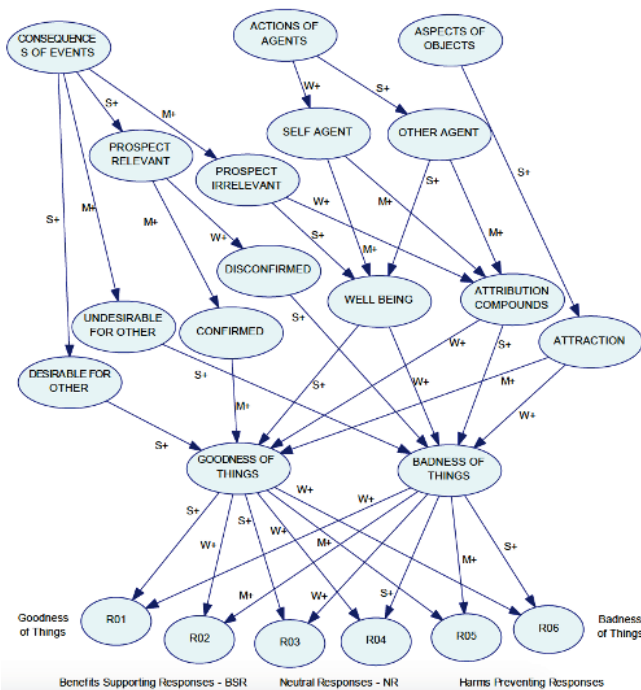
Figure 3 BN architecture used as a mechanism for reasoning under uncertainties

The presented BN is used to resolve ambiguities that appeared as a result of the ontology reasoning where for each sensor combination the system has more than one possible solution, as shown in Tab. 1.

This BN contains the OCC model of emotion that has a taxonomy of emotions in three main pillars (Consequences of Events, Actions of Agents, and Aspects of Objects), as described in [23]. The overall description of all network variables is given in Tab. 3.

Table 3 Network nodes

Node (variable)
Consequences of Events (GE): believes about the nature of events (*pleased* or *displeased*).
Actions of Agents (AA): believes about the intentions of agents (*approving* or *disapproving*).
Aspects of Objects (AO): believe in the likeness of perceived objects (*liking* or *disliking*).
Prospect Relevant (PR): expectations about some event (*hope* or *fear*).
Prospect Irrelevant (PI): expectations about some event (joy or distress).
Self-Agent (SA): feelings about the relation of the robot towards the environment (*pride* or *shame*).
Other Agent (OA): feelings of the robot towards actions of the person in interaction (*admiration* or *reproach*).
Desirable for Other (DO): reasoning about events concerning some other person (*happyFor* or *resentment*).
Undesirable for Other (UO): reasoning about events concerning some other person (*gloating* or *pity*).
Confirmed (C): feelings about some event that happened (*satisfaction* or *fearsConfirmed*).
Disconfirmed (D): feelings about some event that does not happen (*relief* or *disappointment*).
Well Being (WB): evaluation of action or event during interaction (*gratification* or *remorse*).
Attribution Compounds (AC): evaluation of action or event during interaction (*gratitude* or *anger*).
Attraction (A): evaluates the level of affection (*love* or *hate*).
The Goodness of Things (GT): aggregated effect of other nodes about the goodness of things (*good* or *neutral*).
The Badness of Things (BT): aggregated effect of other nodes about the badness of things (*bad* or *neutral*).
Query Nodes (R): 01, 02, 03, 04, 05, 06 (*true* or *false*).

Each of these nodes in BN has its Conditional Probability Table – CPT which is calculated using a hand-crafted approach based on strength of influences, as shown in Fig. 3. The procedure of BN development is described more in detail in [24, 25]. For example, at the top of the network, the "Consequence of Events" variable is positioned which has a strong positive influence on the "Desirable for Others" variable. That node, at the same time, has a strong influence on the "Goodness of Things" node which at the end of BN has a weak influence on the R02 query node. This influence is spreading from the top node through the network. The strength of influence is used to calculate CPT for each node using the Eq. (1).

$$WF = \frac{\left(TV - \dfrac{1}{NS}\right)}{NP} \tag{1}$$

WF stands for Weight Factor, *NS* for Number of States, *TV* for Threshold Value, and at the end *NP* stands for Number of Parents. The threshold is the value that is directly connected to the Strength of Influences, where S+ has a threshold value of 0.98, M+ has a threshold value of 0.8, and W+ has a value of 0.6. These values are defined arbitrarily to represent the real influences of links.

Condition probability tables for each of the nodes are calculated using the same methodology in which the previously calculated values for Weight Factors are used. The equations for calculating the values in CPT for the query node $R01$ are listed in Eqs. (2) - (9).

$$(R01 = true/GoodnessOfThongs = good \& BadnessOfThings = bad) \qquad (2)$$

$$(R01 = true/GoodnessOfThongs = good \& BadnessOfThings = neutral) \qquad (3)$$

$$(R01 = true/GoodnessOfThongs = neutral \& BadnessOfThings = bad) \qquad (4)$$

$$(R01 = true/GoodnessOfThongs = neutral \& BadnessOfThings = neutral) \qquad (5)$$

$$(R01 = false/GoodnessOfThongs = good \& BadnessOfThings = bad) \qquad (6)$$

$$(R01 = false/GoodnessOfThongs = good \& BadnessOfThings = neutral) \qquad (7)$$

$$(R01 = false/GoodnessOfThongs = neutral \& BadnessOfThings = bad) \qquad (8)$$

$$(R01 = false/GoodnessOfThongs = neutral \& BadnessOfThings = neutral) \qquad (9)$$

As seen, equations express the influences that parents have on the child node. The same procedure is repeated to calculate all other CPTs in BN. Within the BN reasoning phase, evidence can be acquired in advance which can affect the reasoning output of the network.

3 INTERACTION DRIVEN REASONING

Interaction is a very important part of communication [26, 27]. During the interaction, all participants exchange verbal and nonverbal signals that affect and drive the communication. These signals usually contain crucial information representing the proofs that shape the communication process. In the same way, BN is used as a part of the reasoning model in this work, as it contains variables (nodes) which can be affected by information acquired from the environment. As explained earlier, CPTs directly control the reasoning outputs of the network. In this way, CPT stores beliefs and influences of all parent nodes that are connected to some node. In the case that the proof about some node in the network is provided, this node is not altered by parent influences anymore. The influence of this node starts spreading through the network until it reaches the query nodes. In this way, the network can change the

reasoning output during the interaction. For example, the robot could find out the specific information about some node in the network and update CPT accordingly. That could strengthen believes of the network that some query node is the right solution according to the current context. On the other hand, it is rare but possible that BN cannot decide about one solution, as shown in Fig. 4.
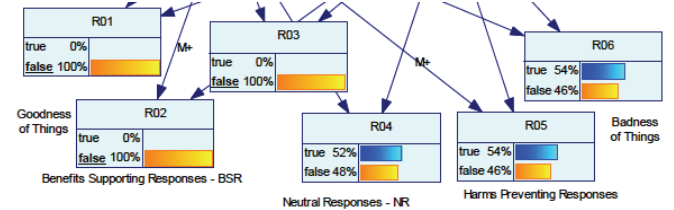
Figure 4 Ambiguities in BN reasoning

In this example, the ontology suggested $R04$, $R05$, and $R06$ as solutions (query nodes $R01$, $R02$, and $R03$ are set to false because the ontology did not suggest them as solutions). As can be seen, BN expressed the same percent of certainty in all three solutions meaning that BN cannot decide which one is the most appropriate. In this case, the robot can find the proofs through interaction which can resolve ambiguities and suggest only one solution.

Every node in BN has its influence on expressing beliefs when deciding which query node is the most suitable candidate for a final solution. In that case, some nodes in the network will generate a more significant change in percent of certainty for query nodes compared to some less influential nodes. Therefore, it could be very useful to determine the most influential nodes in the network. By knowing this information, the robot can plan its interaction to resolve all ambiguities efficiently.

The approach used in this work is based on the entropy reduction method which is closely related to sensitivity analysis [28]. By using Eq. (10), it is possible to calculate the current level of uncertainty in any node of interest.

$$H(P) = -\sum_{s\hat{I}S} P(s) * \log_2 P(s) \qquad (10)$$

As a part of information science, Shannon's Entropy is a measure of uncertainties [29]. Every node in BN contains a certain level of uncertainty. By using the entropy reduction method, it is possible to determine a drop in uncertainty in query nodes when evidence or proof is provided to some particular node in the network, as shown in Eq. (11).

$$I = H(before) - H(after) = H(Q) - H\left(\frac{Q}{F}\right) \qquad (11)$$

By using this approach, it is possible to calculate the entropy decrease in query nodes in relation to other nodes in the network, as shown in Fig 5.

Fig. 5 shows that the nodes CE (Consequences of Events - *pleased* or *displeased*), DO (Desirable for Other - *happyFor* or *resentment*) and PR (Prospect Relevant - *hope* or *fear*) have the greatest influence on all query nodes when evidence

is provided because they cause the greatest drop in uncertainty. In this way, the robot must find out the information about these tree nodes during the interaction to resolve ambiguities. The nodes GT and BT are not involved in the graph representation as they are representing the Goodness and Badness of Things. As shown in Fig 6., these two nodes are influenced by all previous nodes and all these influences are summed in them so they have the greatest influence on the query nodes and showing them would cloud all others.
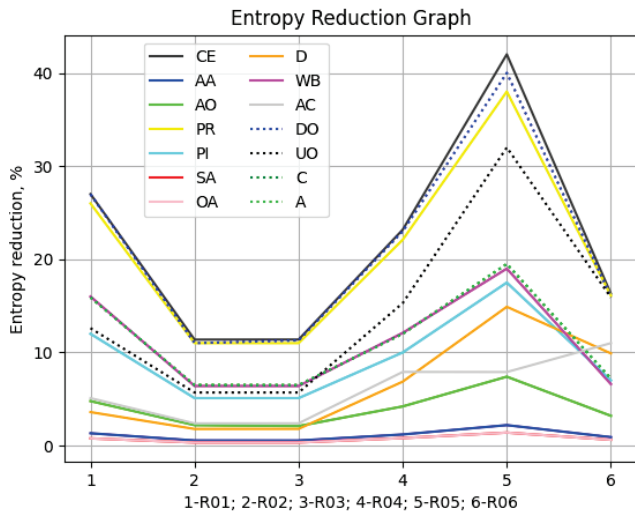
Figure 5 The graphical representation of entropy reduction
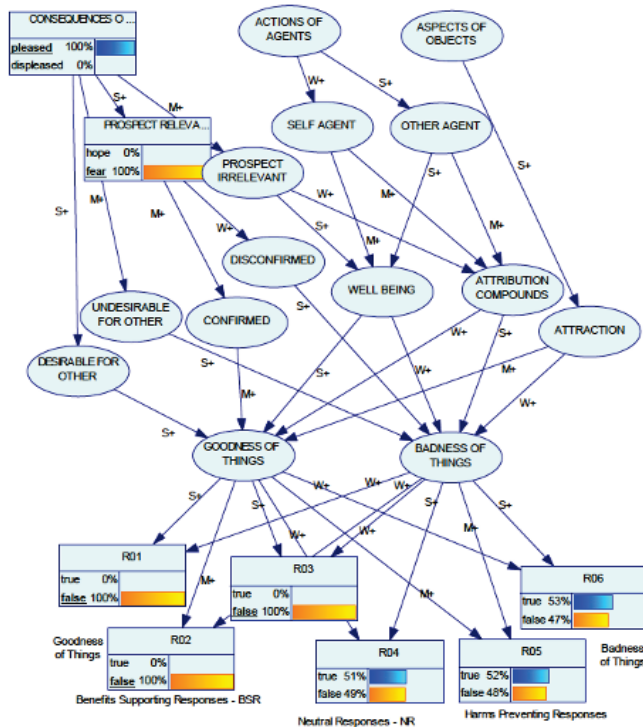
Figure 6 The BN interaction reasoning procedure

To resolve ambiguity presented in the Fig. 4 example, where the ontology suggested three possible solutions having the same percent of certainty (*R*04, *R*05, and *R*06), BN

reasoning is used during the interaction. The robot can then find proofs about the three most influential nodes (CE, DO, and PR) and update its reasoning in real-time. BN representing the process of such reasoning is shown in Fig. 6. During the interaction, the robot firstly acquired the information about the CE node, and according to this information the CE node is set to "pleased". But that did not cause any change in the query nodes. Within the next step, the PR node is set to "fear" which caused the query node *R*06 to prevail with 53 %. The proposed solution is in accordance with the current context because the response *R*06 represents the reaction of the robot when the context in the environment is perceived as bad.

4 PHYSICAL MODEL IMPLEMENTATION

The model implementation is shown in Fig. 7.
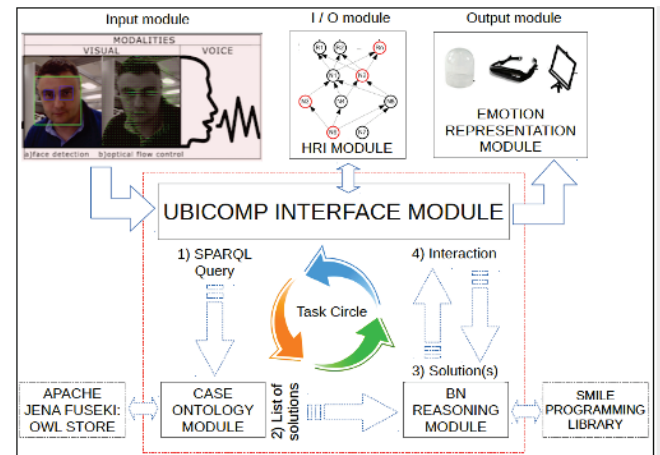
Figure 7 Physical model implementation

The very true heart of the system is the Ubicomp Interface Module which is used to receive data from the Input Module and present results using the Output Module. The Input Module contains mechanisms for multimodal acquisition and fusion of information, as explained earlier. The Ubicomp Module receives the query vector containing the information on whether the face(s) is (are) detected, or whether the detected movements are significant or not. The last information is acquired by the sound modality as the level of noise in the room.

When the query containing the status of sensing modalities is received by the ontology, the list of possible solutions is proposed, and the BN reasoning module can determine the single solution that is going to be executed. This solution is a facial expression in which the robot is expressing its current emotions. The HRI module is used if the BN reasoning module cannot find a single solution and resolve ambiguities. This module then uses the described interaction strategy to determine a single solution.

The Output Module is used to show the face of the virtual agent and can be a physical head of the robot or any other device like a Smart TV, XR glasses, or the screen of a PC.

5 DISSCUSION AND CONCLUSION

The presented methodology enabled a virtual agent to resolve the reasoning ambiguities and find the most optimal solution in relation to the current context. This methodology is a part of a research project in which the virtual agent PLEA is exchanging nonverbal signals with people in interaction. By changing the facial expressions, PLEA can drive the interaction and guess about the next steps in communication by analysing the previous facial expressions of the communicating person. The methodology that controls the robot, in this case, is based on Deep Learning models and state-of-the-art computer network technology, as the virtual agent can respond to distant connections and show up using communication interfaces wherever in the world. The virtual agent can accomplish its actions using XR or devices that operate within the real world.

The computational model presented in this work is a step forward to putting PLEA in communication with a group of people where the virtual agent can observe and analyse the interaction as a more passive member of the group. The model is in a testing phase and a couple of refinements could be implemented before this model becomes a part of the main model. For example, the interaction when PLEA is resolving ambiguities is currently realized as a chatbot agent that asks questions. The result of such an approach is a break in the communication grounding process that takes place between people in interaction whenever PLEA asks something [30, 31]. To be more natural and less intrusive, in future work the virtual agent will guess independently, without asking direct questions, to resolve ambiguities. By using new sensing modalities within the multimodal approach, PLEA will analyse hidden communication cues to resolve whether somebody is happy or not.

Another improvement and analysis can be made in providing different strength of influence values to BN links. These values are subjectively defined and represent the vision of a system designer about the nature of the agent's responses. By changing these values, the agent can express different moods during the interaction. For example, sometimes the agent can be more sensitive. The way the agent behaves can be also context-driven and can depend on the way how people interact and communicate mutually.

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DISPO 4.0 | Simulation-Based Optimization of Stochastic Demand Calculation in Consumption-Based Material Planning in the Capital Goods Industry

Alexander Schmid*, Felix Kamhuber, Thomas Sobottka, Wilfried Sihn

Abstract: This paper presents a digital material planning approach, utilizing simulation-based optimization to select and parametrize article specific demand forecasting methods. Demand forecasts are the basis of material requirements planning in consumption-based material planning, and are an essential lever for efficient inventory and order calculation. Despite their acknowledged potential, digital tools for optimized demand calculation are still lacking in practice. Thus, the goal of the presented approach to provide an application-oriented method to optimally select and parametrize state-of-the-art forecasting methods, based on product-specific demand data. In this approach, a rule-based selection heuristic is combined with static simulation of demand time-series and a metaheuristics-based optimization of forecasting parameters, to provide automatically optimized article-specific demand forecasts. Case studies for two companies in the capital goods industry evaluate and quantify the application potential. The results point to significantly improved, item-specific demand planning.

Keywords: demand planning; exponential smoothing; forecasting; parameter optimization; simulation

1 INTRODUCTION

Data and information are the *oil of the digital age* [1]. *Kirchner et al.* describe algorithms as crucial in order to be able to process the rapidly increasing amounts of data in a targeted manner [1]. This applies in particular to material requirements planning, which is facing a volatile, global market environment with increasing complexity and is confronted with an increasing amount of information and data [2]. Disruptions due to digitalization, smaller batch sizes, fluctuating demand, globalized supply chains and cost pressure are the key complexity drivers in material requirements planning [3]. Material requirements planning refers to the coordination of the flow of materials into the company and the stock so that the right items are available on time and in the right quality at the right place [4]. The aim of material requirements planning is to ensure that the company's material supply is economically secure in terms of type, quantity, time and quality [5]. The sub-disciplines of material requirements planning are divided into requirements planning, calculation of stock and purchase order calculation [4], see Fig. 1. Each of the mentioned sub-areas can achieve large savings through digitalized processes and employing optimization algorithms [6].

Figure 1 Sub-disciplines of material requirements planning

This paper deals with the sub-disciplines of requirements planning and specifically with the application of forecasting algorithms in consumption-based material requirements planning. Demand forecasting is about predicting future needs as accurately as possible, taking into account all available information, existing historical data and knowledge of future events [7]. Today, a variety of procedures and complex logics exist in consumption-based material requirements planning to make material requirements planning more efficient. In everyday operations, however, only a very small proportion of mathematical models are used [8]. Forecasting systems require the development of expertise in identifying forecasting problems, applying a range of forecasting methods, selecting appropriate methods for each problem, and evaluating and refining forecasting methods over time [7]. The applicability of forecasting methods depends on the properties of the time series to be forecast, the properties of the forecasting methods, the intended use of the forecasts and the cost-benefit ratios of competing methods [9]. The digitalization and automation of a forecasting system can provide item-specific material requirements planning and spare parts stocking. Accurate demand forecasts lead to an increase in supply security in consumption-controlled material requirements planning, to a reduction in inventories and the resulting warehousing and capital commitment costs, as well as to a reduction in scrapping costs [8]. Consequently, shortages and resulting profit losses can also be reduced and customer loyalty can be secured through improved customer satisfaction [9]. Despite the acknowledged potential, practically available digital planning tools like SAP-APO (**A**dvanced **P**lanner and **O**ptimizer of the Software system SAP) are still lacking autonomous forecast parameter adjustment [10].

This paper presents the development of a digital planning tool for material requirements planning and operational purchasing, which enables an automatic item-specific optimized demand calculation in consumption-based material requirements planning. Using static simulation of sales and demand volumes and a rule-based heuristic as an evaluation criterion, the best possible item-specific forecast values are automatically determined by a *Genetic Algorithm* (GA). The potential benefits of using algorithms in consumption-based material requirements planning for semi-automated forecast calculation are evaluated in two case studies from the capital goods industry. The paper is
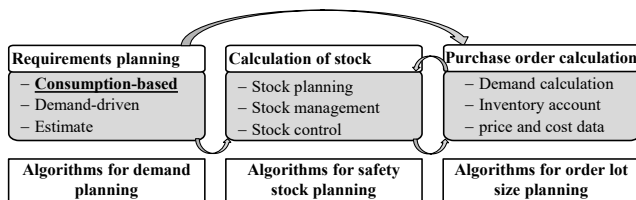
structured as follows: Following the introduction, chapter 2 introduces the research methodology and goals. Chapter 3 gives an overview of relevant literature, followed by chapter 4 with an introduction of the case-studies used in the method development and evaluation. Chapter 5 presents the developed method, and the concluding chapter 6 discusses the case study results as evaluations of the developed planning method.

2 OBJECTIVE, RESEARCH HYPOTHESIS AND RESEARCH METHOD

The objective of the presented research was to develop a method to generate and automate the item-specific planning of consumption-controlled scheduled items. In doing so, it is necessary to consider expert knowledge about forecasting problems, about the application of different forecasting methods, about the selection of suitable forecasting methods as well as about parameterization and optimization of the forecasting methods.

The research hypothesis is that with the proposed planning method, using static simulation and optimization, item-specific material requirements planning for companies in the capital goods industry can be provided automatically, thus significantly improving the forecasting quality and minimizing the cost of material planning.

The research method used was the *Design Science Research Methodology* according to Peffers et al. [11], which combines principle, practices and procedures to achieve a structured, scientific approach in order to develop a solution to an existing problem from industry (demand calculation in materials planning) and then communicate it back into practice.

3 BACKGROUND: STOCHASTIC REQUIREMENTS PLANNING

In a literature analysis, an overview of the available forecasting methods was first determined, the algorithms characterized and the possible applications in the operational environment of the capital goods industry evaluated. The analysis of the forecasting algorithms was restricted to time series models of the stochastic requirements planning.

Fig. 2 shows the result of the identified procedures. The procedures marked in grey were selected as the most common procedures after a frequency analysis in the literature and were considered in the planning method developed. These 5 algorithms are already partly used in ERP (*Enterprise Resource Planning*) systems. However, decision-makers in the companies lack a basis for deciding which of the forecasting methods are the most suitable for the company and how they can be optimally parameterized for specific articles.

Next, an analysis of existing forecasting approaches identified which of the above forecasting methods were being utilized, as presented in Fig. 3. It is shown that authors deal with, describe, or also apply different forecasting methods. However, especially in the case of authors describing multiple methods, no meta-method has been developed, selecting the most suitable forecasting method for each

article in the demand planning. The paper at hand aims to provide this meta-method support, enabling companies to utilize the benefits of multiple forecasting methods, with an automatic selection and optimal parameterization.
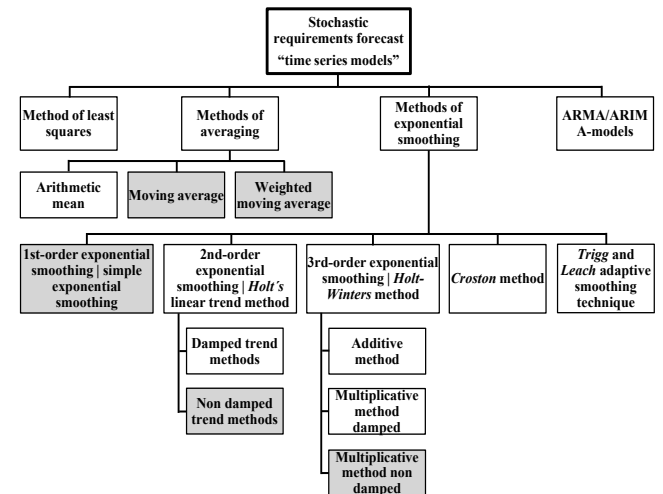
Figure 2 Overview of time series models of the stochastic requirements planning

Time series data from the historical sales demand in the stochastic requirements planning can show a variety of item-specific patterns. Therefore, it is helpful to divide a time series into several components, each of which represents an underlying pattern category (trend, seasonality etc.) [7]. Roughly subdivided, the following time series types can be identified as shown in Fig. 4.

The literature research revealed that authors do not always agree on which forecasting method is best to use for which time series. A summary from the literature research is shown in the Fig. 5.

Since in practice the item-specific time series (demand patterns) can change over time, and no clear guidelines could be identified in the literature for which time series which forecasting method provides ideal forecasts, this research was initiated with the goal of selecting the most suitable method based on product-specific demand data. Optimization is required for optimal selection and parameterization of the identified state-of-the-art forecasting methods. For complex real-life problems, exact methods often do not apply, and rules-based heuristics or stochastic metaheuristics are chosen. Wari and Zu state that the GA is the most frequently applied metaheuristic for solving optimization problems, being applied in 60% of the analyzed cases. With its 3 operators, they are easily adaptable to specific applications [17, 16].

Optimization methods require an evaluation function. In the case of demand forecasting, a time-series consideration is suitable for the evaluation – this can be achieved via simulation. Simulation-based optimization takes into account the consideration of processes dynamically over time, for instance by means of discrete-event-oriented sequence simulation and improves them heuristically rule-based or by metaheuristics on a stochastic basis [18]. In this work, a static-historical time series approach is used, owing to the nature of the forecasting methods and the fact that thousands of articles must be processed, making processing effort and time an important factor to consider.

Literature \ Algorithms	Simple average	Moving average	Weighted moving average	1st-order exponential smoothing | simple exponential smoothing	2nd-order exponential smoothing (damped trend methods) | Holt's linear trend method	2nd-order exponential smoothing (non damped trend methods) | Holt's linear trend method	3rd-order exponential smoothing (additive method) | Holt-Winters method	3rd-order exponential smoothing (multiplicative method damped) | Holt-Winters method	3rd-order exponential smoothing (Multiplicative method non damped) | Holt-Winters method	Croston method	Trigg and Leach adaptive smoothing technique	Least square method	ARMA/ARIMA-models
Abolghasemi, et al., (2020)				x									x
Babai, et al., (2020)				x						x			
Bandeira, et al., (2020)				x		x				x			
Blackwood, et al., (2019)		x	x	x		x							
Claus, (2015)	x			x	x	x	x	x	x				
Claus, (2021)	x			x	x	x	x	x	x				
Doszyn, (2019)		x	x	x						x			
Doszyń, (2018)		x	x	x						x			
Dutta, et al., (2017)				x									
Entrup, (2018)		x	x	x		x							x
FerbarTratar, et al., (2016)					x	x	x						
Gasparian, et al., (2018)		x	x	x		x							
Gronwald, (2017)		x	x	x									
Hyndman, et al., (2021)	x			x	x	x	x	x	x				x
Hyndmana, et al., (2002)				x	x	x	x	x	x				
Jacobi, (2005)												x	x
Jayant, et al., (2020)		x	x	x									
Kellner, (2018)		x	x	x		x			x				
Kolade, (2019)		x	x	x								x	
Kühnapfel, (2019)		x	x	x									
Lasch, (2021)	x			x	x	x	x		x	x			
Mertens, (2005)	x		x	x	x	x	x	x	x				
Mertens, (2012)	x	x	x	x	x	x	x	x	x	x	x		x
Nikolopoulos, et al., (2016)				x						x			
Patak, et al., (2015)	x			x		x	x						
Razmi, et al., (2015)		x	x	x									
Schönsleben, (2016)		x	x	x		x	x		x		x		
Schönsleben, (2020)		x	x	x		x					x		
Schuh, et al., (2014)	x			x		x				x			x
Segerstedt, et al., (2020)				x						x			
Silitonga, et al., (2018)		x	x	x									
Sing, et al., (2017)				x		x			x				
Soni, et al., (2017)						x							
Thalles, et al., (2019)						x			x				
Thommen, (2017)	x	x	x	x									
Tratar, et al., (2019)						x	x	x					
Trigg, et al., (1967)											x		
Trull, et al., (2020)						x	x	x					
Wannenwetsch, (2014)	x	x	x	x		x							
Waters, (2008)	x	x	x	x									
Xu, et al., (2012)										x			
Zhu, (2019)									x				x
Abolghasemi, et al., (2020)				x									x
Total:	**10**	**19**	**19**	**33**	**7**	**18**	**14**	**9**	**15**	**10**	**4**	**2**	**7**

Figure 3 Literature assignment to time series models of the stochastic requirements planning
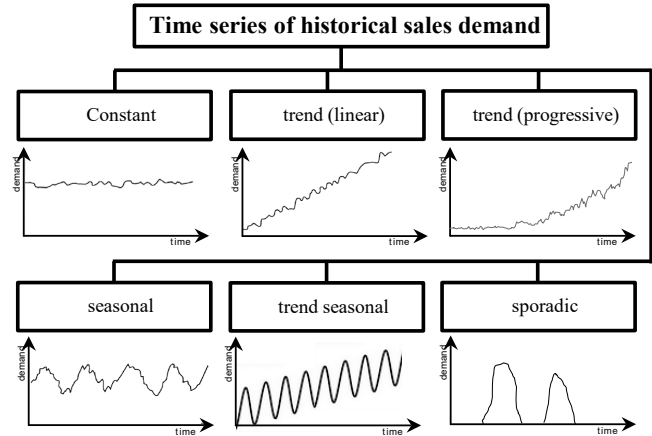
Figure 4 Time series of historical sales demand (Own representation based on [13,12])

Forecasting method \ Time series of historical sales demand	Constant	trend (linear)	trend (progressive)	seasonal	trend seasonal	sporadic
Simple average	suitable					
Moving average	suitable					
Weighted moving average	suitable	limited suitable				limited suitable
1st-order exponential smoothing | simple exponential smoothing	suitable					limited suitable
2nd-order exponential smoothing (damped trend methods) | Holt's linear trend method	limited suitable	suitable				
2nd-order exponential smoothing (non damped trend methods) | Holt's linear trend method	limited suitable	suitable	suitable			
3rd-order exponential smoothing (additive method) | Holt-Winter method	limited suitable	limited suitable	limited suitable	suitable	suitable	
3rd-order exponential smoothing (multiplicative method damped) | Holt-Winters method	limited suitable	limited suitable	limited suitable	suitable	suitable	
3rd-order exponential smoothing (Multiplicative method non damped) | Holt-Winters method	limited suitable	limited suitable	limited suitable	suitable	suitable	
Croston method						suitable
Trigg and Leach adaptive smoothing technique		limited suitable	limited suitable			suitable
Least square method						
ARMA/ARIMA-models	suitable	suitable	suitable	suitable	suitable	suitable

Legend: ● suitable ◐ limited suitable

Figure 5 Relationship between time series and forecasting method according to literature study (Own representation based on [14,13,15])

4 CHARACTERIZATION OF THE CASE STUDY

The focus of the case studies is the finding that there is a trend that customers in the capital goods industry do not order products based on long-term strategies. Increasingly, products are being ordered through short-term orders. This requires shorter delivery times and a high degree of flexibility. Shorter delivery times mean that the customer in turn reacts with increasingly late order placement and still expects reliable delivery [19]. For the material planning, the implications are that many different articles with varying demand profiles must be considered, making it challenging for human planners to create and maintain article-specific demand forecasting profiles. Since the share of bought-in articles in the Austrian capital goods industry is relatively high, this motivation for an automated digitalized planning support is especially relevant. Two companies considered in the Austrian capital goods industry were included (see Tab. 1).

Table 1 Case Study - Characterization Company 1 and Company 2

	Company 1	Company 2
Sector	Fittings and valves production	Automotive industry
Employees	115 (full-time equivalent)	243 (full-time equivalent)
Annual sale	22,3 m €	89 m €
Customers	346 from 51 countries	38 800 from 22 countries
Purchasing volume	11,5 m €	59 m €
Suppliers	1 780 from 61 countries	1 258 from 28 countries
ERP-system	SAP	Infor M3
Different demand articles (-36 months)	4 341 items	17 724 items

5 DEVELOPMENT OF THE DIGITAL PLANNING METHOD

This paper describes how a digital tool for an optimized demand requirement planning of consumption-based items was developed in the capital goods industry. The method is meant to base the selection and parametrization of forecasting methods on quantitative data analysis, i.e. simulation and optimization, thus providing a structured approach, providing consistent results, independent of the experience time and of human planners. The modelling of the tool aims at the highest possible forecasting quality. In doing so, changing market conditions (static vs. dynamic data) are to be considered, with the objective of a future digitalization or automation of the requirements planning.

The methodological core of the optimization is a *Genetic Algorithm* (GA), which improves the method-specific forecast parameters in each case. The GA uses a simulation-based optimization of monthly sales forecast for each method. A rule-based heuristic then compares the sales predictions to actual sales for historical data, determining the forecasting error and using the latter to select the most suitable forecasting method. In this developed digital planning method, the *Mean Squared Error* (MSE) is used as an evaluation criterion for the forecasting error. The optimally parametrized method for each article is then used to forecast medium-term future sales.

The digital planning method was implemented in *MS (Microsoft)-Excel* with *Visual Basic for Applications* (VBA). It comprises the following steps:
1. General settings for the forecasting methods
2. Data preparation and data processing
3. Importing prepared data
4. Forecast optimization and calculation
5. Export of results

5.1 Parameterization of the Planning Method

In the first step, the planning method is parameterized and set up for the specific use case, using the *MS-Excel* Solver. The forecasting methods are then parameterized in the following steps:
- Setting the number of periods of sales history that should be considered

- Setting the number of forecast periods (the further into the future, the less reliable is the result – 12 months should be the maximum)
- Setting the maximum optimization runtime per item – this is a termination criterion for the *Genetic Algorithm* GA optimization and thus determines the runtime of the entire planning method
- Setting the relevant periods to calculate the forecasting error MSE
- Limit predictability: Input for which articles no forecast will be provided, due to too high forecasting errors MSE for historic sales data (the error threshold can be set by the planner and the identified articles are labelled "*Non-predictable items*")
- Forecasting method *weighted moving average* additionally allows the setting of the "number of periods for averaging" or the reduction factor.
- exponential smoothing of the 1st and 2nd order as well as the *Holt-Winters* procedure allow the setting of the limit values of the respective forecast parameters to prevent unusual values, e.g., a potential result of overfitting, that could lead to high-risk parameters
- Finally, the five currently available forecast algorithms are parameterized with the GA. For each method, the values for the parameters "surplus" and "shortage" can be defined before the calculation.

5.2 Data Preparation and Data Processing

For the relevant input data, a distinction is made between the following two different data sets:
- Input data needed for the forecast calculation.
- Input data required for the preparation of the user-specific result files (warehouse and supplier data).

It must be ensured that the input data corresponds to the specified data formats to enable automated processing of the data without reprocessing the data records. The time series of the historical sales figures are automatically prepared according to the settings from *section 5.1*. This generates a clear time series monthly for each article from a data set of several hundred thousand article withdrawals.

In addition, "replacement articles" are read in. These are articles that will no longer be needed in the future or that will be replaced by another article (discontinued item). No forecast is issued for these articles by the planning method. This automated data preparation takes about one minute for the dataset in the use-case.

5.3 Importing Prepared Data

The data prepared in *section 5.2* (item number, item name, time series, base unit etc.) are automatically read into the planning tool, in separate tables for each forecast method. In the two case studies, the *forecast error Mean Squared Error* (*MSE*) is used because it penalizes and minimizes the largest deviations the most. In planning, these large deviations are especially costly when there is no sufficient safety stock.

5.4 Forecast Optimization and Calculation

After completing the preparatory steps, the forecast calculation of all five implemented forecast algorithms is compiled. The following is a list of the actions executed in this planning step:

a) Forecast parameter(s) is/are optimized by using *Genetic Algorithm* (GA), considering the product specific constraints
b) All results (forecast values, parameters, forecast errors etc.) are gathered in a result sheet
c) Identification of "*Non-predictable items*"
d) The forecast result with the lowest forecast error (*MSE*) is transferred to the result sheet for each article
e) Export of results (.csv files and *MS-Excel* based result analysis)

The following five forecasting methods are executed consecutively:

1. *Holt-Winter* method or *3rd-order exponential smoothing* procedure (multiplicative, non-damped)
2. *Holt´s linear trend method* or *2nd-order exponential smoothing* procedure (non-damped)
3. *1st-order exponential smoothing* procedure or *simple exponential smoothing*
4. *Moving average*
5. *Weighted moving average*

Figure 6 Calculation worksheet *3rd-order exponential smoothing* or *Holt-Winter* method 1/2

The forecast calculation and, for parameter-dependent methods (1) - (3), additionally the forecast parameter (smoothing parameter α, trend parameter β, seasonality γ) optimization is carried out per item number. The calculation and optimization are carried out in sequence, article per article. The forecast parameters (e.g. for *exponential smoothing*: alpha, beta, gamma) are optimized by the *Genetic Algorithm* (GA) according to the stored parameter "Maximum optimization runtime" as well as the stored GA settings per article. The solver and integrated GA [20] provided in *MS-Excel* were automated in *VBA* and adopted with the corresponding settings (convergence, mutation, population size etc.) as well as the solver objective function, constraints and variable parameters.

The forecast is calculated and optimized for each article and each of the five forecast methods according to the stored constraints (limits, surplus, shortage, number of periods for averaging, reduction weighting).
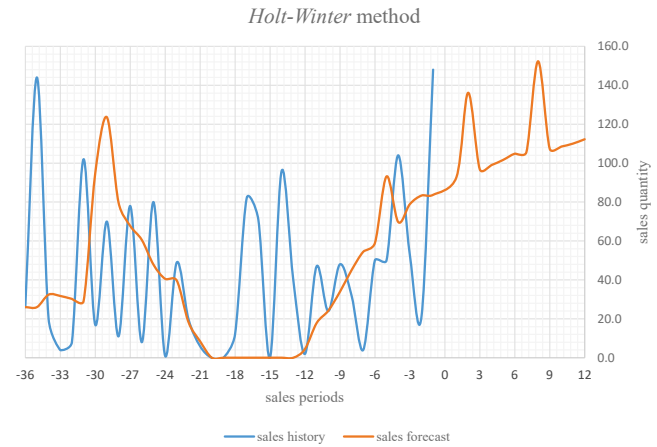
Figure 7 Calculation worksheet *3rd-order exponential smoothing* or *Holt-Winter* method 2/2

The calculated results are the basis for a rule-based heuristic and the evaluation of the "optimal" forecast method and the associated "optimal" forecast values.

For the case studies, a "limit of predictability" was empirically determined for each company over several data sets. In this process, no forecast is to be issued for items that have very high uncertainties. This is a pre-emptive effort to avoid wrong decisions. The uncertainty is defined as the relation between the forecast error **M**ean **S**quared **E**rror (MSE) and the historical consumption of the article and a defined relation value per case study.

From the five generated forecast results, the rule-based heuristic selects the forecasting method with the lowest forecast error (MSE) for each article. After several empirical tests, the period considered for the forecast error (MSE) was made adjustable for the selection of the optimal, item-specific forecast algorithm. In the case studies, the forecast error (MSE) of the past 12 months was used for the evaluation, although at least 36 months of past data were available. Experience has shown, however, that complex forecasting algorithms such as exponential smoothing learn over time (seasonality, trend etc.) and that the forecasting error (MSE) is successively reduced by the learning effect. This distinguishes the simple forecasting methods (*moving average* and *weighted moving average*) from the more complex mathematical methods. The item-specific optimal forecast algorithm, the monthly rolling future forecast values as well as one of the forecast errors *MSE, MAD (**M**edian*

Absolute Deviation) or *MAPE (Mean Absolute Percentage Error)* to be selected for optimization and the standard deviation of the forecast error are transferred to the result sheet. The calculated forecast errors *MAD* and *MAPE* as well as the standard deviation of the forecast are used as input for additional digital tools developed by the authors for the calculation of stock [21].

When transferring the rolling monthly future forecast values to the result sheet, depending on the parameterization (see *section 5.1* "*Rounding for general cargo items*") and the article-specific base unit of measure, the forecast results are rounded commercially or output as a two-digit decimal number. Especially with low forecast quantities in the single-digit range (e.g., spare parts), rounding leads to the output of values that are too high compared to the forecast values determined. For this reason, the decimal places in the integrated "Round" function are always added up and only shown in the result sheet when a whole number is reached. This avoids rounding errors in the forecast shown.

Finally, there is a result sheet in which for each article from the input database, except for the "replaced articles", an optimal forecasting procedure from the five considered forecasting algorithms as well as the corresponding forecast values are shown. Depending on the system performance/server performance and the data volume of the input file, the execution of the forecast calculation can take several days to compute. As parameterized in *section 5.1*, a maximum optimization time of several seconds per item (3 seconds is recommended, based on the analysis of optimization quality vs. time for the use-case datasets) is available for parameter optimization per forecast method.

5.5 Export of Results

To ensure that the item-specific forecasts can also be directly integrated into the company's daily routine, practical company-specific requirements were formulated for the preparation of the result reports.

A .csv-file with all results for each article is generated. This is normally used as input to parametrize the warehouse management systems installed in the company. In addition, a company-specific result report can be generated. By importing two supplementary input files, item-specific storage data (stock value and stock quantity across all warehouses, safety stock etc.), scheduling data (item owner, replenishment time, order point etc.) and supplier-specific data (main supplier, supplier item number, price etc.) are automatically added to the item-specific forecast. Mathematical data, as listed in the .csv-result report, are reduced to a necessary minimum. The objective was to enable material requirements planners and operational purchasers to continue working with the result report directly in *MS-Excel*. This result report can be used both for internal company communication and for communication with suppliers. Due to the extensive supplementary input data for this report and the complex linking of the data with each other (identification of the main supplier, consolidating stock data across all warehouses etc.), this last calculation in the case studies takes anywhere from one to several hours.

6 CONCLUSION

The developed digital planning tool for an optimized requirements planning was verified using the example of two case studies (see chapter 4).

The limitation of this research relates to the (Austrian) capital goods industry and the utilization of five forecasting methods, as the development and evaluation of the digital planning method was carried out on basis of two companies from the capital goods industry (see chapter 4) and five different forecasting methods (see section 5.4). The following distinction is made between the two companies in the case study. In company 1, 4341 articles from material planning are considered, which subsequently flow into the processing of a small batch production. In company 2, in total 17.724 articles from material planning are considered, which are purely spare parts and subject to a corresponding spare parts planning. The developed planning tool, also implemented in a software tool "*Demand Planning Falcon*", is suitable for both series production and spare parts planning. Tab. 2 shows the selected optimized forecasting methods for the two use-cases and the differences, due to the different time series of the articles considered, become apparent.

During the development of the planning tool, it was found that the naive *moving average* forecasting method most widely used in practice, mainly due to the low implementation and maintenance effort, is replaced with complex *exponential smoothing procedures*. Essential for this result is also the item-specific optimization of the forecast parameters by means of *Genetic Algorithm* (GA). This allowed the complex forecasting methods to be optimally adjusted and applied according to the item-specific characteristics. However, it is also evident from the case studies that each of the forecasting methods is required for optimal item-specific forecasting and is applied in the case studies. The results in both cases identify *3rd-order exponential smoothing* as the most frequently chosen method. This can be explained by pronounced seasonality of many of the involved articles – in company 1 resulting from products for the agricultural technology. In company 2 strong long-term sales trends lead to *2nd-order exponential smoothing* being chosen for many articles.

Table 2 Results of the forecast calculation per item

Implemented forecast algorithms	Company 1		Company 2	
Moving average	345	7,9%	4 969	28,0%
Weighted moving average	737	17,0%	2	0,0%
*1st-order exponential smoothing procedure	simple exponential smoothing*	581	13,4%	2 310	13,0%
*Holt´s linear trend method	2nd-order exponential smoothing procedure* (non-damped)	650	15,0%	3 926	22,2%
*Holt-Winter method	3rd-order exponential smoothing procedure* (multiplicative, non-damped)	1 665	38,4%	6 372	36,0%
Non-predictable items	255	5,9%	43	0,2%
replacement articles: no forecast	108	2,5%	102	0,6%
Total:	4 341		17 724	

The use of different forecasting methods ensures that the respective, item-specific time series are considered more efficiently. This is a process improvement compared to sales planning based on a single forecast method (e.g. *moving average*) [22].

The applied *Design Science Research Methodology* shaped the research procedure: The starting point is an existing problem from industry, from which an objective and a research hypothesis were derived (see *chapter 2*). Based on theory research on the current state of the art (see *chapter 3*) and a specification of the problem in the capital goods industry (see *chapter 4*), a solution to achieve the objective was developed (see *chapter 5*). The results from the developed planning method were demonstrated and evaluated in terms of applicability using real company data and subsequently communicated back to the industry. During the evaluation and communication, suggestions for improvement of the developed digital planning method were identified. The resulting necessary adaptations in the adjustment of the objectives or in the design and development of the digital planning method were run through in several loops.

The research outlook comprises the following elements: Identifying and implementing continuous improvements by monthly application of the planning tool (*Demand Planning Falcon*) at the application partners. An expansion to other forecasting methods (see Fig. 2) to sustainably increase the quality of forecasts is planned. In addition, the results are used as input for further research projects within the framework of the research project *DISPO 4.0*. These include the digitalization of *calculation of stock* using safety stock algorithms [21] and the digitalization of *purchase order calculation* using order lot sizing algorithms [23]. The results of the *Demand Planning Falcon* enable significantly improved, item-specific demand planning and are a first step towards the automation and digitalization of the *requirements planning* of consumption-based material requirements planning.

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Notice

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Advanced Technologies in Logistics Engineering: Automated Storage Systems with Shuttles integrated with Hoisted Carriage

Tone Lerher*, Primož Bencak

Abstract: This paper presents automated storage systems with shuttles integrated with hoisted carriage for successful application in intralogistics. The first part of the paper presents classic and advanced AVS/RS along with specific intralogistics automation systems known as AutoStore from Swisslog and Skypod from Exotec. The second part of the paper focuses on an advanced system with shuttle vehicles capable of serving multiple tiers of the storage rack. An analytical model for the shuttle vehicles capable of serving multiple tiers of the storage rack is presented, which is based on (*i*) the sequences of acceleration, constant velocity and deceleration, and (*ii*) randomised assignment policy. Based on the presented model, the expected Single Command (SC) and Dual Command (DC) travel (cycle) time as well as the throughput performance of the shuttle vehicles capable of serving several tiers of warehouse, could be calculated. A programme code in MATLAB has been presented for the computation of throughput performances of automated storage systems with shuttles integrated with hoisted carriage capable of serving several tiers of the storage rack.

Keywords: analytical and numerical model; automated vehicle-storage and retrieval systems AVS/RS; automated warehouses; cycle time and throughput performance; shuttles integrated with hoisted carriage

1 INTRODUCTION

The processes in Logistics are crucial for the existence of modern society, as they provide the right services at the right time. The Council of Supply Chain Management Professionals [1] defines the Logistics as an integral part of Supply Chain in the way, that it plans, implements, controls the efficient flow and storage of goods, services and related information between point of origin and consumption. Of course, Logistics services must be organised in the way that they meet the ever-increasing customer requirements.

One of the most important parts of Logistics is Intralogistics (or Internal Logistics), which ranked second in 2018 global Logistics market share [2]. Intralogistics describes the organisation, realisation and optimization of internal material flow between different logistics hubs – material flow in production, in goods distribution centres and in airports and seaports along with the related information [3]. To ensure reliable and predictable flow of physical goods in the nodes of a supply network, processes of the intralogistics domain must be as efficient as possible. Therefore, many investments in intralogistics are related to warehouses and internal transport.

The strive for more efficient processes to reduce the Carbon Greenhouse Emissions (CGH), achieve lower energy consumption and fill the gap of worker deficiency, new technologies and concepts have been proposed, such as Industry 4.0 [6] and based on its paradigms, Logistics 4.0 [7]. Automation and robotization (along with the application of collaborative robots) [8] is therefore practically a necessity to overcome all of the above challenges.

To keep up with the increasing demands of e-commerce, such as minimum order sizes, high product range, short delivery and variable order quantities [9], new types of warehouses have emerged. Conventional warehouses hardly meet those requirements, since one of the most labour-intensive and demanding processes in warehouses (both automated and non-automated) is the order-picking process [10]. Due to the order-picking process demands for high precision work and the costs associated with its automation, the process is usually at the most partially automated. Order-pickers often suffer from musculoskeletal disorders due to the poor ergonomics along with psychical stress that stems from the demand for high precision work [11]. Furthermore, the work usually takes place in multiple work shifts, which makes the work further unattractive. However, simply employing automation and robotization without highly skilled logistics employees, which are sparse, the efficiency of logistics processes does not increase. Along with the digitization [13] this is one of the major challenges in logistics [14]. Owing to the above, automation and robotization of warehousing processes are certainly key factors in warehouses of the future [12], where we see a great potential for progress.

This paper is structured as follows. Chapter 2 presents classical and advanced AVS/RS as well as specific intralogistic automation systems such as AutoStore by Swisslog and Skypod by Exotec. In chapter 3, travel-time models for automated storage systems with shuttles integrated with hoisted carriage will be presented. Finally, chapter 4 presents main conclusions.

2 AUTOMATED-VEHICLE BASED STORAGE AND RETRIEVAL SYSTEMS

The development of Automated and (autonomous) Vehicle-Based Storage and Retrieval Systems (AVS/RS) contributed significantly to warehouse automation. AVS/RS consist of storage rack with an elevator capable of executing vertical movements of stock keeping units and shuttle vehicles which are performing horizontal movements. AVS/RS are superior compared to classical crane-based AS/RS in terms of higher throughput capacity, higher flexibility and scalability, lower energy consumption, etc. AVS/RS are therefore preferentially chosen over crane-based AS/RS in practice.

A study by the European Materials Handling Federation (FEM) shows that the use of AVS/RS in practise has increased significantly since 2015 compared to other automated storage systems [15]. This confirms the fact that the application of AVS/RS in practice is effective.

The concept of using a combined lift and automatic vehicles dates back to the 1970s in the form of technical sketches and patent applications. Although the concept of a combined system for the use of elevators and automatic vehicles was relatively advanced, the technology was not sufficiently developed for practical use at that time.

In 2015, the Association of German Engineers (Verein Deutscher Ingenieure; VDI) published the technical guideline "VDI 2692 Blatt 1 - Automated vehicle storage and retrieval systems for small unit loads" [16]. Also in 2017, the European Materials Handling Federation (FEM) published the technical guideline "FEM 9.860 - Cycle time calculation for automated vehicle storage and retrieval systems" [17]. The two technical guidelines "VDI 2692 Blatt 1" and "FEM 9.860" describe in detail the individual AVS/RS components and models for calculating throughput capacity under various AVS/RS operating conditions.

2.1 Classical Automated Vehicle-Based Storage and Retrieval Systems

Classical AVS/RS are special type of automated warehouses that are used for handling totes and is comprised of the elevator with a lifting table that is moving in the vertical direction and is feeding the storage rack (Fig. 1).

The elevator's lifting table has its own drive and operates according to the non-constant ($v \neq$ constant) velocity-time relationship. The velocity of the elevator's lifting table is capable of reaching up to v_y = 6 m/s, meanwhile the acceleration/ deceleration can reach up to a_y = 5 m/s². The elevator's lifting table operates on single and dual command sequence.

The Storage Rack (SR) consists of columns in the horizontal direction and tiers in the vertical direction. The maximum length of the SR could reach up to L_{SR} = 100 m, while the maximum height of the SR could reach up to H_{SR} = 15 m. A buffer location is situated at the beginning of each tier, where totes are delivered by the elevator's lifting table. Delivered totes wait for a shuttle vehicle to be transferred in the SR.

In each tier of the SR is a single tier-captive shuttle vehicle that is traveling in the horizontal direction (Fig. 2).

The shuttle vehicle is an automatic vehicle with four wheels, capable of carrying loads of up to 50 kg. It has its own drive and operates according to the non-constant ($v \neq$ constant) velocity-time relationship. The velocity of the shuttle vehicle can reach up to v_x = 3 m/s, meanwhile the acceleration/ deceleration can reach up to a_x = 2 m/s². The shuttle vehicle operates on single and dual command sequence.
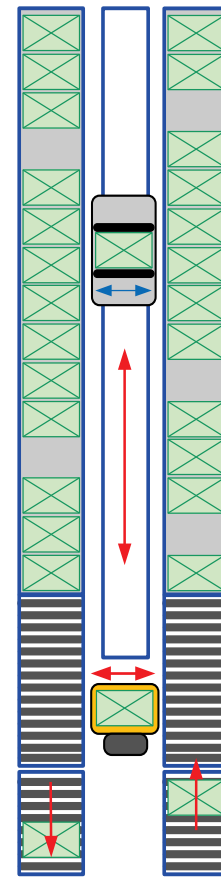
Figure 1 Layout of the Classical AVS/RS
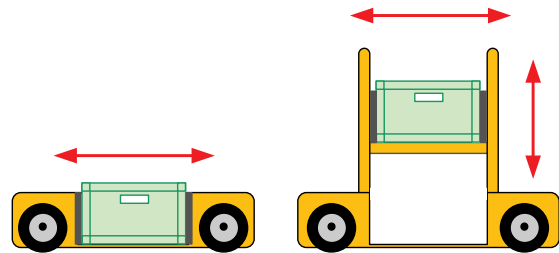
Figure 2 Shuttle vehicle

2.2 Advanced Vehicle-Based Storage and Retrieval Systems

Throughput performance of the elevator's lifting table and shuttle carriers depends on the number of transactions for the single and dual cycles. According to a sequential processing policy, a throughput performance of the elevator's lifting table and shuttle carriers is calculated individually for both material handling devices. Usually, it happens that the elevator's lifting table is not capable of keeping up with the shuttle carriers and, therefore, it works with max. utilization ($\gg \eta_{LIFT}$). On the other hand, shuttle carriers work with relatively low utilization ($\ll \eta_{SCAR}$) especially with short types of storage rack as they wait in idle mode for tasks to be performed. The most efficient design of the AVS/RS will be achieved when the elevator's lifting table and shuttle carriers utilization will be maximum ($\eta_{LIFT} = \eta_{SCAR} \approx 1.0$). This problem can be solved by using other designs of AVS/RS as follows (Figs. 3, 4, 5).
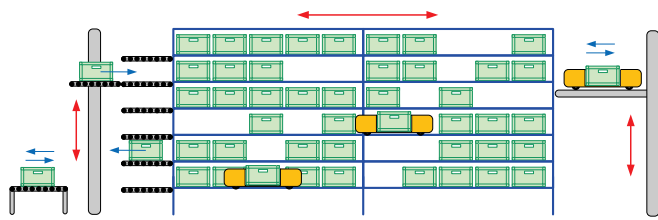
Figure 3 Tier-to-tier AVS/RS
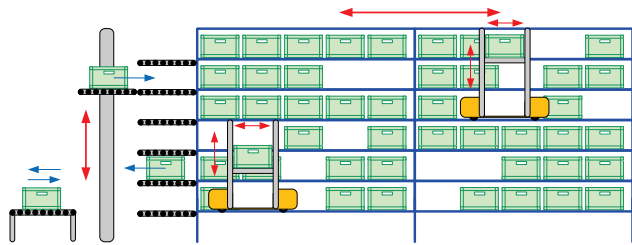
Figure 4 AVS/RS with shuttles integrated with hoisted carriage
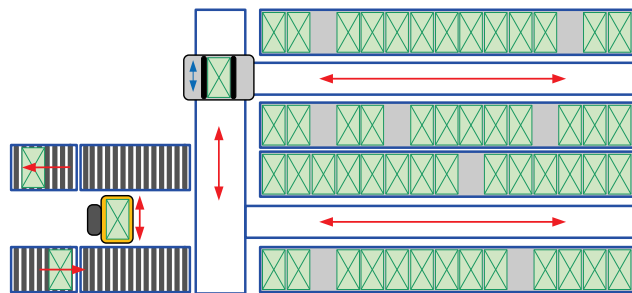
Figure 5 3D-level-captive shuttle carriers in AVS/RS

2.3 Specific Automated Vehicles-Based Storage and Retrieval Systems

AutoStore is a unique solution that uses robots and bins to quickly process small parts orders. AutoStore provides better use of available space than any other automated system thanks to its unique design that enables direct stacking of bins on top of each other and storage of multiple SKUs in a single bin (Fig. 6) [18].
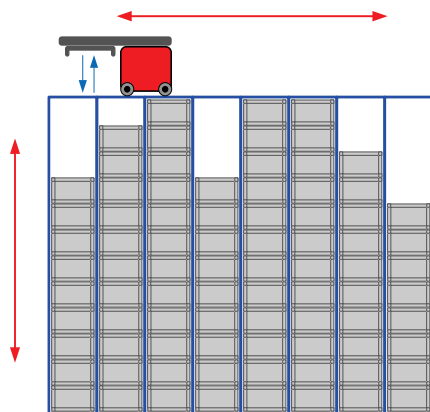
Figure 6 Autostore Swisslog

Skypod (Fig. 7) is a retail order picking solution, which offers the best performance on the market while remaining flexible and adaptable to the customer's needs. The system sizing considers storage requirements and flows independently. This allows extreme adaptability to

customer's specifications and allows subsequent phasing as needs evolve [19].
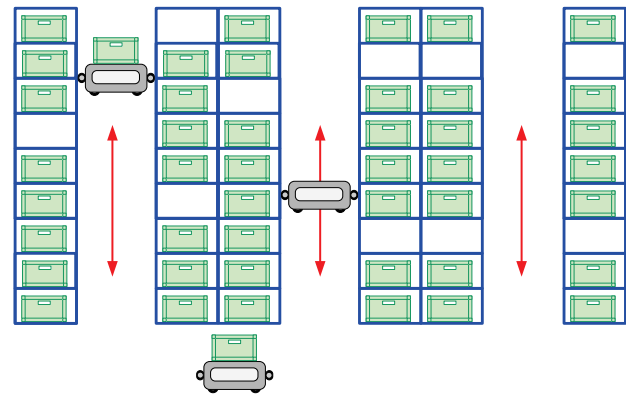
Figure 7 Skypod Exotec

3 MODEL FOR THE THROUGHPUT PERFORMANCE OF AUTOMATED STORAGE SYSTEMS WITH SHUTTLES INTEGRATED WITH HOISTED CARRIAGE

Throughput capacity of automated storage systems with shuttles integrated with hoisted carriage is inversely dependant from the travel (cycle) times of the shuttle vehicles.

Note: In this research paper, the elevator will not be included, although is very important part in a system throughput performance of AVS/RS.

Cycle time of automated storage systems with shuttles integrated with hoisted carriage, which are capable of serving numerous tiers of the storage rack is founded on the analytical travel-time model with the assumption on a non-constant velocity time distribution (the sequence of acceleration, constant velocity, and deceleration) and the probability theory.

The proposed model is based on the following assumptions:

- The AVS/RS is divided into SR on both sides (left and right). Totes can be therefore stored at either side in i^{th} tier of the AVS/RS.
- The I/O location is located at the first tier of the SR.
- The dwell-point location of the shuttle vehicle in the ith tier of the SR (when idle) is located at the I/O$_i$ buffer location.
- The SR is divided by columns and tiers.
- At each level of the SR, there are two buffer locations (left and right) and a single shuttle vehicle capable of serving numerous tiers of SR. One level is combined by individual number of tiers.
- The shuttle vehicle works on a Single Command (SC) and on Dual Command (DC) cycles.
- The sequence of (i) Acceleration, constant velocity and deceleration have been used.
- The shuttle vehicle travels simultaneously in the horizontal (x) and vertical (y) directions.
- The shuttle vehicle's drive characteristics, as well as the length L_{SR} of the SR, are known in advance.

- The shuttle vehicle can reach its maximum velocity v_{max} in the horizontal (x) direction, as the length L_{SR} of the SR is large enough.
- A randomized assignment policy is chosen meaning any storage location is equally likely to be selected for storage or retrieval location to be processed by the shuttle vehicle capable of serving numerous tiers of SR.

Abbreviation

AS/RS	Automated storage and retrieval systems.
AVS/RS	Automated Vehicles-Based Storage and Retrieval Systems.
DC	Dual command.
LIFT	Elevator (elevator's lifting table).
I/O	Input/output location.
MTC	Multi-tier-captive.
SCAR	Shuttle vehicle capable of serving numerous tiers of SR.
SC	Single command.
SR	Storage rack.

Notations

L_{SR}	–	length of the storage rack.
H_{SR}	–	height of the storage rack.
H_{LEVEL}	–	height of one level of the storage rack.
H_{TIER}	–	height of one tier of the storage rack.
v	–	velocity.
a	–	acceleration/deceleration.
b	–	shape factor.
A	–	surface of the storage rack.
$E(SC_1)_{SCAR}^{MTC}$	–	the expected single command cycle time ($b \leq 1$).
$E(SC_2)_{SCAR}^{MTC}$	–	the expected single command cycle time ($b > 1$).
$\lambda(SC)_{SCAR}^{MTC}$	–	throughput capacity of the single command cycle time.
$E(DC_1)_{SCAR}^{MTC}$	–	the expected dual command cycle time ($b \leq 1$).
$E(DC_2)_{SCAR}^{MTC}$	–	the expected dual command cycle time ($b > 1$).
$\lambda(DC)_{SCAR}^{MTC}$	–	throughput capacity of the dual command cycle time.
$t_{P/S\ SCAR}^{MTC}$	–	time to pick up and set down the load.

Based on work of Gudehus [20], the expressions for SC and DC cycles along with throughput performance have been developed.

In continuation the expressions $E(SC_1)_{SCAR}^{MTC}$, $E(SC_2)_{SCAR}^{MTC}$ and $\lambda(SC)_{SCAR}^{MTC}$ for single command cycle along with the expressions $E(DC_1)_{SCAR}^{MTC}$, $E(DC_2)_{SCAR}^{MTC}$ in $\lambda(DC)_{SCAR}^{MTC}$ for dual command cycles will be presented.

Shape factor (b) of one level of the AVS/RS equals Eq. (1):

$$b = \frac{H_{LEVEL}}{L_{SR}} \cdot \frac{v_x}{v_y} \tag{1}$$

Note: According to Fig. 8, one level of the storage rack represents 3 consecutive tiers.

Surface of one level of SR (A) equals Eq. (2):

$$A = H_{LEVEL} \cdot L_{SR} = \text{const.} \tag{2}$$

Single command cycle of automated storage systems with shuttles integrated with hoisted carriage
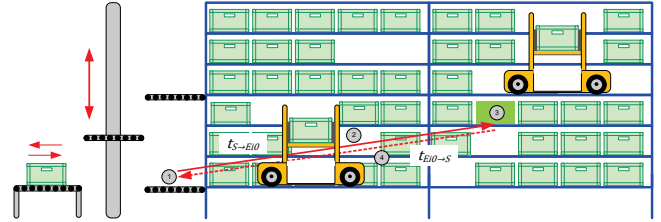
Figure 8 Single command cycle of automated storage systems with shuttles integrated with hoisted carriage

Note: (1) – I/O location, (2) – travelling of the shuttle vehicle to destination storage location (3), (4) – travelling of the shuttle vehicle to (1); Fig. 8.

The expected single command cycle time $E(SC_1)_{SCAR}^{MTC}$, when ($b \leq 1$) equals Eq. (3):

$$E(SC_1)_{SCAR}^{MTC} = 2 \cdot t_{P/S\ SCAR}^{MTC} + \frac{L_{SR}}{v_x} + \frac{2v_x}{a_x} + \frac{A \cdot v_x}{L_{SR}^2 \cdot a_y}$$
$$+ \frac{A^2 \cdot v_x}{3L_{SR}^3 \cdot v_y^2} - \frac{A \cdot v_x^2}{L_{SR}^2 \cdot a_x \cdot v_y} \tag{3}$$

The expected single command cycle time $E(SC_1)_{SCAR}^{MTC}$, when ($b > 1$) equals Eq. (4):

$$E(SC_2)_{SCAR}^{MTC} = 2 \cdot t_{P/S\ SCAR}^{MTC} + \frac{A}{L_{SR} \cdot v_y} + \frac{2v_y}{a_y}$$
$$+ \frac{L_{SR}^2 \cdot v_y}{A \cdot a_x} + \frac{L_{SR}^3 \cdot v_y}{3A \cdot v_x^2}$$
$$- \frac{L_{SR}^2 \cdot v_y^2}{A \cdot a_y \cdot v_x} \tag{4}$$

Throughput capacity of the single command cycle time $\lambda(SC)_{SCAR}^{MTC}$ equals Eq. (5):

$$\lambda(SC)_{SCAR}^{MTC} = \frac{3600}{E(SC_i)_{SCAR}^{MTC}} \cdot 1 \tag{5}$$

Dual command cycle of automated storage systems with shuttles integrated with hoisted carriage

The expected dual command cycle time $E(DC_1)_{SCAR}^{MTC}$, when ($b \leq 1$) equals Eq. (6):

$$E(\mathrm{DC}_1)_{\mathrm{SCAR}}^{\mathrm{MTC}} = 4 \cdot t_{\mathrm{P/S\ SCAR}}^{\mathrm{MTC}} + \frac{4L_{\mathrm{SR}}}{3v_x} + \frac{3v_x}{a_x}$$
$$+ \frac{3A \cdot v_x}{2L_{\mathrm{SR}}^2 \cdot a_y} - \frac{A^3 \cdot v_x^2}{30L_{\mathrm{SR}}^5 \cdot v_y^3} \qquad (6)$$
$$+ \frac{A^2 \cdot v_x}{2L_{\mathrm{SR}}^3 \cdot v_y^2} - \frac{3A \cdot v_x^2}{2L_{\mathrm{SR}}^2 \cdot a_x \cdot v_y}$$
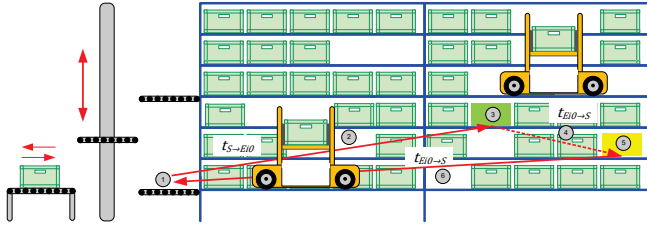
Figure 9 Dual command cycle of automated storage systems with shuttles integrated with hoisted carriage

Note: (1) – I/O location, (2) – travelling of the shuttle vehicle to destination storage location (3), (4) – travelling of the shuttle vehicle to retrieval location (5), (6) – travelling of the shuttle vehicle to (1); Fig. 9.

The expected dual command cycle time $E(\mathrm{DC}_2)_{\mathrm{SCAR}}^{\mathrm{MTC}}$, when ($b > 1$) equals Eq. (7):

$$E(\mathrm{DC}_2)_{\mathrm{SCAR}}^{\mathrm{MTC}} = 4 \cdot t_{\mathrm{P/S\ SCAR}}^{\mathrm{MTC}} + \frac{4A}{3L_{SR}v_y} + \frac{3v_y}{a_y}$$
$$+ \frac{2L_{\mathrm{SR}}^2 \cdot v_y}{2A \cdot a_x} - \frac{L_{\mathrm{SR}}^5 \cdot v_y^2}{30A^2 \cdot v_x^3} \qquad (7)$$
$$+ \frac{L_{\mathrm{SR}}^3 \cdot v_y}{2A \cdot v_x^2} - \frac{3L_{\mathrm{SR}}^2 \cdot v_y^2}{2A \cdot a_y \cdot v_x}$$

Throughput capacity of the dual command cycle time $\lambda(\mathrm{DC})_{\mathrm{SCAR}}^{\mathrm{MTC}}$ equals Eq. (8):

$$\lambda(\mathrm{DC})_{\mathrm{SCAR}}^{\mathrm{MTC}} = \frac{3600}{E(\mathrm{DC}_i)_{\mathrm{SCAR}}^{\mathrm{MTC}}} \cdot 2 \qquad (8)$$

Note: for more complex AVS/RS analytical model that is based on travelling of the shuttle vehicles capable of serving numerous tiers of SR with (*i*) acceleration and deceleration and (*ii*) acceleration, constant velocity and deceleration, see paper from Lerher et al. [21].

For the performance calculation of automated storage systems with shuttles integrated with hoisted carriage, a programme in MATLAB has been developed.

A calculation of SC and DC cycle times along with the throughput performances is presented by using the following parameters: $L_{\mathrm{SR}} = 30$ m, $H_{\mathrm{LEVEL}} = 2{,}1$ m, $v_x = 2{,}5$ m/s, $v_y = 2$ m/s, $a_x = 1{,}5$ m/s², $a_y = 1{,}5$ m/s², $t_{\mathrm{P/S\ SCAR}}^{\mathrm{MTC}} = 3{,}4$ s.

Note: $H_{\mathrm{LEVEL}} = 2{,}1$ m which means that one level has 6 consecutive tiers; hight of the tier equals $H_{\mathrm{TIER}} = 0{,}35$ m.

```
%Input data

H_SR = 2.1 %m
L_SR = 30 %m
vel_x = 2.5 %m/s
vel_y = 2 %m/s
acc_x = 1.5 %m/s^2
acc_y = 1.5 %m/s^2
T_PS = 3.4 %s

%Single command cycle

%Shape factor

b=(H_SR/L_SR)*(vel_x/vel_y)

%Surface of the storage rack

A=H_SR*L_SR

if b<=1

    E_SC_1 =
2*T_PS+(L_SR/vel_x)+((2*vel_x)/acc_x)+((A*ve
l_x)/(L_SR^2*acc_y))+((A^2*vel_x)/(3*power(L
_SR,3)*vel_y^2))-
(A*vel_x^2)/(L_SR^2*acc_x*vel_y)
    L_SC_1 = 3600/E_SC_1

elseif b>1

    E_SC_2 = 2*T_PS +
(A/(L_SR*vel_y))+((2*vel_y)/acc_y)+((L_SR^2*
vel_y)/(A*acc_x))+((power(L_SR,3)*vel_y)/(3*
A*vel_x^2))-
((L_SR^2*vel_y^2)/(A*acc_y*vel_x))
    L_SC_2 = 3600/E_SC_2

end

%Double command cycle

if b<=1

E_DC_1 =
4*T_PS+((4*L_SR)/(3*vel_x))+((3*vel_x)/(acc_
x))+((3*A*vel_x)/(2*L_SR^2*acc_y))-
((power(A,3)*vel_x^2)/(30*power(L_SR,5)*powe
r(vel_y,3)))+((A^2*vel_x)/(2*power(L_SR,3)*v
el_y^2))-
((3*A*vel_x^2)/(2*L_SR^2*acc_x*vel_y))
    L_DC1 = (3600/E_DC_1)*2

elseif b>1

E_DC_2 =
4*T_PS+((4*A)/(3*L_SR*vel_y))+((3*vel_y)/acc
_y)+((2*L_SR^2*vel_y)/(2*A*acc_x))-
((power(L_SR,5)*vel_y^2)/(30*A^2*vel_x^3))+(
(power(L_SR,3)*vel_y)/(2*A*vel_x^2))-
((3*L_SR^2*vel_y^2)/(2*A*acc_y*vel_x))
    L_DC2 = (3600/E_DC_2)*2

end
```

```
%Results

b = 0.0875 %/

A = 63 %m^2

E_SC_1 = 22.1348 %s

L_SC_1 = 162.6399 %totes/hour

E_DC_1 = 34.6019 %s

L_DC1 = 208.0809 %totes/hour
```

4 CONCLUSIONS

The aim of this paper is to present a specific design for an automated storage systems with shuttles integrated with hoisted carriage, which can move synchronously parallel, and vertically.

An analytical model for calculating the throughput performance of an AVS/RS with shuttle vehicles capable of serving numerous tiers of SR was presented. The proposed model assumes the condition of a non-constant velocity (sequence of acceleration, constant velocity and deceleration) of the shuttle vehicle and a randomised allocation policy for the storage and retrieval requests. A programme in MATLAB has been developed for the performance calculation.

The advantages of the proposed analytical and numerical model are that it is relatively simple and quick to evaluate the performance of automated storage systems with shuttles integrated with hoisted carriage. This is very important for warehouse integrators and warehouse managers, as they can very quickly compare a relatively large number of different AVS/RS designs before deciding on the most optimal one.

This study can be extended by applying environmental aspects such as energy consumption and CO_2 emissions, which can be considered in further analysis.

Acknowlegements

Notice

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Condition Monitoring of Rotary Machinery Using Industrial IOT Framework: Step to Smart Maintenance

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Abstract: Modern maintenance strategies, such as predictive and prescriptive maintenance, which derived from the concept of Industry and Maintenance 4.0, involve the application of the Industrial Internet of Things (IIoT) to connect maintenance objects enabling data collection and analysis that can help make better decisions on maintenance activities. Data collection is the initial step and the foundation of any modern Predictive or Prescriptive maintenance strategy because it collects data that can then be analysed to provide useful information about the state of maintenance objects. Condition monitoring of rotary equipment is one of the most popular maintenance methods because it can distinguish machine state between multiple fault types. The topic of this paper is the presentation of an automated system for data collection, processing and interpretation of rotary equipment state that is based on IIoT framework consisting of an IIoT accelerometer, edge and fog devices, web API and database. Additionally, ISO 10816-1 guidance has been followed to develop module for evaluation of vibration severity. The collected data is also visualized in a dashboard in a near-real time and shown to maintenance engineering, which is crucial for pattern monitoring. The developed system was launched in laboratory conditions using rotating equipment failure simulator to test the logic of data collection and processing. A proposed system has shown that it is capable of automated periodic data collection and processing from remote places which is achieved using Node RED programming environment and MQTT communication protocol that enables reliable, lightweight, and secure data transmission.

Keywords: accelerometer; automated data collection; Industrial Internet of Things (IIoT); MQTT; Node RED

1 INTRODUCTION

In today's era of modern digital based technology there is a huge amount of data being generated every second. Companies are trying to adopt the new trends by using all sorts of data to gain competitive and financial advantage by optimising production lines, increasing productivity and efficiency of processes and utilizing modern information technologies. In many cases, companies try to increase production and machine usage to bring their product to market with maximum output and capacity but fail to do so because of inadequate maintenance strategies [1]. Using modern data based maintenance strategies, such as Predictive maintenance, has shown that there are more benefits in terms of operation and maintenance costs. To implement such strategy, several modern Industry 4.0 technologies are required which can appear as high cost to companies which want to implement them [2]. One of the required technology is an Industrial Internet of Things (IIoT) framework which provides environment for data acquisition and transmission from data source to the desired destination. IIoT can integrate various manufacturing devices to sense, identify, process, communicate, operate and network [3]. IIoT sensors are small, flexible, versatile and cost efficient solution for modern data acquisition requirements. The use of sensors in Predictive maintenance is associated with monitoring of a rotary machinery, which includes motors, pumps, fans, turbines, gearboxes and similar equipment. Vibration analysis is one of the main techniques used to monitor rotary machinery equipment state because vibration forms unique patterns that are associated with specific rotary equipment faults [3]. To acquire such data, the most common sensor for such measurement are accelerometers. A key advantage of accelerometers are their versatility and in the embedded domain, microelectromechanical systems (MEMS) accelerometers are widely used due to their small size, low cost and low power consumption [4]. Using an IIoT MEMS accelerometer has even more advantages because of its

ability to be connected to Internet and transmit data over it. Because of this characteristic, data can be acquired from variety of locations where some sort of Internet connectivity is available.

The main purpose of this paper is to showcase the development of an automated periodic data collection IIoT system that can collect, process, visualize and transmit data from an IIoT sensors in a place where conventional network is not available. The system can also automatically evaluate machine state using ISO 10816-1 reference. The rest of the paper is organized as follows: Section 2 overviews the related work in the field of IIoT vibration condition monitoring and data acquisition, Section 3 contains system architecture and components description after which data collection and transformation into knowledge process is described in Section 4. Results of system evaluation are discussed in Section 5 and finally, conclusion is drawn in Section 6.

2 RELATED WORK

As the field of application of IIOT in the field of maintenance is emerging, there are few papers that are linked to this research which cover similar topics. In this section, the papers are briefly described. Paper [5] gives an overview of current state of predictive maintenance and intelligent sensors in smart factories. Authors concluded that the importance of predictive maintenance is growing over time in relation to Industry 4.0 technologies which gives an advantage to intelligent sensor that can connect to the Internet. As already mentioned, IIoT MEMS accelerometer is the main solution for intelligent data acquisition which is demonstrated in paper [2]. This paper demonstrated the use of MEMS accelerometer for condition monitoring of induction motors and an expander machine in two different industrial settings. Each sensor was connected to the data acquisitioning device (NI CDAQ9191) and every 3 seconds vibration signal was stored with a use of a generic web

application on a web server. The research concluded that the faults on two different machines can be detected using a low-cost sensor. Authors in paper [6] developed a versatile wireless sensor unit called "Mesimo" which is operated from web browser making it remotely accessible from a broad range of devices. Such device was used to measure translatory movement of linear actuator and the vibrations of large rotary machinery. Similarly in [7] the authors used Zigbee enabled IIoT MEMS accelerometer which uses low power so it can be used in a situation where there is no power source available. The IIoT sensor was used to collect data from robot joints to evaluate the system performance. In [8] the authors developed and implemented an IIoT system designed to monitor electric motors in real time. This setup also used low-cost MEMS accelerometers, temperature sensor and open source IoT software. The setup used 1 kHz sampling frequency with data transmitted over wireless access point as an input to scripts written in Phyton. The paper also touched on the topic of edge computing where in one case the data was processed right after sampling before being sent to the server. In [9] condition monitoring on four CNC machines was conducted using a remote vibration monitoring system which used MEMS accelerometer. The Raspberry Pi was used to send data to the database in real time after which the Phyton script analysed the data in terms of acceleration in the time domain and applied FFT to obtain the acceleration in the frequency domain. It is important to point out that in the papers above, software components weren't highlighted enough. The authors in [10] used Node RED software designed to handle IoT to implement MQTT based air quality monitoring system. In this paper we followed similar strategy to handle and visualize data. Similar approach was used in [11] to capture temperature and humidity data using a Raspberry Pi and Node RED, however in this paper the visualization has not been showcased. Another great example of an IIoT system that uses 4G is in [12] where authors used low-cost MEMS accelerometer with Raspberry Pi and cloud technologies to monitor vibration impact on the surrounding environment during construction activities to gain better insight into structure safety, human comfort and equipment functionality. This paper has also many connecting points with our previous research [13]. The papers above highlighted the importance of remote data collection ability which is where the industry is oriented in this present moment. This paper focuses on the remote data collection, processing and interpretation of data using modern IIoT technologies and protocols such as Node RED and MQTT to achieve described functionality.

3 SYSTEM REQUIREMENTS AND COMPONENTS

Based on the conducted research and internal requirements, the system requirements can be defined as the following:
1) Automated periodic data acquisition – the system must be able to periodically collect data from sensors, process it and transmit it to the web API on the server.
2) Ability to acquire and process data from remote locations – the system must be able to collect data from remote locations where conventional WiFi and Ethernet

networks are not available. The data must also be processed and aggregated accordingly.
3) Data acquisition from different types of sensors – the system must be able to collect data from multiple different types of sensors such as an accelerometer, temperature, air pressure sensor and other.
4) Data processing and visualisation - the system must be able to process the data and interpret it based on an ISO 10816-1 reference. Also, data must be visualized in a convenient way i.e. in a dashboard.
5) Secure data transmission – data must be securely transmitted over the Internet to assure data integrity and security.

The system must be designed in such way to satisfy the requirements above. This can be achieved by using modern IoT software and hardware components the system architecture is shown in Fig. 1.
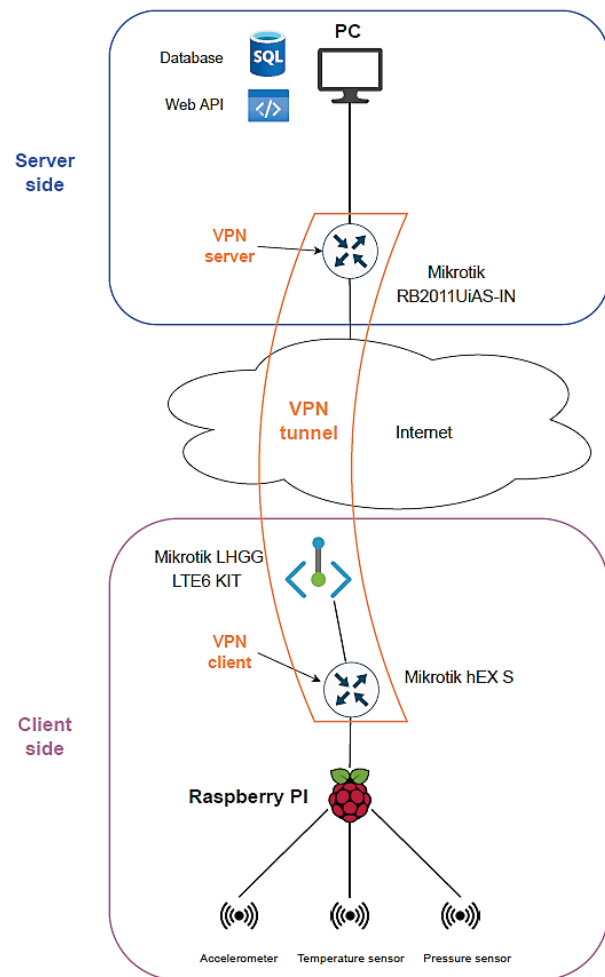
Figure 1 System design

The architecture is divided into two parts: the server side and the client side. The server side consists of the following components:
(1) MikroTik RB2011UiAS-IN router - configured with static IP address and DHCP server, which enables it to have more than one client connected. This router also runs a VPN server.

(2) Application/database server - hosts an IIS web server that runs the Web API. There is also an MSSQL server with a database on this server. The client side consists of the following components:

1) MikroTik LHGG LTE6 KIT - LTE router with antenna designed for Internet access in remote locations with low network coverage.

2) MikroTik hEX-S router - designed for places where wireless connection is not required, contains five Gigabit Ethernet ports as well as PoE output on the rear port.

3) Raspberry PI 4 - a small computer suitable for various types of tasks. A 4 GB RAM model was used.

4) HAT module - HAT extension that plugs into Raspberry's GPIO port. Sensors are connected to the HAT module.

5) IOT sensors - for acceleration, temperature, and air pressure:

- Accelerometer - KX122 MEMS sensor
- Temperature sensor - STS3x sensor
- Air pressure sensor - LPS22HB sensor.

Communication takes place via a site-to-site VPN network. This method is also known as VPN between routers. In this method, a router that supports a VPN client always establishes a VPN tunnel with a VPN server that allows private networks located behind the router to communicate with each other. OpenVPN was chosen for the VPN system due to its availability on MikroTik routers. Using a virtual private network, it is possible to connect remote locations in a secure and reliable way. What is important to emphasize is that one always strives to achieve communication over a virtual private network. It is not recommended to expose the server and communication directly to the Internet because then the level of security is reduced, and it is necessary to provide additional security settings. The client side uses a 4G router and antenna which provides connectivity in a remote locations or other places where WiFi or Ethernet is not available. On the client side, the Raspberry Pi serves as the edge node where the sensors connect to, and which also processes the collected data. Raspberry Pi runs Node RED programming environment that is designed for IoT environments. Node RED is an open-source rapid embedded environment design for easier integration of IoT devices and related software. Node RED provides visual browser based editor that is easy to understand and use [11]. Since the system is based on IOT technology, for communication between the sensor and the Raspberry Pi the MQTT protocol will be used. MQTT is a fast and lightweight protocol that allows messaging between devices located on unstable networks and ensures secure, reliable and two-way messaging [14]. The protocol uses the principle of publication/subscription on the topic. Fig. 2 shows an example of such system.

In this case, the MQTT broker and client will be on the same device, the Raspberry Pi. If there were more than one edge nodes, only clients connecting to the broker would be installed on the others. The IIoT sensors are connected to the Raspberry Pi using the HAT module. The HAT module is a Raspberry Pi HAT with a standard Raspberry Pi HAT shape

factor. The module follows the HAT specification and will work with Raspbian automatically and without any changes. Up to 8 sensors can be connected to the HAT module. HAT module is replacing stack used in [13] because of its simplicity and Raspberry Pi compatibility. The appearance of the Raspberry Pi with HAT can be seen in Fig. 3.
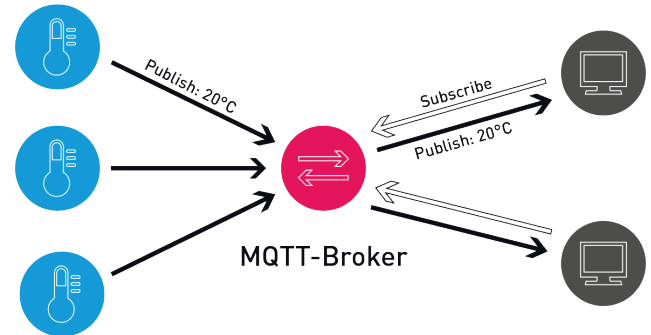
Figure 2 MQTT system [15]
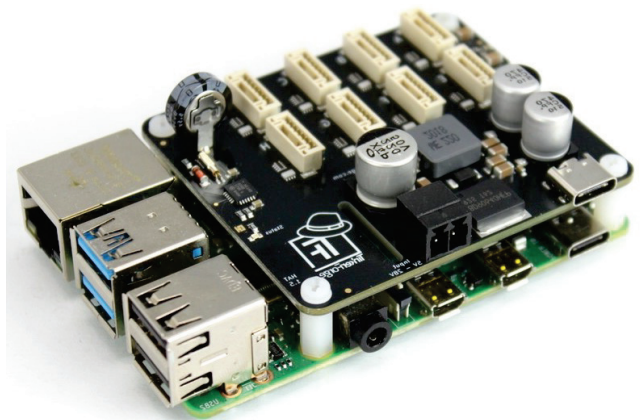
Figure 3 Raspberry Pi with HAT module

For this research, our setup used three different types of sensors: an accelerometer, temperature sensor and pressure sensor. All sensors were produced by same manufacturer which simplifies integration process. MEMS accelerometer can sample data from three axis (x, y, z) with data rate up to 25,6 kHz [16]. Accelerometer is shown in Fig. 4.
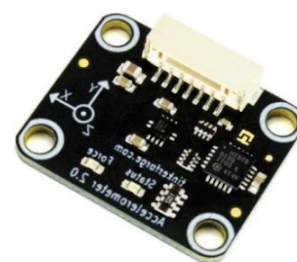
Figure 4 KX122 accelerometer sensor

Accelerometer specifications are listed in Tab. 1.

This system was configured to sample data at 3200 Hz and ±8g range with 16bit resolution. For acquiring temperature information, a temperature sensor was used. Temperature sensor can measure ambient temperature with

0.2 °C accuracy and a temperature range from –40 °C to 125 °C with an output of 0.01 °C step. Temperature sensor specifications are listed in Tab. 2.

Table 1 Accelerometer specification [16]

Property	Value
Output data rate	0.781 Hz - 25.6 kHz
Full-scale range	± 8g
Sensitivity	4096 - 16384 counts/g
Offset	± 20 mg
Non-Linearity	0.6 %
Resolution	0.0001 g, 16-bit
Input voltage	1.71 – 3.6 V
Current consumption	145 mA
Output voltage	1.368 - 28.8 V

Table 2 Temperature sensor specification [16]

Property	Value
Sensor	STS3x
Current consumption	28 mW (5.6 mA at 5V)
Ambient Temperature	–40 °C to 125 °C in 0.01 °C steps
Accuracy	typical 0.2 °C in the range of 0 °C to 65 °C*
Dimensions ($W \times D \times H$)	$25 \times 15 \times 5$ mm
Weight	2 g

Air Pressure sensor with integrated air pressure, temperature and altitude measurement was also used. The sensor has the capability to measure air pressure in range of 260 to 1260 hPa with a resolution of 0.0075 hPa. Detailed specifications are listed in Tab. 3.

Table 3 Air Pressure sensor specification [16]

Property	Value
Sensor	LPS22HB
Current consumption	30 mW (6 mA at 5V)
Pressure Range	260 to 1260 hPa
Resolution	0.0075 hPa / 6.25 cm
Accuracy (0-65 °C)	±1.1 hPa uncalibrated, ±0.2 hPa calibrated*
Dimensions ($W \times D \times H$)	$25 \times 15 \times 5$ mm
Weight	1.6g

Temperature and air pressure sensor are shown in Fig. 5.
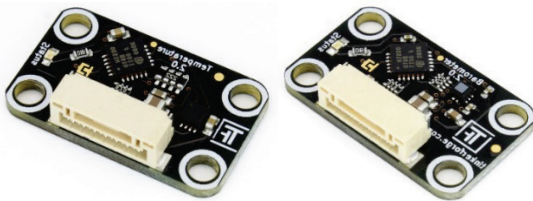
Figure 5 Temperature and air pressure sensor

4 DATA COLLECTION AND PROCESSING

The data collection work process consists of multiple flows. A flow can be viewed as a standalone program (script) which contains functions and methods to achieve specific tasks. Node RED supports the creation of multiple flows that can interchange data and have its own sub flows. General data collection workflow can be seen in Figure 6. For the

purpose of this paper, the system ability was evaluated using a rotational equipment fault simulator referenced in [13] using a accelerometer, temperature and air pressure sensor.
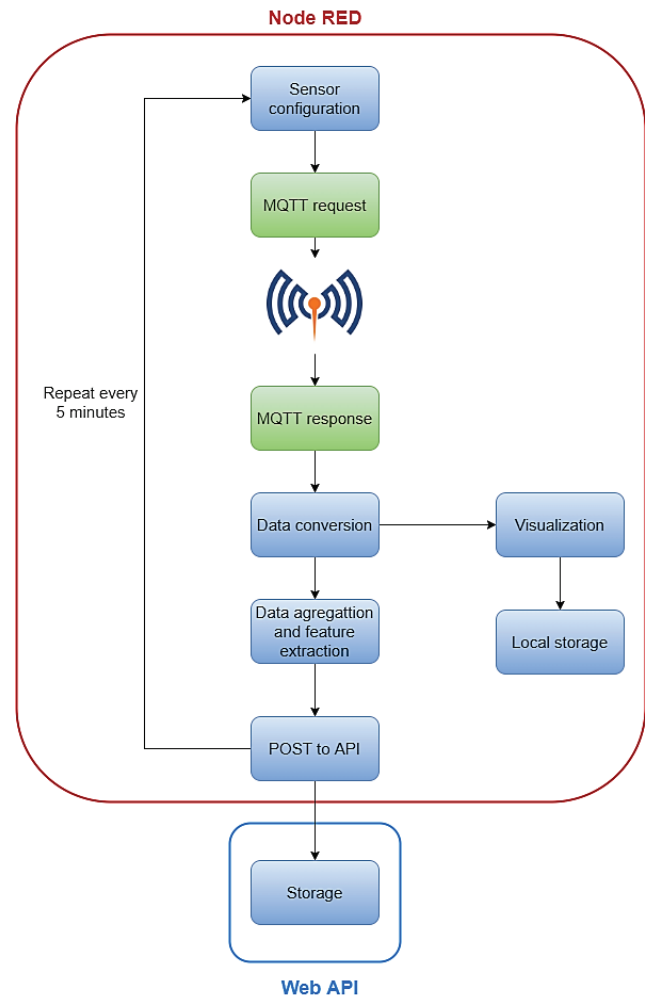
Figure 6 Data collection workflow

Data collection process starts with setting the sensor configuration. The configuration setting is sent over the MQTT broker to the MQTT client which governs the sensors. Data from sensors is then sent back over to the main process where data is converted, aggregated and in a case of acceleration, features are extracted and interpreted. The data is then simultaneously visualized in a dashboard, stored locally and sent to the server where it is stored in a database. The whole process repeats every 5 minutes. Detailed explanation is provided below.

The flow begins with a request that is sent over the MQTT broker to the MQTT client that is responsible for data acquisition process. Since the accelerometer supports a wide frequency range of sampling (from 0.718 Hz to 10 kHz) and a range of values (from ± 2g to ± 8g) it is necessary to define these parameters before the process starts. In this experimental setup, the sampling rate is 3200 Hz and the range is ± 8g. Also, in addition to the frequency and range, it is necessary to define the collection resolution as well as the number of axes from which the data is collected. There is an

option to select 8-bit or 16-bit resolution and any number of axes. A higher resolution is taken, i.e., 16-bit and all three axes are enabled. This process of configuring and enabling data collection from the accelerometer is performed only once, 30 seconds after startup. The temperature and air pressure configuration are set by the default so that only the values must be called.

After sending the configuration and the request to the broker comes the phase of receiving values from the broker. The acceleration values arrive in a series of 30 data points which allows the collection of values at higher frequencies (> 800 Hz). The standard "Get" invocation of values works by sending a request to the broker every n millisecond. Due to the very nature of the MQTT protocol, it is not possible to have a reliable flow of information at low values of the collection interval (< 3 ms). Therefore, the accelerometer allows continuous invocation of values which accelerometer then sends in series, allowing a higher frequency of collection. If the object received from the broker is empty, an error is logged and sent to the API. The data coming from the sensor takes the shape of an array with 30 values. The acceleration data inside an array is grouped by three (x, y, z, x_1, y_1, z_1…) and it needs to be separated so that further manipulation can take place. After dividing the data into groups of three, it is necessary to convert the data into the correct form because the data arrives in "raw" form, and it needs to be converted into g values. This is done by multiplying the acceleration values by a range-dependent constant. The equation for calculating the acceleration at 8g range is:

$$a_x = value * \frac{2500}{1024} \tag{1}$$

$$a_y = value * \frac{2500}{1024} \tag{2}$$

$$a_z = value * \frac{2500}{1024} - 1 \tag{3}$$

The value of the Z axis must be subtracted with 1 to compensate the influence of gravity. After conversion of values, an object is created that contains only x values, only y values and only z values. The data is now properly grouped but needs to be separated into three separate streams: one for x values, another for y and a third for z. After separation, each individual stream has only its own specific values for each axis. Since the collection frequency is 3200 Hz, and the values arrive in a series of 10 values, it is necessary to accumulate the values until the specific number of data values is reached. The system is configured to "wait" for the arrival of 320 messages (ten data points 320 times) so that all acceleration values are grouped together. When 3200 values arrive, the flow continues to the point where RMS (root mean square value) for each axis is calculated. To calculate RMS values, the data needs to be converted to velocity; the following equation is used [17]:

$$v = \frac{9,81a}{2\pi f} \tag{4}$$

where: a – acceleration value, f – frequency.
Finally, the equation for *RMS* is:

$$RMS = \sqrt{\frac{1}{n}\sum_i x_i^2} \tag{5}$$

where: n – number of values (3200), x – acceleration values.

After calculating the *RMS* values for each axis, the values are consolidated into a single object. The final object contains the following parameters:

- RMS x - RMS value of the x axis.
- RMS y - RMS values of the y axis.
- RMS z - RMS values of the z axis.
- UID - unique sensor identifier.
- Location - the location of the sensor.
- Timestamp - timestamp.

The object thus created is further sent to the Web API and to the dashboard. Unlike acceleration workflow which has data transformation and feature extraction, temperature and air pressure flow is much simpler. After receiving data from the broker, data is converted to JavaScript object for simpler manipulation. The temperature values need to be divided by 1000 to get values in °C after which a temperature and air pressure variables are created. The data is then visualized in a dashboard and sent to the Web API. Once the data from the sensor is collected, it needs to be stored somewhere. A database is a digital way of storing data based on a relational model. Relational databases use a database management system that allows you to define, create, maintain, and control a database. The Microsoft SQL Server database management system will be used for data storage and management on the server side. To enable different clients to store and read data from the database, a Web API was created. The Web API is a server-side programming interface that operates based on a request-response system, usually expressed in JSON or XML format, and is available via the Internet, most commonly via HTTP web servers. Currently, there are various programming environments that can be used to create a Web API. The ASP.NET Core desktop environment was chosen for its simplicity, speed, and reliability. Web API also have the functionality of error handling which is useful in a case when an accelerometer, temperature sensor or air pressure sensor stop sending values. Alongside traditional relational database, which is located on the server, a separate local database was created. Local database was created with Influx DB, an open-source time series database (TSDB) optimised for storage of time series data. Local database is used as a backup in a case of network problems, so that the values are not lost because of connectivity problems.

Finally, the observed object state is assessed based on values from the sensors. By calculating the *RMS* (5) and referencing the values by ISO 10816-1, machine "health" and

state can automatically be assessed, and the user can be notified. This is one of the most important features of this IIoT system because it provides users with direct and upfront information about system state without the need for further data analysis. To achieve described functionality, an ability to visualize and interpret data is necessary. Data visualisation is achieved using a Node RED dashboard module. Dashboard module provides a set of nodes to quickly create a live data visualization based on incoming data. Dashboard contains nodes such as gauge, line chart, form input, data picker, and other common items. Dashboard is configured to contain several items:

1) ISO 10816-1 reference picture - a reference picture containing an ISO 10816-1 evaluation of machine vibration using measurements made on rotating parts.
2) Air pressure and temperature gauge - gauge displaying air pressure and temperature values.
3) Vibration parameters gauge - gauge displaying RMS values of vibration.
4) Vibration state information.
5) History of measurements - time series plot of history trends for vibration, temperature, and air pressure.

Interpretation of the data is possible due to developed logic that follows ISO 10816-1 guidance. Fig. 7 shows ISO 10816-1 machine state classification categories.

Figure 7 ISO 10816 classification [18]

Fig. 8 shows acceleration data transformation, processing and interpretation flow, which was described above.

Temperature and air pressure flow, as already mentioned, have much simpler flow, which does not include automated decision making. The idea behind including temperature and air pressure sensor is to use this information to observe abnormal behaviours. It can be assumed that temperature and air pressure values correlate i.e., when temperature increases the air pressure also increases. If the air pressure is constant, and the temperature of the system is increasing, we can assume that there is something going on in the system.
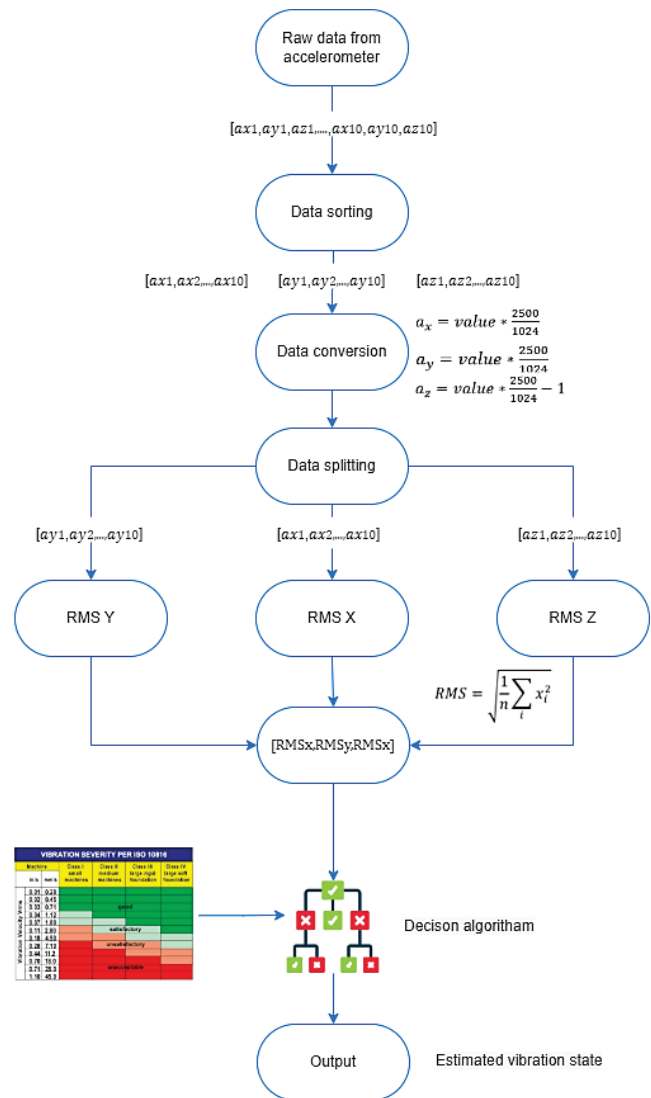
Figure 8 Decision making flow

5 SYSTEM EVALUATION AND RESULTS

To test system performance, a series of experiments have been concluded. The system performance was tested using a rotating equipment failure simulator in a laboratory condition with following states:

1) State 0 - machine down.
2) State 1 - machine up and running at 1500 rpm
3) State 2 - machine up and running at 1500 rpm with fault (eccentric rotor fault).
4) State 3 - machine running at 1500 rpm with enhanced fault (eccentric and cocked rotor fault).

Below are figures taken from dashboard for each state, followed by description. General dashboard layout can be seen on Fig. 9. This screenshot of a dashboard was taken in State 0 where the machine was down and not operating. It can be observed that vibration gauges are displaying low values, which correspond to natural environment vibration.
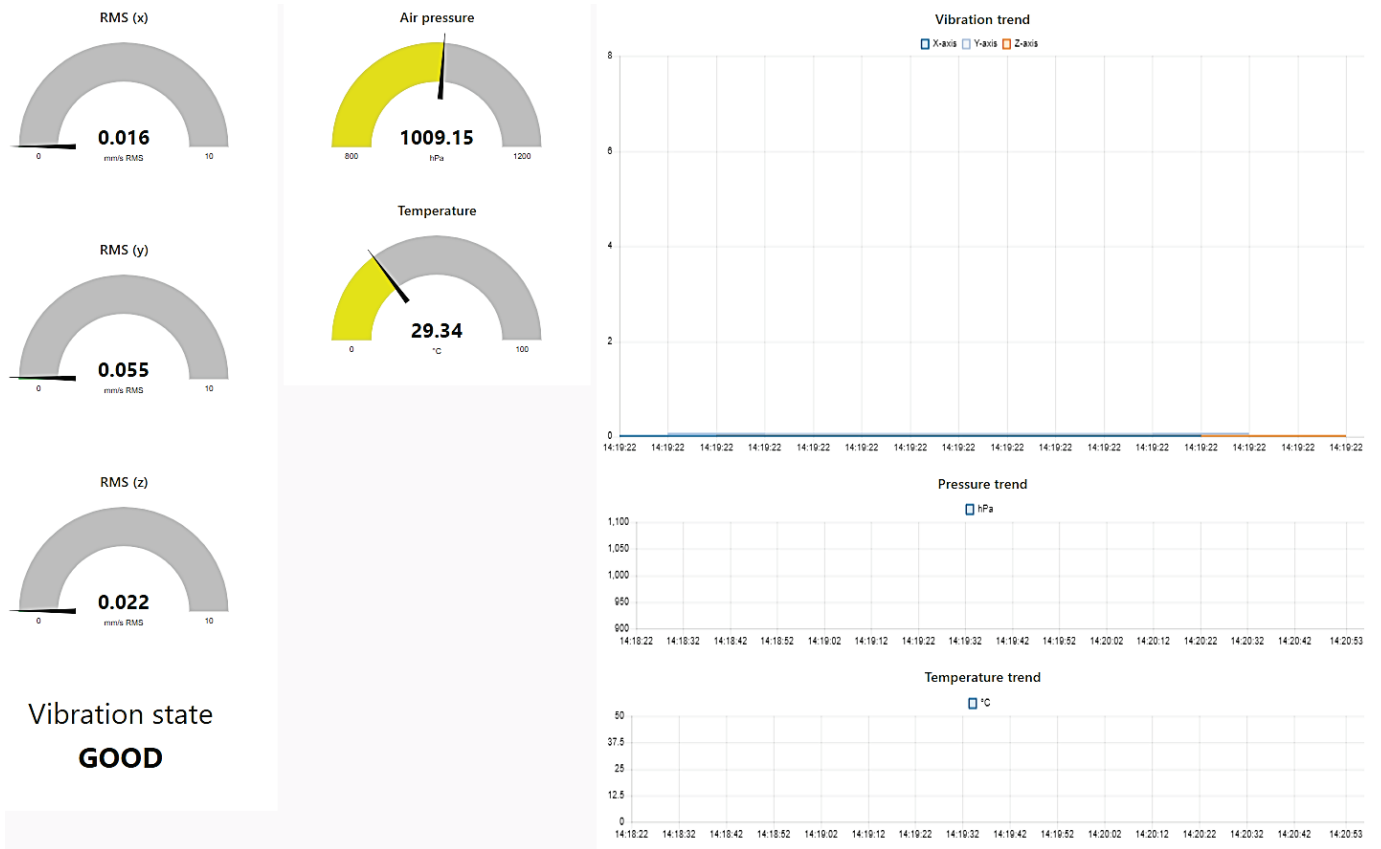
Figure 9 State 0 dashboard
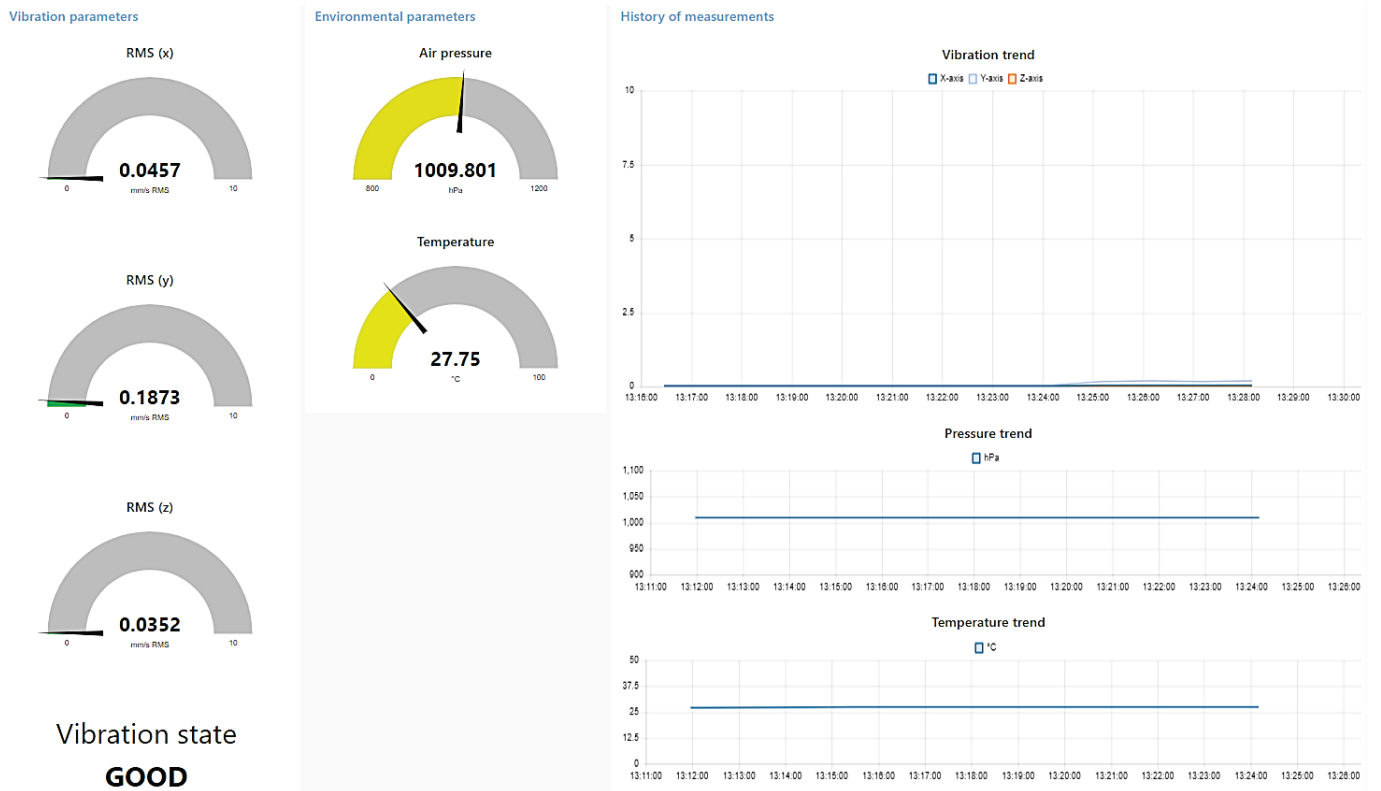
Figure 10 State 1 dashboard
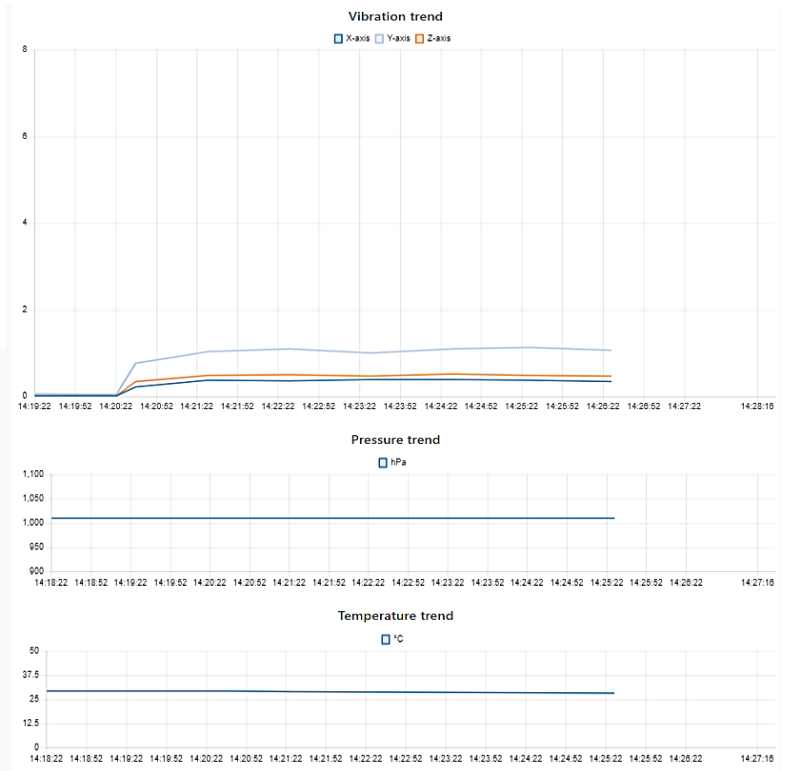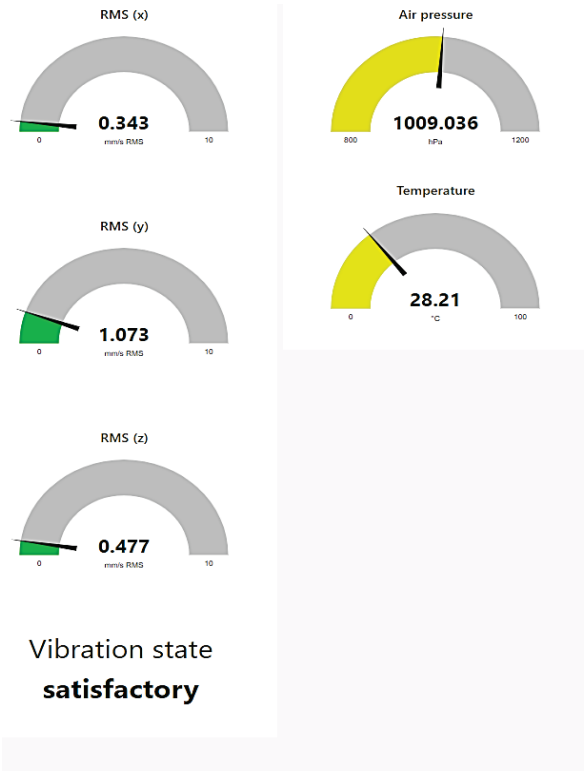
Figure 11 State 2 dashboard
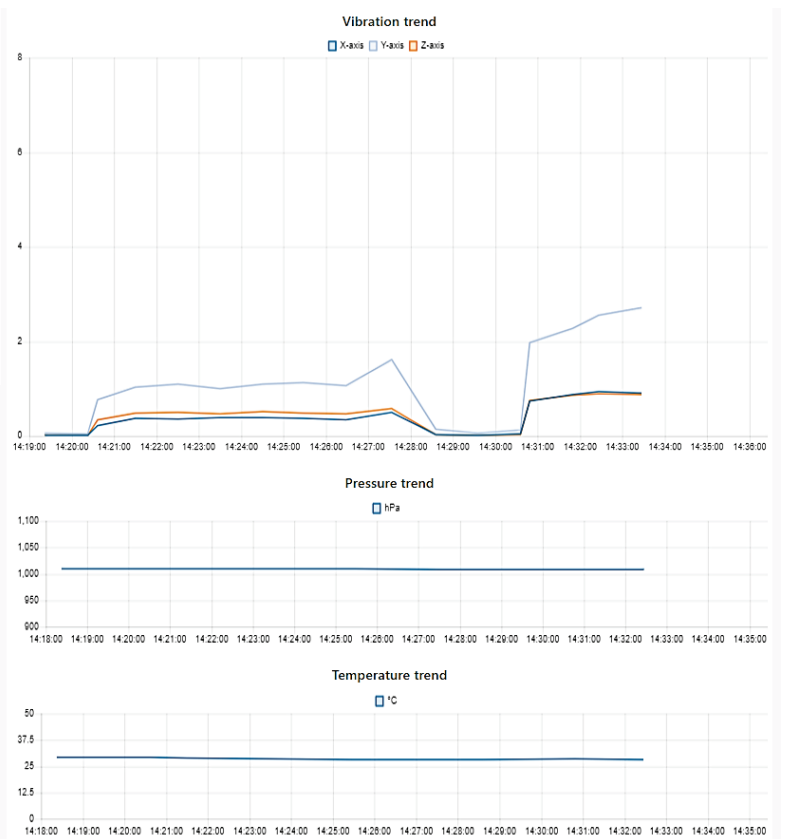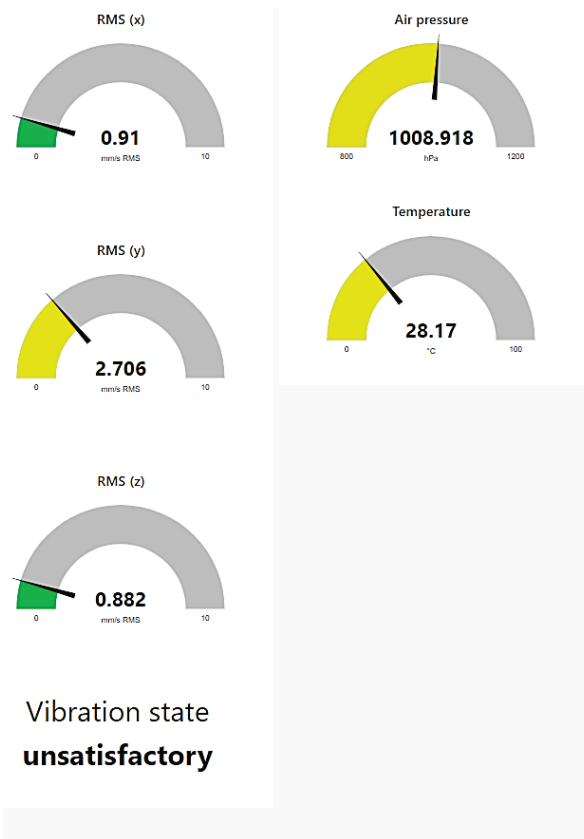
Figure 12 State 3 dashboard

Temperature and air pressure values are corresponding to the natural ambient in which the machine is located. Because the machine is not in operation, the system classifies the condition as good. In addition, on the vibration plots, nothing significant is showing up. Switching the machine on and configuring the rotational speed of 1500 rpm, the system now acts differently. Fig. 10 shows system in its natural running state - State 1.

The slight change on vibration gauges can be observed. The machine state remains good. To observe system ability to classify multiple states, major eccentric rotor fault was simulated in State 2. Fig. 11 shows the system parameters in this state.

The system classifies this state as satisfactory, which corresponds to ISO 10816-1 reference. Vibration plot is also showing significant jump from initial values. Finally, the State 3 was simulated with two simultaneous failures (major eccentric rotor fault + cocked rotor). Fig. 12 show the system dashboard in that state.

It can be observed that *RMS x*, *y* and *z* values have significantly jumped (vibration plot also increases in value) and the system classifies vibration state as unsatisfactory.

The simulated machine states gave us an important insight into system ability to successfully classify system vibration state based on ISO 10816-1 reference. As it was shown, the system successfully classified between "Good", "Satisfactory" and "Unsatisfactory" vibration states based on near real time vibration data. The system is therefore ready to be tested outside laboratory environments.

5 CONCLUSION AND FUTURE WORK

The result of this paper provides a possibility to use such IIoT system for remote data collection and automated near real time condition monitoring in a real production environment. Using low cost IIoT sensors, such as MEMS accelerometer, temperature sensor and air pressures sensor, enables a low-cost functional ability for the system to gather data about environmental parameters. Data processing and transformation was possible using developed Node RED flows, which contained functions for data transformation, feature extraction and decision-making logic. Specifically, acceleration data was used to calculate *RMS* values for each axis, which was then, compared to ISO 10816-1 reference that provides users with system state classification. The Node RED range of nodes can be expanded with additional functionalities making this program truly comprehensive in the IIOT area. By storing data locally, the system is more redundant in a case of network connectivity problems. On the server side, the Web API enabled easy, fast and reliable entry of incoming data which is then stored into a relational database.

Based on all the above, it can be concluded that the system successfully collects and interprets data in a laboratory environment. The next step in the further development of the experimental system is to test the system at a remote location to gain insight into the reliability of the system. To achieve more precise control, monitoring, and configuration of the data collection process, it is necessary to develop a web application that will serve as a control panel for the entire process which was described and configured in our previous research. Web application integration also implies necessary changes within the program logic of Node-RED and Web API, but this is not a problem since both components of the system are extremely flexible. Also, it is important to mention that the collected data can be used for multiple predictive machine learning algorithms which is a right step towards smart maintenance. The goal of the future works will be to configure the edge node to use machine learning algorithms such as Convolutional Neural Networks (CNN) directly on the edge which will enable automated prediction of faults without the need to send potentially large amount of data to the server for processing. Implementation of the machine learning model can be used to detect anomaly or classify the type of anomaly. CNN model can be trained on labeled raw vibration signal data to detect and diagnose type of anomaly and then implemented directly on edge nodes in a way that smart sensor reports only detected and diagnosed anomalies to central supervisory system. Such workflow reduces the amount of data that is interchanged between edge node and central supervisory system, consequently affects the lower energy demand and has a positive effect on network throughput. The final goal is to use this information for prescriptive maintenance decision making.

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Inspecting the Effects of Moisture Bridge on the Performance of Building and Providing Appropriate Preventive Solutions

Hayyan Ashrafi*, Behrouz Mohammad Kari

Abstract: Although many studies have investigated the effects of thermal bridges on building energy performance, multidimensional thermal humidity analysis of building coatings remains a challenge due to multiple problems such as complexity of modeling, computer analysis execution time, numerical convergence restraints, and numerous properties related to humidity. The study's main aim is to investigate the effects of moisture bridges on building performance and provide appropriate preventive solutions. In this study, thermal-humidity simulation for evaluating heat and mass transfer in walls of a historic building (building No. 4, Tehran University of Arts, The National Garden Campus) was analyzed using WUFI 2D software. This study evaluated the effectiveness of executive details used in the studied building and compared the performance with recent common details. The obtained results indicate that the information obtained from the moisture and heat audit of the building should be investigated simultaneously and the results lead to a solution to reduce the heat transfer and minimize condensation risks. Appropriate solutions have been studied, according to the conditions of each building element.

Keywords: building envelope; combined heat; humidity transfer analysis; hygrothermal problems; moisture bridge; walls

1 INTRODUCTION

The abundant water on our planet constantly leads to interactions with all living and non-living organisms, driving substances to physicochemical processes. As much as water is essential for all species, it can destroy many natural and man-made building materials and products, such as the blocks used to make building walls that are meant to serve for decades [1-3].

Thus researchers, designers, and building contractors are always trying to reduce tructive role of moisture in buildings to improve human comfort and building durability. This is while the results of this research will cause an annual reduction of billions of tomans in energy consumption. Meanwhile, the main question raised in this research is the effect of moisture transfer on the efficiency of buildings in terms of energy consumption [4, 5].

Saving energy is one of the most important and vital expectations in building and using a building. Some measures for optimizing energy consumption, such as using thermal insulation, reducing air infiltration, limiting ventilation regardless of the function of the building, and the using proper execution details, can cause moisture problems. On the other hand, moisture problems not only increase thermal problems and energy consumption, but also impose huge costs for the destruction and renovation of materials [6-9].

Exterior wall is always exposed to the influx of natural factors such as Humidity. In case of inappropriate design regardless to detailing rules and guidelines, the excessive increase of humidity can have a significant effect on reducing the thermal resistance of the wall. Moisture bridge or in other words, concentrated condensated moisture in the building envelope walls, especially in cold climates, increases heat exchange through the moisture bridge which is most of the time initiated by a thermal bridge, leading to serious damages of the wall materials, when freezing and thawing cycles occur, and causing serious problems in terms of thermal performance and durability of the building. On the other hand, accumulation of moisture in the building wall lead to the growth of fungi and mold, which causes many health problems for residents, including respiratory diseases. Therefore, it is necessary to identify and eliminate the moisture problems of the outer wall of the building, in order to protect national assets, reduce annual energy consumption and increase the useful life of the building [4, 10, 11].

Moisture bridge is a phenomenon occurring due to the condensation of moisture in the building envelope elements, such as double-glazed windows with metal prefixes, corners, thermal bridges, etc., which causes problems and damages more than rainwater infiltration in a cold climate. This phenomenon is considered one of the most essential moisture problems in the building wall, which can significantly affect the performance and durability of the outer wall and cause damage to thermal and humidity insulation. This not only imposes problems for the wall in terms of indoor health conditions (consequences of fungal and mold growth in the wall), but also has a significant negative effect on the thermal performance of the building [7, 8, 12].

Moisture bridge is an example that highlights this problem and causes the destruction of materials and increases the annual energy consumption of a building. The existence of thermal bridge in the building is one of the factors causing this phenomenon in the inner layers of the wall and consequently the formation of moisture bridge changing the heat transfer of the wall from vertical and one-dimensional state to a multidimensional one. Thus, the amount of heat transfer and energy consumption in the building also increases. In this research, by recognizing the types of condensation cases and influencing factors causing moisture bridge in building elements, we try to obtain adequate solutions to prevent condensation risk by eliminating or minimizing moisture bridge. This will lead to a better understanding of their effect on the durability and thermal performance of buildings in cold climate.

The building envelope constantly interacts with changes in indoor and outdoor temperature, pressure and humidity, leading to variable heat and mass (air and humidity) exchange between the indoor and outdoor environment. Building physicists refer to this phenomenon as "heat, air,

and moisture transfer" in building materials and components. Building envelope designers and constructors are always trying to provide optimal durable building envelope elements. In this regard, moisture is one of the most influencing factors affecting the energy balance of the building envelope elements.

Moisture bridge is a phenomenon occurring due to deep condensation in thermal bridges of the building envelope elements, such as metal prefixes of windows, structural elements at the junction of the wall with the roof and floor.
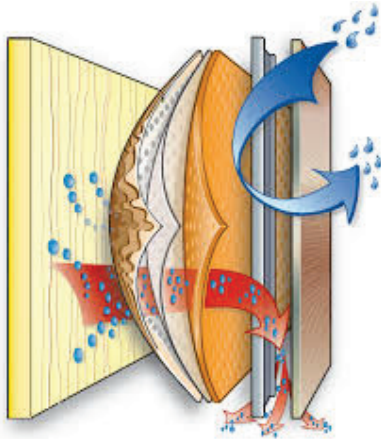
Figure 1 Simultaneous transfer of moisture and heat from the moisture bridge in the building

The formation of a moisture bridge changes the heat transfer of the wall from vertical and one-dimensional state to multidimensional state. Hence, the rate of heat transfer and consequently energy consumption in the building also increases [3]. It is very important to note that in these points, moisture and heat transfer takes place simultaneously (Fig. 1). Generally, the factors affecting moisture problems such as moisture bridge, can be mentioned as follows:

- Hgrothermal (hyumidity and thermal) properties of wall materials
- Climate and hgrothermal conditioning of the interior spaces (with HVAC systems), acting as driving forces on either side of the wall
- Thermal properties of outer and inner surfaces of the wall
- Design of executive details of the wall and its thermal insulation
- Locating the interior spaces of a building (building architecture) [4]

In cold climates, the main moisture concerns are originated from rainwater infiltration, groundwater, deep condensation (condensation in building components), and inner space fungus and mold, which are often associated with high levels of inner humidity.

In this research, after the identification of moisture damage, such as moisture bridge, calculations are formulated, in order to provide appropriate solutions to reduce the above-mentioned damages and improve the humidity-thermal behavior of the external wall of the building.

2 LITERATURE REVIEW

In order to analyze the effects of thermal bridges on building energy performance, some researchers in the 1990s - such as Hagentoft and Claesson [2], Anderson [1], Karti and Blomberg [12] - considered heat loss to the ground, and the effect of peripheral insulation on conventional slab foundations on degree, but no moisture transfer was considered. Narowski et al. [10] described a simple method that enables the modeling of conduction transfer functions for conventional thermal bridges. The aim of the present study is to improve the building energy calculation results obtained from dynamic simulations by combining thermal bridge correction factors in building simulation codes. Al-Sanea and Zadan [11] used a computer model based on the finite volume method in order to quantify the effects of mortar joint height on the thermal performance of building walls under stable two-dimensional periodic conditions. Also Blomberg [12] conducted a study on moisture bridge in the outer wall in 2014. In this study, the location of thermal insulation in different layers has been optimized according to the moisture status of the wall. In the results, the best place for insulation of the inner part of the wall is obtained, while it has many problems in terms of moisture. In order to solve this problem, they suggested the use of silica aerogel in the outer layers, without suggestions related to the durability problems of this gel. In 2012, Häkkinen [6] conducted a study on how to renovate and improve the exterior walls of buildings in Europe and provided a comprehensive solution according to meeting expectations such as modern European standards, annual energy savings, increasing the life span of the building, economic justification of investment payback time. This approach, which is called SUSREF (Sustainable Renovation), ultimately leads to the provision of executive details and suitable materials for a wall that is validated by humidity-thermal simulation [6].

However, there is only a few studies on the effects of humidity on thermal bridges. Therefore, mass transfer in porous media is assumed to be unsaturated and solved using the matrix algorithm MultiTriDiagonal; problems related to numerical instability are avoided by introducing a strong coupling between the energy and mass conservation equations. In the results section, the multidimensional transfer effect in the lower hot-humidity stairs consisting of soil, wall and floor is shown and analyzed in terms of temperature and relative humidity profiles and steam and heat flux in the floor for different foot configurations. For the upper corner, the effects of concrete beams on temperature and relative humidity profiles are presented.

3 METHODOLOGY

The Research prerequisites have been met through field and library studies, using existing databases, as well as observation, photography, and computer simulations. According to the criteria obtained in the theoretical framework, identification of the moisture cases and problems and provision of solutions in various areas are performed; Afterwards, the technical evaluation and validation of best

solutions are made by WUFI 2D software, using descriptive statistical methods and logical reasoning.

According to the computational method used in this software, all modes of moisture transfer, including the transfer in gas and liquid phases are investigated. Also, temperature conditions and thermal resistance are simultaneously calculated in each detailed layer of the wall. Due to fluctuations in relative humidity and the ambient temperature inside and outside the building elements, humidity may be long-lasting and vary depending on the type of materials used and their physical characteristics.

Another effective feature of this software is to the possibility of evaluating the moisture storage capacity, by taking into consideration the capillary property of various used materials. Moisture transfer speed is much less than heat transfer time; therefore, the occurrence of condensation at high partial vapor pressure is associated with an increase in ambient temperature and humidity levels. In WUFI software, the boundary conditions on both sides of the wall can be considered dynamic; in another term, the daily and seasonal temperature and humidity fluctuations can be taken into account as dynamic driving forces. For this purpose, in the computational model, building elements are divided into finer layers (meshing). In this case, the nonlinear distribution of temperature and humidity in different layers of a building element can be investigated more precisely. The computational algorithm of this software is briefly described in the Fig. 2.
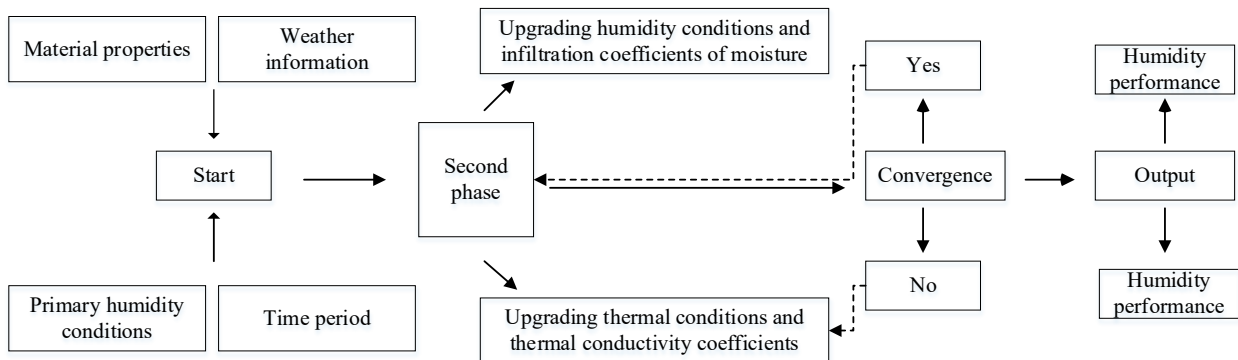
Figure 2 Computational algorithm of WUFI software [13]

To provide appropriate solutions to prevent humidity bridges, Tehran climatic conditions are taken into consideration. Due to the lack of rainfall information in the weather data file of this city, Las Vegas, NV in North America was substituted by similitude to Tehran, in terms of latitude, altitude, temperature, humidity, and annual rainfall information (Fig. 3).
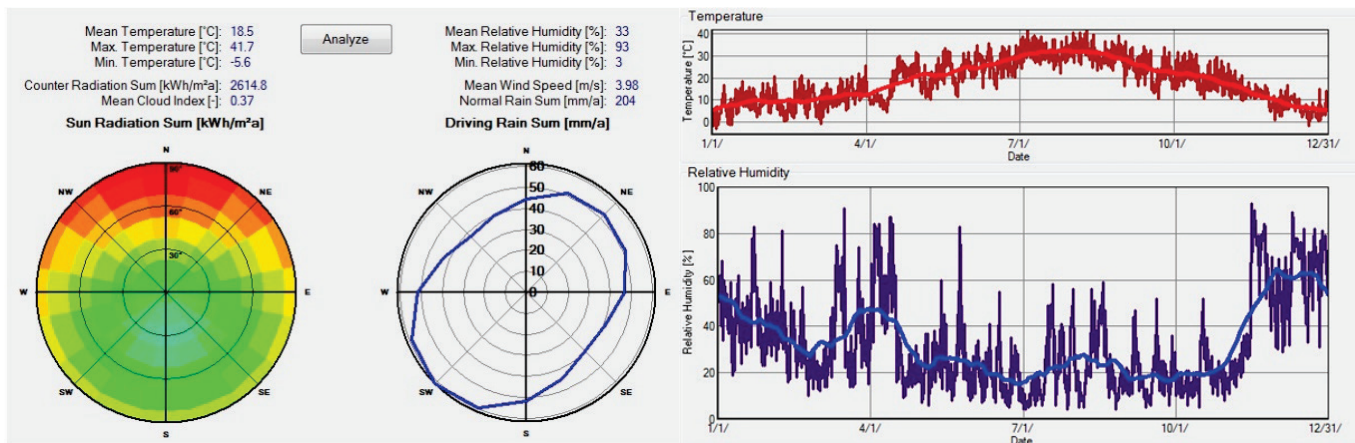
Figure 3 Climate information of Las Vegas, NV [13]

3.1 Data Analysis

Data of the walls of an educational building in Tehran has been analyzed based on the following equations. Given the higher temperature fluctuations in the south-oriented facades, this orientation will contain the most critical humidity-thermal hazards; For this reason, south-oriented walls have been simulated. The internal thermal humidity is considered in accordance with the previous cases and EN15026 standard. Which include:

Outer boundary conditions simulated in WUFI software: surface thermal conductivity coefficient = 17 W/(m^{2}K), short-wavelength radiation absorption coefficient and long-wavelength radiation emission coefficient based on outer materials, rain adhesion coefficient to surfaces 0.7.

Internal boundary conditions simulated in WUFI software: Surface thermal conductivity coefficient = W/(m²K).

Internal temperature and humidity conditions: Internal conditions in all models are considered according to EN15026 standard with humidity and thermal information according to the following figure (Fig. 4).
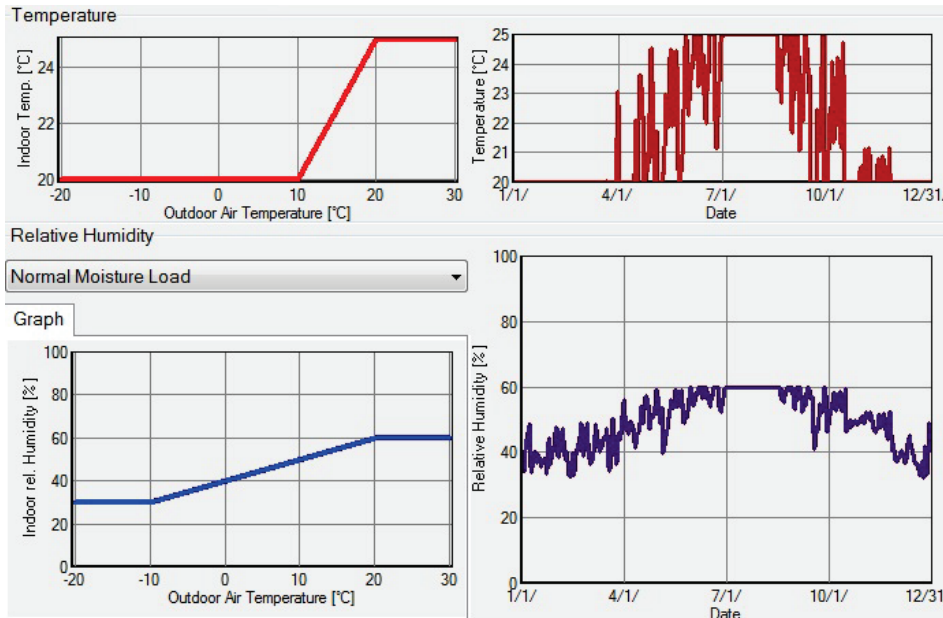
Figure 4 Upper right, internal temperature conditions based on time - upper left, internal temperature conditions based on outside temperature - lower right, relative internal humidity conditions based on date - lower left, internal humidity conditions based on outside temperature [13]
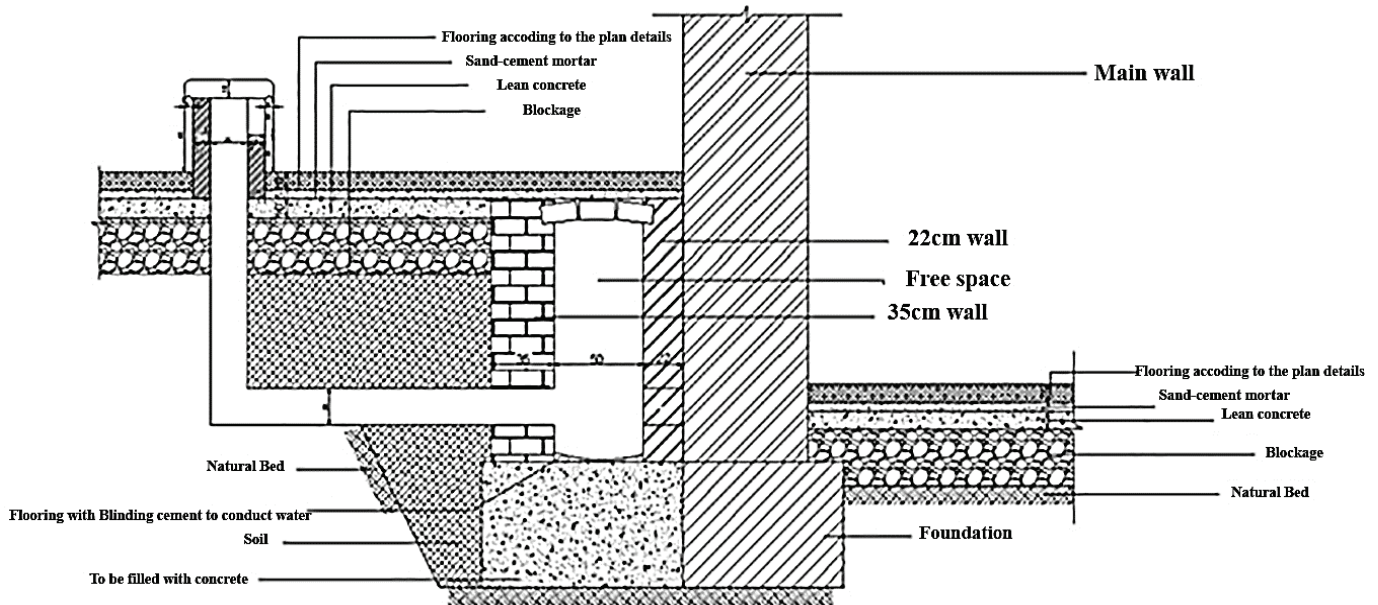
Figure 5 Executive details of the building No. 4, University of Arts, Garden Campus (Technical Department and Supervision of Development Plans of the University of Arts)

The executive details of the basement wall of building No. 4, University of Arts, National Garden Campus are as follows (Fig. 5).

According to the current situation, the drainage channel has not been fully implemented. The following images show the current status (Fig. 6).

According to the current situation, the simulation was performed in two configurations. In the first mode, the drainage channel was simulated in accordance with the current situation (Fig. 6), contiguous to the wall; In the second configuration, the outer channel was modeled, in full compliance with the executive details of the plan approved by the University of Arts.

Figure 6 Images of the construction of building No. 4, University of Arts, National garden Campus, Source: (Technical Department and Supervision of Development Plans of the University of Arts) 1400

3.2 First Configuration

As shown in Fig. 7, the wall layers consist of 350 mm brick (1), 500 mm non-ventilated air layer (2), 220 mm brick (3), 700 mm brick wall (4), and floor layers, respectively, 20 mm of stone (1), 50 mm of sand-cement mortar (2), 100 mm lean concrete (3), 300 mm blockage (4 and 5) and rammed earth (5), outer floor layers respectively, floor bricks 100 mm (a), cement-sand mortar 50 mm (b), lean concrete 100 mm (c) 400 mm blockage (d), rammed earth, concrete under humidity absorbent layer (f), grass table (g).
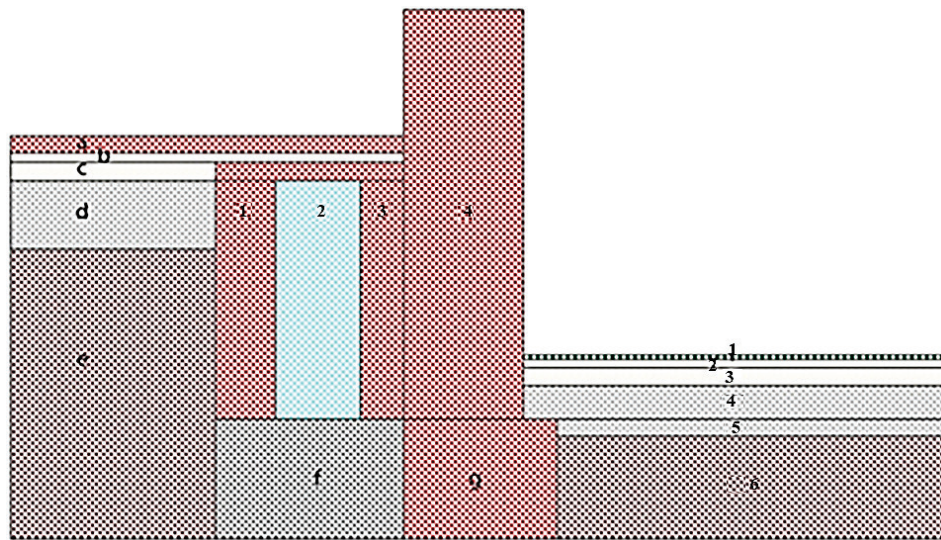
Figure 7 Simulated Executive Details Mode 1, University of the Arts, National Garden Campus, Building No. 4, Current Status (Author)

The above executive details have been simulated for a year in the conditions mentioned earlier. The most critical point during the design year is at 2 o'clock in the morning on April 2, for which surface and internal temperature and humidity (water content) of the wall layers are proof investigated.

Fig. 8 shows the temperature of the different layers of the intersection of the inside and outside floor with the basement wall. All levels at the beginning and end of each layer are numbered according to the executive details. According to the selected time and the outside air temperature, integrated temperature conditions are observed. The obtained results indicate that due to the high thermal inertia, the executive details of the above temperature fluctuations are low in day and night and the temperature of each layer is not much different from the other layers. It was observed that during the one-year simulation period, due to the proximity to the soil at a depth lower than the freezing point, temperature fluctuations below the floor on the soil are neglectable. Considering that the executive details are related to the construction period of the building, thermal insulation has not been used in the renovation of this building. Although this indicates an increase in energy consumption at first glance, the simulations show that due to the excessive thickness of the wall and the use of an air layer, heat transfer through the wall is greatly reduced (Fig. 9).

According to the temperature study of the surfaces in the previous diagram, it is quite clear that the relative humidity at levels 2 and 3 of the inner floor, b and c of the outer floor and all wall surfaces is at its highest. The layer under the

drainage channel (layer f) has a high relative humidity during construction due to the water in the concrete. The high moisture content of this layer increases the relative humidity in the wall layers. Layer No. 2 of the inner floor (cement-sand mortar) is also causing similar problem in the inner part.
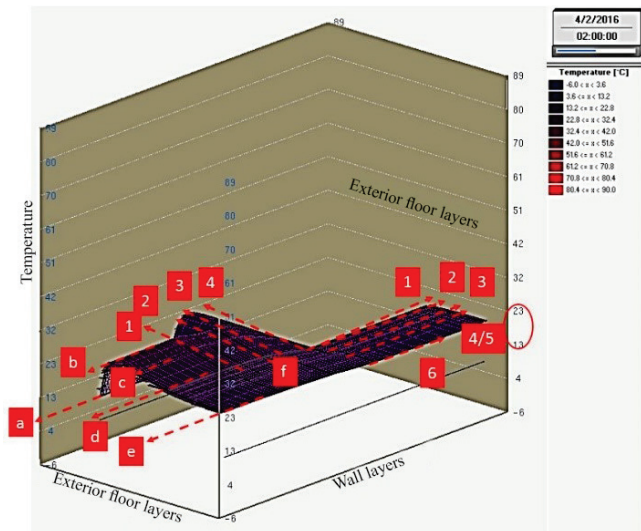
Figure 8 Temperature of floor and wall layers at 2 o'clock in the morning, April 2, Mode 1, University of Arts, National Garden Campus, Building No. 4, Current status (Author)
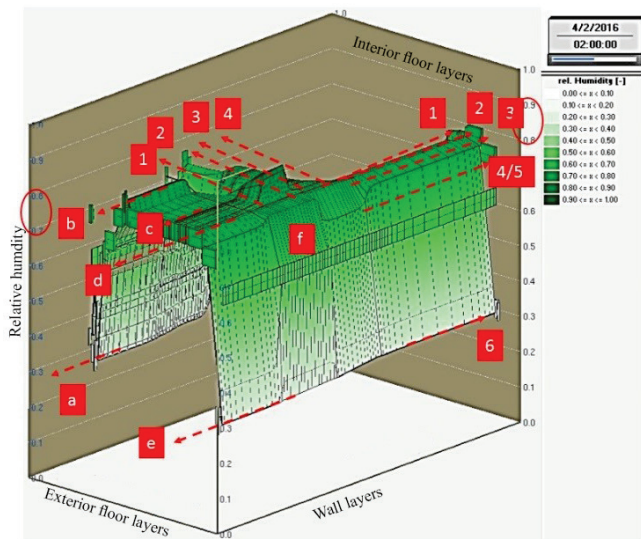
Figure 9 Relative humidity of floor and wall at 2 o'clock in the morning, April 2, Mode 1, University of Arts, National Garden Campus, Building No. 4, Current status (Author)

As shown in Fig. 10, layers 3 and 4 of the wall, layers 1 and 2 of the inner floor and layer f are in critical moisture conditions. The high water content in layer 3 and 4 of the wall is about 29 kg / m3 and also in layer 1 and 2 of the floor due to the water used in the mortar in layer 2 and the high water absorption of (about 42 kg/m^3), layer f (Concrete) with 94 kg/m^{3}will not have the possibility to dry due to the adjacent layers being high. In addition, the trapped air layer, due to lack of proper ventilation, cannot have the expected functionality and drain the moisture trapped in this layer. For this reason, the water content of layer f diffuses through the

wall layers. Due to the high water content of layer 2 of the inner floor (cement-sand mortar), dry floor technics instead of wet methods are more appropriate.
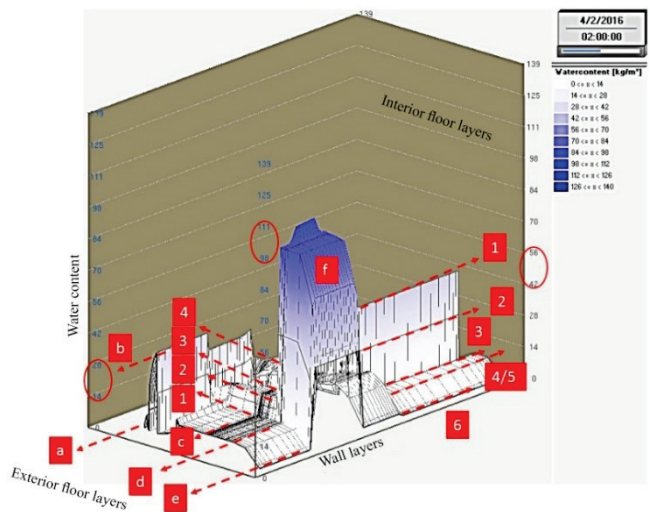
Figure 10 Floor and wall water content at 2 am, April 2, Mode 1, University of Arts, National Garden Campus, Building No. 4, Current status (Author)

3.3 Second Mode

As shown in Fig. 11, the wall layers consist of 350 mm brick (1), 500 mm non-ventilated air layer (2), 220 mm brick (3), 700 mm brick wall (4), and floor layers, respectively, 20 mm of stone (1), 50 mm of sand-cement mortar (2), 100 mm lean concrete (3), 300 mm blockage (4 and 5) and rammed earth (5); The outer floor layers consist of floor bricks 100 mm (a), cement-sand mortar 50 mm (b), lean concrete 100 mm (c) 400 mm blockage (d), rammed earth, concrete under humidity absorbent layer (f), grass table (g). It is also modeled for humidity absorbent output the same as executive details of the stone cap.

The above executive details have been simulated for a year in the conditions mentioned earlier. The most critical point during the year occurs at 2:00 AM on April 2. The ambient temperature and relative humidity, the temperature and water content of the wall layers are investigated. It should be noted that all simulation conditions are in accordance with mode 1.

Fig. 12 shows the temperature of the different layers of the intersection of the inside and outside floor with the basement wall. All levels at the beginning and end of each layer are numbered in accordance with the executive details. According to the selected time and the outside air temperature, integrated temperature conditions are observed. The obtained results show that due to the high thermal inertia, the executive details of the daily temperature fluctuations are low and the temperature of each layer is not much different from the other layers. It was observed that during the one-year simulation period, due to the proximity to the soil at a depth lower than the glacier, temperature fluctuations below the floor on the soil are minimized. The state of the layers is very similar to the previous mode. During some cold winter hours, the draining channel was observed to be colder than mode 1, which did not affect the temperature of the inner layers.
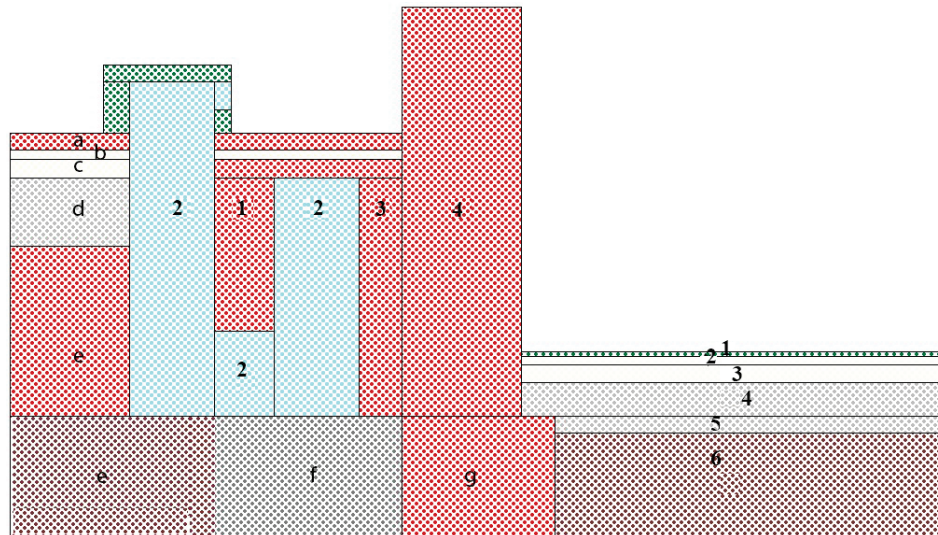
Figure 11 Simulated Executive Details of Mode 2, University of the Arts, National Garden Campus, Building No. 4, Approved Design (Author)
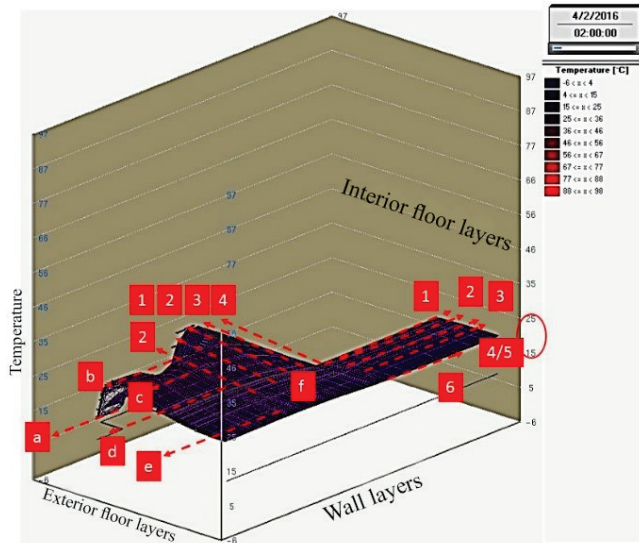
Figure 12 Temperature of studied floor and wall layers at 2 o'clock in the morning, April 2 (Author)
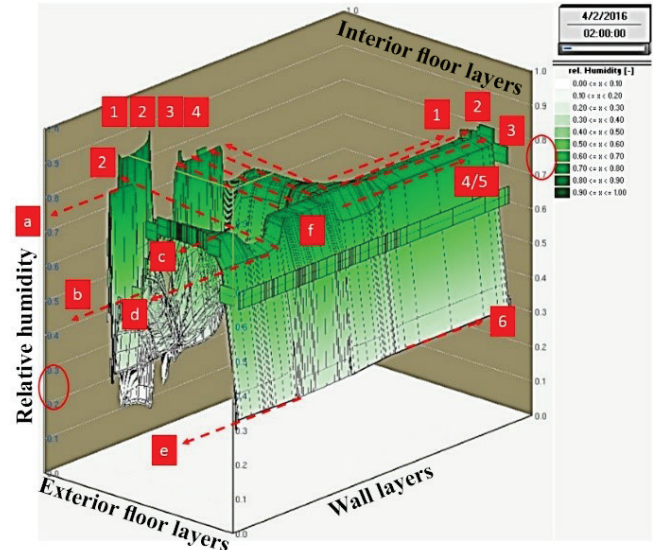
Figure 13 Relative humidity of floor and wall at 2 o'clock in the morning, April 2, Mode 2, (Author)

According to the above (Fig. 13), there is a significant decrease in relative humidity in the wall layers compared to the previous mode. This phenomenon is due to the connection of the draining channel with the outside air and the establishment of ventilation. In mode 1, the air layer adjacent to the basement wall is unventilated and trapped, which prevents moisture from draining and consequently diffuses to the inner layers. In this mode, with the ventilation of the air layer, not only the relative humidity in layers 3 and 4 of the wall is reduced, but also the relative humidity of layer f (humidity absorbent floor) is dimmed. Also, similar to mode number 1, the use of cement-sand plaster in the interior has increased the relative humidity in the interior flooring layers.

As shown in Fig. 14, there is a decrease in water content in layers 1, 2, 3 and 4 of the wall, layers 1 and 2 of the inner floor and layer f. As illustrated above, the water content in layer 3 and 4 of the wall is about 12 kg/m^3 and also in layers 1 and 2 of the floor due to the water used in the mortar in layer 2 and due to the high absorption of moisture by the stone is about Is 39 kg/m^3, both of which are reduced compared to mode 1, layer f (concrete) with 84 kg of water per cubic meter, the water content is also reduced by 10 kg per cubic meter compared to the previous mode, this phenomenon is due to the connection of the humidity absorbent with the air layer adjacent to the wall. Given the high water content in layer 2 of the inner floor (cement-sand mortar), it is recommended to use dry floor execution technics instead of the current wet method. It also seems that there are more suitable concrete options for the draining channel flooring material.
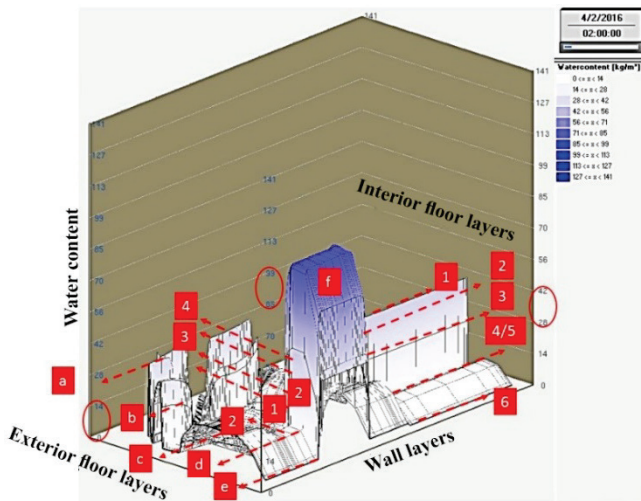
Figure 14 Floor and wall water content at 2 am, April 2, mode 2, (Author)

In the following step of this research, we will examine the chart of relative humidity and water content in the fifth year after execution. In order to achieve this information, the simulation was performed with previous information and in accordance with the approved executive details for 5 consecutive years, and comparative information at the same time and day is provided below.

Figure 15 Relative humidity of floor and wall at 2 am, April 2, Mode 3 (Author)

3.4 Third Mode (Fifth Year after Execution)

As shown in Fig. 15, the decrease in relative humidity of all wall layers and draining channel floor layer (f) is remarkable; Relative humidity has been reduced by up to 20% in the inner floor layers and up to 30% in the wall layers. This result indicates the proper functioning of the draining channel.

According to Fig. 16, there is a decrease in water content in layers 1, 2, 3 and 4 of the wall, layers 1 and 2 of the inner floor and layer f. The water content in layer 3 and 4 of the wall is about 3 kg/m³ and also in layer 1 and 2 of the floor

due to the water used in the mortar in layer 2 and due to the high absorption of moisture by the stone is about 30 kg/m³; Compared to mode number 1, remarkable decrease is observed in wall and layer f (concrete) with 75 kg of water per cubic meter is also reduced in water content by 9 kg per cubic meter compared to the previous mode. This phenomenon is due to the proper functioning of the draining channel and the proper ventilation of the humidity absorbent channel.

Figure 16 Water content of floor and wall at 2 am, April 2, Mode 3 (Author)

4 CONCLUSION

In this study, thermal-humidity simulations for evaluating heat and mass transfer in walls of a historic building were analyzed using WUFI software. This study was conducted to evaluate the effectiveness of executive details used the studied building and to compare the performance with recent standard details.

After simulating each detail, the problematic cases and critical points were identified, and finally, the thermal-humidity audit was performed according to the principles and logic of executive details. The simulation results related to configurations before and after the audit are compared. The most appropriate executive detail is selected based on simulation results for a general wall section (from the roof to the foundation). Appropriate solutions have been studied according to the conditions of each building element. Based on the results, the following general results can be formulated:

- Regardless of humidity conditions, thermal audit not only does not reduce the problems of the building but can also lead to humidity problems.
- The information obtained from the humidity and thermal audit of the building should be checked simultaneously and the results will lead to a solution to improve the thermal and humidity conditions.
- Proper and ventilated air gap is always effective in reducing the relative humidity of the wall and floor on the ground.

- Dry execution technics will always dim the condensation risks, compared to the situation with wet execution, due to the reduction of the water content of materials.
- The presence of proper thermal insulation is effective in reducing moisture problems when adequate executive details are used. Also, thermal bridges always play a role in increasing humidity problems and lead to the formation of moisture bridges.
- The presence of moisture bridges in the building causes internal cold surfaces during the cold period and increases heat transfer.
- The hydrophobic layer added on the outer side of the building envelope element has a positive effect in reducing moisture problems.
- The presence of the vapor barrier layer in the right place reduces the moisture problems of the building and protects the thermal insulation.

In the executive details related to the intersection of an intermediate floor with the external wall, the use of external insulation is always suggested. This will reduce the thermal bridge and limit the thermal-humidity problems of the building.

Finally, the existing case study of the basement wall of this historic building has shown that the study of moisture problems, before making decisions related to renovation can minimize eventual problems that can occur when existing draining technics, such as ventilated canals are eliminated by mistake.

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Analysis of Economic-Physical Resilience of Cities: Islamshahr City, Iran

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Abstract: Resilience is a new approach to assessing and enhancing the resilience and resilience of the foundations of development in cities. Explaining and recognizing its effective and promotional components can pave the way for many programs related to crisis management and passive urban defense, which is very necessary given the complexities of today's threats. Different dimensions of human society resilience are examined in the physical, social, economic, environmental-institutional fields. In fact, resilience as a framework goes back to a concept that can easily relate to all stages and sections of disaster and crisis management. In this regard, the present study has been compiled with the aim of evaluating the dimensions of economic-physical resilience of cities around the metropolis of Tehran in the Islamshahr region. In this study, first through library studies, indicators and factors affecting economic and institutional resilience were identified and operational defined, then using a questionnaire in the form of hierarchical analysis process, the final weight of indicators by domestic experts and External was determined. Descriptive and inferential statistics (one-sample t-test and Friedman test) were used to analyze the data. Institutional resilience with an average of 2.5325, infrastructure resilience with an average of 2.4377 and urban resilience with an average of 2.3786 is therefore urban resilience and components of urban resilience in Islamshahr city are at a low level.

Keywords: economic resilience; institutional resilience; Islamshahr; metropolis

1 INTRODUCTION

Today, cities as the most dynamic residential areas are facing development and its dimensions and components [1]. Despite the acceleration of innovation and efforts for development and excellence, these places face numerous infrastructural and structural damages and challenges. These damages can cause threats and crises to cities in various ways in the process of urban development [2]. The mentioned damages in both human and natural parts can cause a crisis in the ability to live in cities and disrupt the living conditions in these places. On the other hand, the disasters that have occurred in recent years in cities and the complexity of its dimensions and aspects indicate an increase in vulnerability and dangers posed by these threats in cities [3]. Therefore, in this regard, having new and confronting attitudes towards threats and presenting strategic measures is essential. What is presented today as an inclusive and planned concept for cities and urban structures to be exposed to human and natural threats is the concept of resilience [4]. In the first understanding of the concept of resilience, it can be introduced as a process in the face of disorders, surprises and changes [5]. Researchers believe that there are two types of strategies in cities today to deal with the threats and damage caused by them. Predictive strategies and strategies related to resilience [6].

The concept of resilience was first proposed by Halling in 1319 in the field of ecology. According to Halling, resilience is defined as the way to understand the dynamic and nonlinear pressures absorbed in the ecosystem and the amount of perturbation that the ecosystem can absorb and maintain without major structural changes. Has been. With the introduction of resilience into urban planning and crisis management as a cultural birth, some refer to it as a new model in urban development [1]. Since 2010, the movement of resilient cities. Globalization has begun to take effective steps to improve the resilience of cities, and currently 2,500 cities are members of this movement. The last principles considered in the urban movement are resilience, organization and integration of urban management, and government attention to urban resilience, risk assessment and risk identification, and the use of financial capacity and sustainable income to increase urban resilience [5].

The main issue in urban resilience is prevention. Urban resilience management in each city requires its own definition, which is based on a deep understanding of the inherent and natural features of the city. In this definition, it is also necessary to know the biological features in different urban areas and neighborhoods separately, which based on each of the types of urban context, specific policies of urban management in the field of financing are explained and specified [5]. Resilience makes sense in the face of crisis, both in metropolitan and small cities. When talking about crises in cities, the general public refers to natural disasters such as floods, hurricanes, earthquakes or fires; But it should be noted that the main problem of Iran's metropolises is not only natural crises; It is also a crisis of human origin that can lead to a natural crisis, such as air pollution or climate change, which, with its human roots, is considered an environmental crisis. Resilient cities are ready to respond quickly in unexpected situations and continue to operate despite difficult conditions. The city of resilience in the long run requires the ability to return to its pre-crisis state and the ability to make subtle and flexible changes over time and the development of the city [7]. In general, a city is resilient, durable, adaptable, stable and strong. All of these characteristics must be seen in four dimensions: social, economic, institutional, and physical.

The social dimension shows the difference in social capacity between societies. In fact, the capacity of social groups and communities to recover after a crisis or respond positively to disasters, and indicators such as social capital, awareness, knowledge, Includes skills and attitudes. In the economic dimension, resilience is defined as the inherent response and adaptation of individuals and communities to risks that enable them to mitigate the potential harms of risks.

In economic activities, resilience addresses the need for the economic system to support the system to maintain stability and balance after accidents and crises, and its indicators are the capacity to compensate, the ability to return to working conditions and a decent income and intensity. Damages. The institutional dimension contains features related to risk reduction, planning and experience of previous accidents. Here, resilience is influenced by the capacity of communities to reduce risk, the employment of local people in reducing risk to establish organizational links, and the improvement and protection of social systems in a community. Institutional dimension indicators are context, relationships and performance. The physical dimension of the environment includes infrastructure facilities, superstructures, and environmental features, and assesses community response and post-crisis recovery capacity. In the physical dimension, in addition to the existence of suitable conditions for after the crisis, principles for the design of the body and the environment before the crisis are discussed. Indicators of environmental physical dimension are the condition of green and open spaces, land use suitability, land (bed), building resistance, accessibility and density [8].

In line with the importance of resilience in urban issues and with the approach of different systems, limited experimental studies have been conducted inside and outside Iran, including: [9] in a study entitled How survivors of the 2011 earthquake in Van, Turkey Understood social? Qualitative research method showed that resilience as providing fair distribution of timely services and good governance, financial resources, also contributes to awareness, preparedness and social solidarity before the earthquake. In [10] showed that the most important factor in promoting capital economic resilience, putting on individual industries in the region. In [11], through a semi-structured interview showed that the role of indigenous institutions after disasters It can be a lever to help create more resilient communities. In [12] in a study entitled Institutional Response to Development Pressures: Resilience of Social Systems and Ecology in Himachal Pradesh, India, using a semi-structured interview research method, showed areas where capacity building for resilience Ecological social is needed, helps to create sustainable development. In [13] showed that there is a significant relationship between resilience variables (social sense, self-efficacy, coping style, and social support) and psychological vulnerability. There was also no significant relationship between the dimensions of resilience and social sense.

In [14] by using comparative descriptive-analytical research method showed that among the different dimensions of resilience, Qazvin urban complex in terms of institutional dimensions and then The physical dimensions are more unfavorable. In [16] they have the most importance and institutional performance index and return ability index in terms of importance in average conditions and institutional context indicators and institutional relations are less important. In [17] explaining and evaluating the components of institutional resilience and Social in spontaneous settlements; Naysar Urban Detached Area; The results of the study indicate very low degrees of institutional and social

resilience of this settlement compared to the optimal level of these criteria. In [18] assessing the resilience of Tehran metropolitan area 12 against natural hazards showed that the environmental sustainability component (20.33) related to the ecological dimension of urban resilience is in the first place and the system adaptability component (10.11) related to the institutional (organizational) dimension has been identified as the least important component. Also, the situation of the economic dimension of urban resilience in the face of natural hazards of quantitative (poor) desirability, the situation of social, ecological and institutional (organizational) dimensions is associated with very poor desirability. Finally, it can be stated that the desirability of urban resilience in the 12th metropolitan area of Tehran against natural hazards has been very weak with respect to all dimensions and components and therefore this area is not resilient and sustainable against natural hazards. The study of [19] showed that among the components of resilience, infrastructure resilience has more priority than other components and that all economic, social, infrastructural, physical and managerial components have a positive effect on the realization of urban resilience and are meaningful. In [19] explaining the relationship between formal form and disaster resilience in Tehran metropolitan areas indicates that different components of formal form have different effects on different resilience factors and in some cases, have had opposite behavior on the components of resilience. Among the dimensions of resilience, community resilience does not take any effect from the components of urban form. The highest correlation is observed between the density component and infrastructure resilience. The social dimension and total resilience had the most to do with the component access component. In general, the direct relationship between the components of access to public transportation and access to parts and the inverse relationship of the components of access to commercial centers and the amount of open and green space with resilience and its dimensions, shows the effect of form components on increasing or decreasing disaster resilience.

Finally, it can be said that the city of Tehran, due to its influential political and economic situation in the country, has special conditions in terms of crisis management in terms of the impact of natural disasters and the organizational and legal structure to deal with them. Accordingly, in recent decades, the risk of major cities in Iran, especially Tehran, against accidents and accidents has increased. Accordingly, this study examines the relationship between urban resilience and the risk of natural disasters such as floods and earthquakes, identifies the indicators and factors affecting economic and institutional resilience. Measures the degree of economic and institutional resilience in the studied neighborhoods.

2 THEORETICAL FOUNDATIONS

In the dictionary, urban resilience means elasticity, reversibility and resilience. Resilience has its roots in physics and means jumping backwards. In fact, resilient people are able to jump back. They have the ability to survive and even

overcome adversity. Resilience can help a person overcome adversity successfully and improve his or her social, educational, and professional competence despite being exposed to intense stress. Resilience is a trait that varies from person to person and can grow or decrease over time. Resilience means the ability to cope with difficult situations and to respond flexibly to the pressures of daily life. Resilience does not limit stress, it does not clear the problems of life, but it gives people the power to face the problems ahead, overcome difficulties and move with the flow of life. Some people have this trait naturally, but the point is that this trait is not exclusive to a few, and experts say that other people are able to learn and improve resilience; thus, resilience is the ability or consequence of successful adaptation to stressful and challenging situations [8]. Since resilience encompasses all sectors and urban considerations, the dimensions defined for it are also considered in all social, economic, physical, and planning dimensions, which are briefly addressed to each one of them is paid.

2.1 Economic Resilience

Resilience in economics is the inherent response and adaptation of individuals and societies to risks; to enable them to reduce potential damages and losses. Due to the wide interconnectedness at the macroeconomic level, economic resilience depends not only on the job capacity of individuals but also on the capacity of all institutions [17].

Economic resilience is also defined as the ability of a society to adapt socially and economically to natural hazards. This resilience has two components: the capacity of society to return to pre-accident economic conditions and the second is the capacity of societies to reduce the risk of future accidents and hazards, both in response to the disaster that society has experienced and before [6]. Therefore, economic resilience to the extent and extent of the damage, the capacity or ability to compensate for the damage and the ability to return to suitable employment and income, the amount of household capital and income convertible into capital and employment, housing status, access to financial services, Insurance, low costs, and the ability to resume household economic activity after an accident are assessed. This increases or decreases economic stability, especially livelihood stability at the community level.

2.2 Social Resilience

The second indicator of resilience is the social dimension, which is obtained from the difference in social capacity between societies. This dimension has economic, political, judicial, institutional and social dimensions at its heart. A resilient community is able to respond positively to change or stress. It can also maintain its core functions as a whole despite the tensions that exist. The social resilience approach is a way of understanding the dynamic systems that relate to the interactions between people and the environment. Social resilience is a useful perspective for understanding management decisions and changes related to natural resources. In particular, social resilience is known for

having three characteristics that include the ways in which people respond to unforeseen events. These three aspects are: resilience, recovery and social creativity that has a high resilience that has the capacity to display all three characteristics mentioned above. The concept of social resilience itself has the same concerns as the concept of resilience and is also particularly complex due to differences in the definition of society. For example, a community is an entity that shares geographical boundaries and a common destiny. Communities are made up of built-in natural, social, and economic environments that interact in complex ways. Just as resilience can be analyzed and understood at different levels, social resilience also has levels [9].

2.3 Institutional Resilience

Institutional resilience is defined as the capacity of communities to reduce risk and create organizational bonds within society; in a way that includes features related to risk reduction, planning and experience of previous accidents [12]. In this dimension, the physical characteristics of organizations such as the number of local institutions, access to information, trained and volunteer personnel and personnel, adherence to crisis management guidelines, the timeliness of rules and regulations, deterrent and incentive rules and regulations to Especially in the construction of housing, the interaction of local institutions with the people and government institutions, satisfaction with the performance of institutions, accountability of institutions and how to manage or respond to disasters such as organizational structure, are evaluated [18].

2.4 Environmental Physical Resilience (Infrastructure)

The physical-environmental dimension (infrastructure) basically includes assessing the community response and post-disaster recovery capacity such as shelters, vacant or rented housing units, and health facilities. These indicators also provide an overview of the amount of private property that may be particularly vulnerable to permanent damage and potential economic losses. One of the most important vulnerable infrastructures is low-durability houses that are sensitive to a catastrophic accident [16]. Provide comparisons between and within each area for communities. It is necessary to explain that there is no consensus on the explanatory indicators of resilience, and each study has addressed separate indicators based on its approach [15].

3 MATERIALS
3.1 Location of the Study Area

Islamshahr city is one of the cities of Tehran province. The center of this city is Islamshahr. The city is bounded on the east and south by Rey, on the west by Baharestan, and on the northwest by Shahriar (Fig. 1). In 2016, the city had a population of 548,620, of which 279,282 were men and 269,338 were women.

The area of the city is about 245 square kilometers, which in terms of geographical coordinates with a slight

difference from the center of Tehran in 51 degrees and 10 minutes north longitude to 30,22,51 and latitude 30,42,34 to 30,27,35 east latitude of the meridian Greenwich is located in 2 districts, 4 villages and 49 villages, with a minimum distance of up to km and a maximum of 10 km. This city is located in the alluvial plain area south of Tehran and its height above sea level is about 1150 meters. Islamshahr consists of 6 districts, of which 1 and 2 are central and 3 are Vavan town, 4 are Shatereh, 5 are parts of Ahmadabad Mostofi (outside Ahmadabad Mostofi district), 6 are between Miyanabad and Imam Khomeini town.

There is no significant elevation in the city, but as mentioned, the city lands are located on the alluvium of the southern slopes of "Tochal" and "Kan" heights and with a very gentle natural slope from north to south from its height slightly It is reduced and the difference in height between the highest and lowest points is a maximum of 10 meters, so due to the gentle slope and flatness of the city lands away from the impact of industrial pollution will not cause the phenomenon of "inversion" or "temperature inversion" and rain. Will be acidic, which will have deadly effects on the environment and the climate of the city.
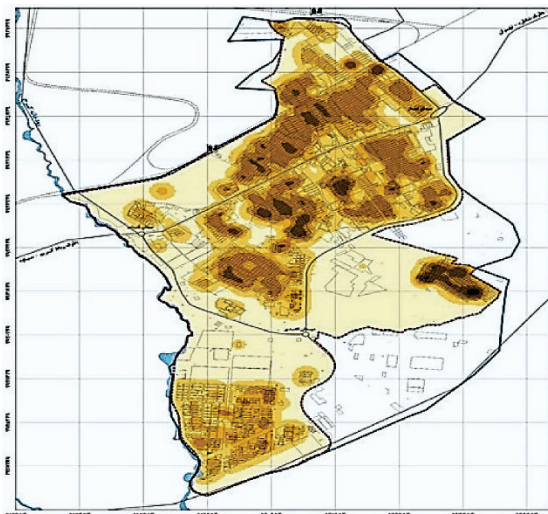
Figure 1 Location of the study area

3.2 Research Methods

Therefore, due to the nascent concept of resilience, no specific methodology or standard framework for assessing resilience against natural disasters is available. Therefore, according to this model, first, physical and infrastructural assets and wealth in Islamshahr city are calculated and a profile of the current situation is drawn. These assets include aspects such as sensitive infrastructure (telecommunications, energy, health, Transportation and water, land use, public spaces, etc.) This component is mainly related to assessing the community response and post-disaster recovery capacity and the overall assessment of the amount of private property that may be subject to permanent damage and loss. Provides potential economic opportunities that are particularly vulnerable. The present study is an applied-developmental research and its study method is descriptive-analytical which

deals with a deep understanding of the causes and factors and analysis, quality and value of phenomena related to the human environment and human behaviors. Part of the statistics and theoretical information of the present study was collected as a library using internal and external sources (books, articles, dissertations, organizational documents) and the other part was collected through field and survey methods. Local observations and interviews with people and officials were conducted and by combining and using thematic studies and the results of official censuses and verifying existing maps, photographs and aerial and satellite images to analyze and infer from studies and references. Government institutions and related organizations such as the municipality, the Housing and Urban Development Organization and other relevant departments to obtain statistics, maps, documents, organizational documents and plans that are related to the organizations in question.

3.3 Statistical Method

This research is a type of cognitive research (geographical studies) which has been done analytically-descriptively. The statistical population of the study is experts in urban planning issues, from which 384 people were selected as a sample and questioned. All research data (urban resilience) have been collected in the form of libraries and fields. The library part of the available resources was done and the survey work included the completion of a questionnaire.

The researcher-made questionnaire was in the form of a Likert scale on a ranking scale (very high, high, relatively high, to some extent, relatively low, low and very low) and its completion was done by field studies. The variables of this study included 5 dimensions of resilience (economic, social, institutional, infrastructure and urban) along with its components. The components considered in this study were selected based on studies conducted inside and outside Iran and its validity (validity) according to the importance of each to the study area, by 10 experts in planning management issues. Urban was reviewed and approved. Cronbach's alpha coefficient was used to determine the reliability of resilience dimensions. The calculated coefficient is equal to 0.83; This value indicates the high reliability of the questions. Statistical analyzes such as frequency, percentages, maximum and minimum, mean and standard deviation have been used to analyze the data in the descriptive part. In the inferential section, one-sample t-test and Friedman test were used with the help of required statistical analysis.

4 RESULTS
4.1 Risk Analysis

The most important natural threat to Tehran province is earthquakes, which Islamshahr city also faces. In this regard, the last condition of the faults is 1, 1, 1, and 3 of the currents.

After that, landslides and subsidence are the most important threat in this province, which is becoming a potential threat in the area due to the load of the city and the amount of water withdrawn from the aquifers of the area. These threats are shown in Fig. 2.
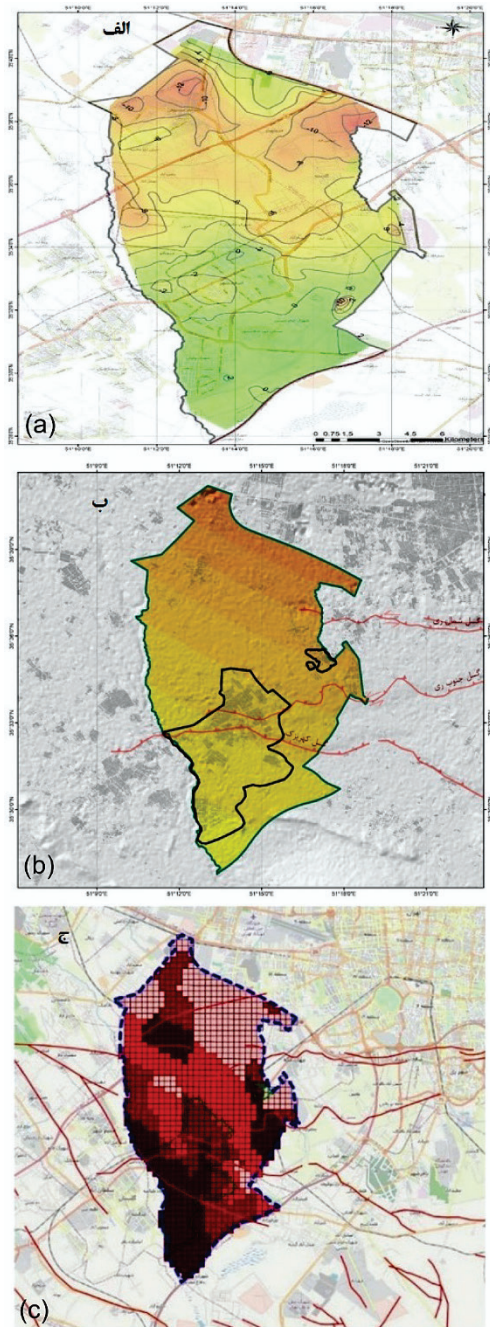
Figure 2 Subsidence status (a), existing active faults (b) and risk of faults (c) in Islamshahr city

According to the fault and subsidence conditions in the study area, the vulnerability of water and electricity network, sewage and surface water, transportation network and current status uses with the risks of these indicators and adaptation and hazard map produced in the city. These studies show that most of the urban areas in areas 2 and 1 are located between two active faults. In this area, a large number of residential uses, several service departments, the governor's office, two municipal areas, four fuel stations, The main hospital of the city, the three main drinking water reservoirs and the areas where the city is being developed in the current development.
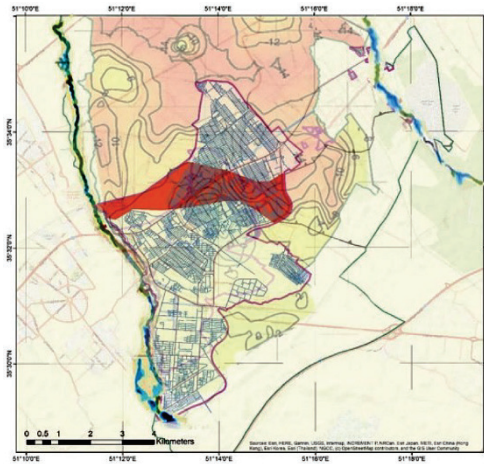
Figure 3 Adaptation of fault layers, subsidence and flooding in Islamshahr city

4.2 Descriptive Findings

In the first part, descriptive findings of the research and in the second part, inferential findings are presented and discussed. The sample statistical population for the distribution of the questionnaire based on Cronbach's alpha formula is 384 people. In terms of assessing the validity of the questionnaire.

Economic resilience:

In order to study the level of economic literacy in Islamshahr city from the perspective of residents, 9 items in the field of economic literacy in Islamshahr city were designed and the audience was asked to answer based on 5 Likert scales. Economic From the perspective of residents of Islamshahr city, the coefficient of variation index was used. In Tab. 1 the items of economic resilience are prioritized from the perspective of the respondents.

4.2.1 Institutional Resilience

In order to study the level of institutional literacy in Islamshahr city from the perspective of residents, 13 items were designed in the field of institutional literacy in Islamshahr city and the audience was asked to express their answers about the level of institutional literacy in Islamshahr city in a Likert scale (Tab. 2). In order to prioritize the items of institutional resilience from the perspective of Islamshahr residents, the coefficient of variation index was used.

4.2.2 Infrastructure Resilience

To examine the rate of infrastructure resilience in Islamshahr city from the perspective of residents, 16 items were designed in the field of infrastructure resilience in Islamshahr city and the audience was asked to give their answers about the rate of infrastructure resilience in Islamshahr city in a range of 5 Likert options. To express (Tab. 3) Tab. 9 shows the frequency and percentage of responses of all subjects for each item. In order to prioritize the items of infrastructure resilience from the perspective of Islamshahr residents, we use the coefficient of variation index. The results of infrastructure resilience items are prioritized from the respondents' point of view.

Table 1 Frequency distribution of respondents according to the response to economic resilience items

Items	Very Low	Low	Medium	High	Very High	Mean	SD	Dispersion coefficient	Priority
Job vulnerability and loss in the event of an earthquake	22/1	34/9	33/1	7/8	2/1	2/3281	0/9730	0/4179	1
The level of safety of property in Islamshahr neighborhood (shops, houses) against earthquakes 3	23/7	22/1	36/2	14/1	3/9	2/5234	1/1145	0/4416	2
The level of support of government and local institutions to compensate for financial losses	28/9	28/4	26/6	12/0	4/2	2/3411	1/1383	0/4862	6
Status of ability to return to working conditions and adequate income of residents after the earthquake	29/1	24/0	25/8	13/3	7/8	2/4661	1/2532	0/5081	8
Probable time to get a new job in case of losing the first job due to the earthquake	23/7	29/9	28/1	10/7	7/6	2/4844	1/1806	0/4752	4
Hope for insurance and other compensatory support to revitalize the living environment	33/3	31/8	20/3	9/6	4/9	2/2109	1/1515	0/5208	9
The amount of household savings to revive their lives	32/3	23/2	29/2	12/2	3/1	2/3073	1/1377	0/4930	7
The level of job and professional skills of the residents	25/5	24/2	32/8	14/8	2/6	2/4479	1/1018	0/4501	3
The household's ability to relocate to new housing and environments outside the crisis zone	28/1	32/0	27/6	7/3	4/9	2/2891	1/1017	0/4812	5

Table 2 Frequency distribution of respondents in terms of response to institutional resilience items

Items	Very Low	Low	Medium	High	Very High	Mean	Standard Deviation	Dispersion coefficient	Priority
The amount of information provided by the relevant agencies about the crisis and post-crisis conditions	21/9	27/9	24/7	20/3	5/2	2/5911	1/1838	0/4568	3
Residents' confidence in urban management measures	26/6	24/5	26/0	16/7	6/2	2/5156	1/2219	0/4857	8
Residents' awareness of the existence of organizations related to crisis management or natural disasters	16/9	22/9	20/6	24/2	15/4	2/9818	1/3293	0/4458	2
Opinion and awareness of residents about the tools and equipment of crisis management organizations	26/8	20/8	29/7	14/1	8/6	2/5677	1/2581	0/4899	9
Extent of volunteer and relief groups	23/4	21/6	32/0	13/8	9/1	2/6354	1/2358	0/4689	4
The degree of adherence to legal guidelines for accident prevention	27/6	21/1	30/7	14/6	6/0	2/5026	1/2070	0/4822	7
Residents' participation in decision-making and planning	33/9	31/0	22/9	8/1	4/2	2/1771	1/1124	0/5109	11
Residents' relationship with institutions such as the municipality, the Red Crescent Society and crisis management	22/9	18/0	27/9	18/8	12/5	2/7995	1/3221	0/4722	6
The level of cooperation of the municipality in facilitating laws, giving credits, loans, etc. for the construction of housing that is resistant to the people	38/8	21/6	23/7	10/7	5/2	2/2188	1/2152	0/5476	13
Preparedness of service institutions such as fire department, hospital, clinic, electricity, water, gas in case of earthquake	18/5	19/0	24/7	26/6	11/2	2/9297	1/2816	0/4374	1
Extent of classes or training courses required for crisis response (earthquake) by institutions	29/2	30/7	23/7	11/5	4/9	2/3229	1/1539	0/4967	10
Extent of general training to residents to prepare before, during and after the crisis	35/7	27/3	22/4	8/6	6/0	2/2188	1/1913	0/5369	12
The degree of participation of social institutions in resolving urban affairs	25/3	27/1	29/2	13/3	5/2	2/4609	1/1555	0/4695	5

Table 3 Frequency distribution of respondents by response to infrastructure resilience items

Items	Very Low	Low	Medium	High	Very High	Mean	Standard Deviation	Dispersion coefficient	Priority
Your assessment of the strength of your home in the face of crises such as earthquakes	32/6	25/3	26/6	12/8	2/9	2/2812	1/1329	0/4966	9
Access to hospital, emergency, pharmacy, clinic medical centers	19/5	30/5	26/6	17/4	6/0	2/5990	1/1587	0/4458	1
Access to educational centers (schools, kindergartens, universities)	23/2	25/5	28/4	14/8	8/1	2/5911	1/2208	0/4711	5
Access to aid agencies	25/5	19/5	30/2	18/2	6/5	2/6068	1/2280	0/4710	4
Access to military-security center	25/8	30/7	27/3	12/0	4/2	2/3802	1/1153	0/4685	3
Access to firefighting	18/5	19/3	25/8	21/4	15/1	2/9531	1/3237	0/4482	2
Access to public transport	33/9	19/3	27/1	15/4	4/4	2/3724	1/2196	0/5140	12
Access to parks and green spaces and evacuation routes	32/0	20/8	23/4	12/5	11/2	2/5000	1/3480	0/5392	15
Access to the main thoroughfare network	30/5	22/4	25/3	15/9	6/0	2/4453	1/2399	0/5070	10
Your awareness of natural hazard areas	30/7	22/1	27/3	12/8	7/0	2/4323	1/2414	0/4991	8
Your awareness of dangerous human areas	35/4	24/7	24/0	11/2	4/7	2/2500	1/1852	0/5267	14
Quality of building materials and buildings	32/8	24/7	24/5	11/7	6/2	2/3385	1/2220	0/5225	13
Sustainable water access during and after the crisis	25/5	29/7	22/9	14/6	7/3	2/4844	1/2219	0/4918	7
The condition of your residential building in terms of strength and depressibility	33/6	22/4	21/4	8/9	13/8	2/4688	1/3896	0/5628	16
Proportion of the width of the passageway that is accessible to you in times of crisis	26/6	21/9	24/0	13/8	13/8	2/6641	1/3650	0/5123	11
Construction and human density	23/7	27/6	28/6	12/0	8/1	2/5312	1/2044	0/4758	6

4.2.3 Statistical Characteristics of Research Variables

The statistical characteristics of the research variables are given in Tab. 4. Social resilience has an average of 2.5917, economic resilience has 2.3776, institutional resilience has 2.5325, infrastructure resilience has 2.4937 and urban resilience has an average of 2.3786. Then, to ensure the statistical distribution of the studied variables was normal, the Kolmogorov-Smirnov fit test was used. When checking the normality of the data, the null hypothesis is based on the fact that the data distribution is normal, which was tested at a 5% error level. Therefore, if the test statistic is greater than or equal to 0.05, then there is no reason to reject the null hypothesis that the data is normal. In other words, the data distribution will be normal. Considering that the significance levels of all variables are above 0.05, the assumption that the distribution of variables is normal was accepted.

Table 4 Test to check the normality of the distribution of research variables

Variable	Mean	SD	KS	DoF	S
Social resilience	2/5917	0/8214	0/258	383	0/074
Economic resilience	2/3776	0/8008	0/270	383	0/051
Institutional resilience	2/5325	0/8535	0/289	383	0/092
Infrastructure resilience	2/4937	0/8303	0/267	383	0/083
Urban resilience	2/3786	0/9975	0/293	383	0/105

4.3 Inferential Findings
4.3.1 Single Sample t-Test

In this study, a one-sample t-test was used to investigate the status of urban resilience components in Islamshahr. Findings showed (Tab. 5) that social resilience with an average of 2.5717, economic resilience with an average of 2.3776, institutional resilience with an average of 2.5325, infrastructure resilience with an average of 2.4377 and urban resilience with an average of The average of 2.3786 is less than the test value (3) and as a result, urban resilience and urban resilience components in Islamshahr city are at a low level. Also, the negativity of the lowest and highest limits about urban resilience and all components of resilience means that the average of the variable in the community is less than the test value and these variables are at a low level in the study population.

Table 5 Sample t-test results

Variable	t	DoF	Mean	S	Mean difference	Assurance difference %95	
						Min	Max
Social resilience	15/229	383	2/5917	0/000	-0/4082	-0/7028	-0/5420
Economic resilience	9/727	382	2/3776	0/000	-0/6224	-0/4908	-0/3257
Institutional resilience	10/735	383	2/5325	0/000	-0/4675	-0/5532	-0/3819
Infrastructure resilience	11/950	383	2/4937	0/000	-0/5063	-0/5897	-0/4230
Urban resilience	12/192	382	2/3786	0/000	-0/6214	-0/7216	0/5212

4.3.2 Friedman Test

Friedman test was used to rank the components of urban resilience (Tab. 6). The value of chi-square statistic in this test was 44.919 and the significance level was 0.000. Therefore, the components differ from the average and can be ranked. According to the average rankings of components, social resilience is in the first place, institutional resilience is in the second place, infrastructure resilience is in the third place and economic resilience is in the fourth place.

Table 6 Friedman test results

Variable	Average rating	Rank	Chi-square	DoF	S
Social resilience	2/77	1			
Economic resilience	2/16	4	44/919	3	0/000
Institutional resilience	2/57	2			
Infrastructure resilience	2/50	3			

5 DISCUSSION

Urban resilience is a relatively new concept in urban studies and urban planning. Resilience is derived from biological discipline, which determines the ability of a system's organism to withstand a shock, disaster, and disease, and to recover from it. As a result, in general, the definition of urban resilience or resilience can be interpreted from the perspective of an urban crisis to the ability of a region or urban system to withstand a wide flood of shock and tension. Because today, urban spaces can best play the role of centers of collective life. The aim of this study was to evaluate the economic and institutional-physical resilience of Islamshahr to identify the capacity and ability to return it at the time of and after accidents.

The results of measuring the economic, institutional and infrastructure dimensions in measuring the urban resilience of Islamshahr against natural hazards showed that the frequency of economic dimension is very low, 27.41, low 27.83, medium 28.86, high 11.31 and 57 / 4 is very marked. Therefore, according to the final score of the economic dimension level, according to all its components and criteria, it is moderate and has a tendency towards low spectrum. Also, the degree of job vulnerability and loss in the event of an earthquake has been a priority. The frequency percentage of social dimension is 26.73 very low, 24.12 low, 26.02 moderate, 15.48 high and 7.67 very high. Therefore, according to the final score, the level of social dimension is moderate according to all its components and criteria and has a very low tendency towards spectrum. The frequency percentage of the infrastructure dimension is 18.18 very low, 24.15 low, 25.84 medium, 19.71 high and 7.83 very high. Therefore, according to the final score, the level of social dimension is moderate according to all its components and criteria and has a very low tendency towards spectrum. Findings obtained from the above studies are in line with the study of [16] which showed that the average resilience rate is 2.23 and indicates that in general the study area in terms of resilience in a completely It is not desirable. The results are also in line with the study of [13] which showed that in terms of economic dimension, there is a downward trend in the rate

of resilience. Also, the results are consistent with the findings of [15] which showed that among the various dimensions of resilience, institutional and then physical-spatial is in an unfavorable position. The results of measuring the economic and institutional dimensions showed that the city of Islamshahr is moderate to low against natural hazards according to all its dimensions, components and criteria, while the same amount has different values in different areas and in worn-out areas and Informal settlements are the lowest, which indicates very unbearable conditions in areas such as Mianabad, Ahmadieh and Faizieh in terms of economic-physical resilience. Despite recent measures, the dependence of Islamshahr city in terms of services and political and economic performance to Tehran has also had the highest negative coefficient on urban resilience.

6 CONCLUSION

Findings of one-sample t-test showed that social resilience with an average of 2.5717, economic resilience with an average of 2.3776, institutional resilience with an average of 2.5325, infrastructure resilience with an average of 2.4377 and urban resilience with an average of 2.3786 and as a result, urban resilience and the components of urban resilience in Islamshahr city are at a low level.

The results of Friedman test in the dimension ranking section showed that the social dimension is in the first place of importance and the economic dimension is determined as the least important dimension. The results of the analysis in this section are in line with the results of the study of [17] which showed the highest level of economic dimension, physical-environmental and institutional-managerial dimension of the second level, infrastructure dimension of the third level, social dimension of the fourth level. And the lowest level, the environmental dimension. The results are also in line with the findings of [6] whose findings show the unfavorable living conditions and its dimensions in the region, the difference between neighborhoods in terms of livability and the greater impact of the economic dimension on the living conditions of the region and neighborhoods.

Considering the importance and necessity of the issue of resilience of communities, in this study, in order to increase the resilience of cities around Kalamshahr, Tehran has presented the following suggestions:
- Increase scientific studies and integrated system research of the center and coordinate to identify and reduce the threatening factors of communities living with the priority of earthquake and subsidence risk.
- Establishment of a joint secretariat for urban resilience in and around the metropolitan area for consolidation and coordinated measures.
- Investing in the field of culture and promoting the intellectual level of society, especially for children.
- Increase the capacity of institutions and create more coordination between departments.
- Increase and update existing standards for resilience of society using knowledge and innovation.

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Role of Business Intelligence and Knowledge Management in Solving Business Problems

Eissa Mohammed Ali Qhal

Abstract: The term "Business intelligence" is described as a plan or a strategy where the operations like reporting, data analysis, data mining, event processing are performed to improve the production and growth of a business enterprise or a business entity. And on the other hand, the "Knowledge management" is explained as well-organized management of resources and information within a commercial organization it can be a business too. Almost all business will have limitations and challenges which can be also known as the business problems. One of the main business problem is demand, the business plans must work according to the demand of the consumers. Analyzing the demand would provide the solutions for queries like what is the business trend? What is the need of the users? What should be the improvement make in the production? Where is the current position of the enterprise? And who all will be the competitors? For the predictive analysis a dataset of bitcoin is taken. The major aim of the study is to implement the strategies to overcome the business problems mainly the demand prediction. And the objective is to find out the relevant issues and the remedies by using knowledge management and business intelligence to the common business problems. The dataset has columns called lowest price, highest price, open price, close price, trading volume and market capital. The research methodology used is predictive analysis using PCA and K-means clustering algorithm. By this dataset predictive plots are developed as achieved results for easy analysis by using research methodology. PCA and K-means are the algorithm used for accurate prediction. The importance of study is to predict the future sale, as it is very essential for a business enterprise to find future demand so that the organization can improve production.

Keywords: Business intelligence; knowledge management; business problems; PCA; K-means

1 INTRODUCTION

BI (Business intelligence) encompasses the technologies and approaches utilised by companies for the data analysis process and organization of business material. General purposes of business intelligence concepts comprises of numerous operations namely analytics, process mining, prescriptive analytics, predictive analytics, dashboard development, online analytical processing, benchmarking, data mining, complex event processing, text mining, business performance management and broadcasting[25]. Business intelligence concepts can operate on bulky quantities of organized and occasionally unorganised data to support, classify, create, and else develop innovative planned business openings. Which object to allow for the easy interpretation of these big data [14]. Identifying new opportunities and applying an operative approach built on perceptions can deliver productions with an enduring constancy and a modest marketplace benefit. Business intelligence (BI) can enhance worth to nearly number of business processes like developing a complete opinion and permitting squads to analyse their particular data to discover competences and style improved upcoming decisions [16].

The procedure of knowledge management is collective for most of the "enterprise business problems". Knowledge Management guarantees large number for its searchers. For an example, knowledge management has the capacity to keep the enterprise a complete of 6 trucks load a year. Inappropriately, corporations regularly flop to put in force on powerful Knowledge Management explanations. The major objective of knowledge management is to share the ideas, viewpoints, information and experiences with in the groups [5, 23]. This process helps to make informed decisions as well as it helps to progress the rate of efficiency by decreasing the requirement of revisit on obtained knowledge. To support the knowledge management process, the knowledge management technologies are used, the knowledge management technologies are nothing but

information technologies for knowledge management. There are mainly four components in knowledge management VIZ the strategy, information technology and content, people and the process. Knowledge management is used to make business decisions depending upon business analytics to acquire business objectives [9].
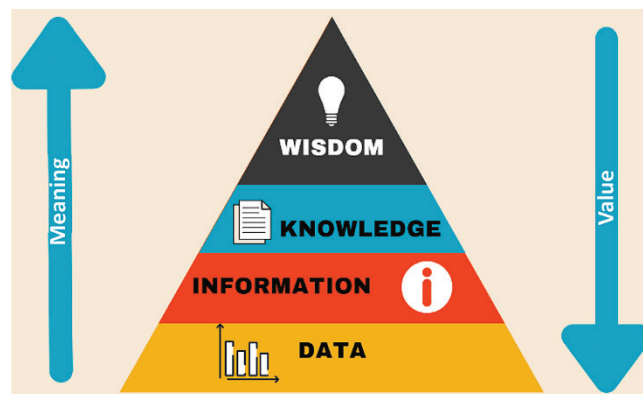
Figure 1 DIKW

As the process continues, there may come a problem in the operations and that can affect the performance of the organisation. These challenges and problems or the issues experienced by the business in a present period or in the long term are termed as business problems [20]. It is very important to identify the business problem, since the business problem might become an obstacle for the well fare of the business. To solve any problem one must find the root of the cause, similarly the main cause should be found out to resolve the business problem. There are many business problems faced by different entrepreneurs such as globalization, innovation, technology, demand, customers' experiences and relationships, complexity, finance, government policies, quality, promotion of the products etc. There are countless business problems, to solve such kind of problems the knowledge management and business

intelligence is used. Solving a complex problem manually is really very difficult task, but by applying business intelligence and knowledge management the task is fragmented and solutions are found easily [24].

The first and foremost procedure to solve a problem is to study the problem. The most valuable entity is data. From data the information is derived, from which the knowledge is acquired, that finally becomes the wisdom. To solve a problem, the problem must be studied properly, so that the root of the problem can be found and the problem can be rectified easily. In the process of problem solving the data is taken from the environment of problem. The data can be how the problem occurred? When did it happened? How many times did that happen? Who all are the sufferers? At which date it occurred? What is the type of the issue? What can be remedies? Which all are the prevention techniques? There arises number of queries when a problem occurs [17].

By using knowledge management and business intelligence the entrepreneur can find out the solutions easily, knowledge management is also known as a process of managing or handling the set of information. The information can of any field here it is business. The data about business is a large entity, it impossible for a human to handle such a data, so the concept of business intelligence is applied.

1.1 Importance of Business Intelligence and Knowledge Management

Business intelligence and knowledge management plays an important role in solving business problems. It is really difficult to maintain the business and also to solve the business problem by a person. Because in the huge process of business solving, there are number of procedures which are difficult and complex for a human being [10].

So for the storage, analysis and control of the business enterprise, the organization needs a structure to handle this critical situation [26]. Here it explains the need of business intelligence and knowledge management. The business intelligence and knowledge management help to control, store, analyze and make a decision from the business problem [8].

There are various types of problems and challenges arise when the business environment possess distinct data sets. The business environment data is an essential source for the efficiency of the business performance. The business intelligence compromises the issues such as perfection in performance management, customs report development by technical teams, organization of day to day operations, limitation in accessing data, time consumption in creation of multiple systems and the future foundation from the actionable intuitions. These kind of data are managed in a business environment along with the collaboration of knowledge management.

1.2 Real Time Applications of Business Intelligence and Knowledge Management

- Hellofresh: It is a centralized reporting system for digital marketing for the progress of alterations. This enterprise had a problem in digital marketing reporting because the reporting was most commonly performed manually, and

inefficiently which was always leading to time intensity. This issue was resolved by implementing a "centralized business intelligence solution" which does automatic reporting of the process for each day which decreased the time of working from ten to twenty hours a day. These in turn reflected in improvement of "customer retention".
- REI: The business intelligence concept is applied to sort out the difficulty in chasing involvement system of measurement with 90 TB of data. They had a difficulty in tracking "membership metrics" with ninety terabytes of data. Here the business intelligence platform was utilized for the analysis of their "multi-work term agreement with one employer" and customer segmentation. These procedures resulted in betterment in customer satisfaction [1].
- Xerox: Xerox established their own Knowledge Management solution termed as Eureka. Which was a workwise attributed system of knowledge sharing in which the technologists would prepare the documents for the solutions. The organization permitted facility technologists to attribute their title to the articles, this resulted in enhanced reputation amongst the colleagues, and invigorated supplementary workforces to yield the time to stake their acquaintance [15].
- Chipotle: The "chipotle Mexican Grill" is a famous American restaurant chain. It has a wide range of locations worldwide. This enterprise possessed a problem for the teams to deal with the desperate sources of data by viewing the unified class of the restaurants. The chipotle updated their conventional business intelligence solution to a self-service business intelligence platform which gave them a centralized architecture of operations that supports tracking of restaurant operations.
- Toyota: This huge company implements knowledge management for the better enhancement of the organization. Toyota scrupulously encourages acquaintance transmission. The corporation directs two to three hundred novel workforces to labor in an already outstanding place of work. In attendance, they labor shoulder to shoulder with the additional knowledgeable workforces on the assemblage line, and training the manufacture system. Subsequently preliminary training on the work, the novel workforces are transported back to the innovative place of work. Then they go together with by one to two hundred exceedingly knowledgeable workforces who put their effort in combined with them, besides guarantee that Toyota's "finely-tuned" manufacture system is entrenched hooked on the novel site [13].
- Coca cola: It difficult to maintain reporting processes manually with limited admission to process data and real-time sales.
- Des Moines: Using business intelligence they solved the preservation of the Excel reporting destined managers could not audit data such as preventing timely attendance, intervention etc. They used manual excel sheet for reporting which was not an apt option for foresee of up to date data. And they started seeking advanced analytics for the improvisation.

- Geisinger medical group: By applying knowledge management they dropped costs, enhanced patient health care, and retained and recruited many healthcare providers for service [19].

1.2.1 What is the Business Problem?

Figure 2 The various business problems

- Customer experience: The customer experience plays a vital role in business, because the upcoming production and ideas always depends upon the customer experience.
- Technology: It occurs due to failure of IT infrastructure; the technical services might be costly for some business groups [21].
- Promotion: this issue arrives when the product or goods or services have no ability to generate demand among the market.
- Customer relationship: If the customer is not satisfied with the service, products or the goods, there is a huge chance of loss. Because the customer may leave this service and move to another production.
- Demand: This is one of major issues in business problem, because without demand there is no growth in the business.
- Quality: Quality of the production is important. For the existence of the business organization the enterprise must provide quality products for the customers [18].

1.3 The Business Problem - Demand

Demand prediction is the manner of the usage of predictive evaluation from existing historic facts to evaluate and are expecting customers' intention call for a service or a product. Demand prediction allows the analyst to support to the benefit perception into what their supporter desires by means of a lot of predicting strategies. These strategies has process like predictive evaluation, conjoined evaluation, customer reason studies. In this, the bitcoin dataset is used for predictive analyses by using k-means clustering algorithm along with PCA (Principal Component Analysis) and SOM (Self-Organising Map) [7].

2 LITERATURE REVIEW

Business Intelligence is a procedure which includes categorization of the obtained information and choose the relevant ones. Business intelligence delivers serious visions which support administrations for proper conclusions. Knowledge management is a main method to business problems [11]. One of the applications of knowledge management explains the usage of knowledge sharing scheme for business intelligence in varying transformations of tactic knowledge and explicit knowledge in e-business system. Innovatively four matrices and four indices were applied in the e-business, this supports the online stores to examine the data with web usage analysis [22].

The external and internal environment monitoring is a complex process; hence it deals with huge amount of data and information. Knowledge management concepts are widely used to handle this complexity in various enterprise. The business intelligence is known as one of the most essential tool off knowledge management because it helps to support the organization's competitiveness [12]. In a study, in the year 2019, organization's competitiveness and business intelligence were quantitatively evaluated. In which it is determined the influencing components in business intelligence off multinational food processing company [28].

Knowledge management it's used to hide the complexity of the entire business process consumers please stop to improve the efficiency of knowledge management, knowledge discovery in database KDD process is being used indirectly. Business intelligence and knowledge management will definitely improve the company's overall performance that's having business intelligence and knowledge management as a combined structure is a huge benefit for an organization [6].

Knowledge management encourages the practice of knowledge and information accessible to the association. Thus, it can be expected that business intelligence and knowledge management perform a vibrant part in emerging the quantitative and qualitative information rate which is accessible to make decision [16]. They can assist each other, which is substantial that business intelligence has a widespread part to perform in knowledge management projects.

For example, business intelligence approaches are pragmatic in knowledge management for generating and storing knowledge. Business intelligence components are castoff globally for rationalization of the "Business Processes" [15]. It provisions the facts for all the business processes, which might be useful in making choices. It styles the "data processing" as mechanical and modified. It operates apt in analytical and financial field [27].

3 METHODOLOGY

The data mining tool called "orange" is applied here for the data visualization. The tool is an open source and is really easy to learn and use this tool. Orange facilitates the provision of drag and drop, the suitable algorithm can be chosen from the control panel and used as it is [3].

In this Fig. 3, the workflow is captured. Starting from the file import, then data table, PCA (Principal Component Analysis), k-means and finally SOM (Self-Organizing Map). This SOM is shown in another window with three clusters C1, C2 and C3.

The variance of the PCA (Fig. 4) must be always greater than 60%, if the variance is less than 35% then the data is meant as an unusable dataset. But if the variance is more than 60% then it means this has more complete original data [1].
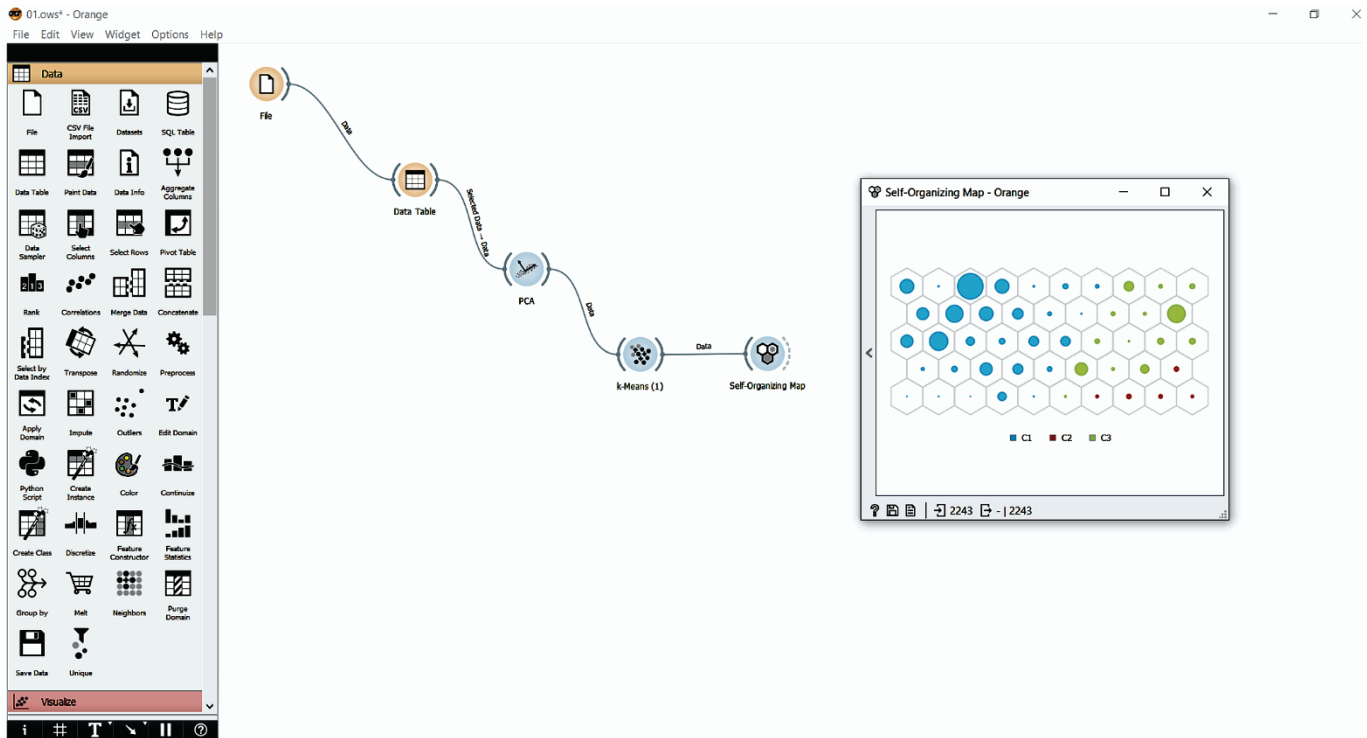
Figure 3 A sample workflow in the orange tool
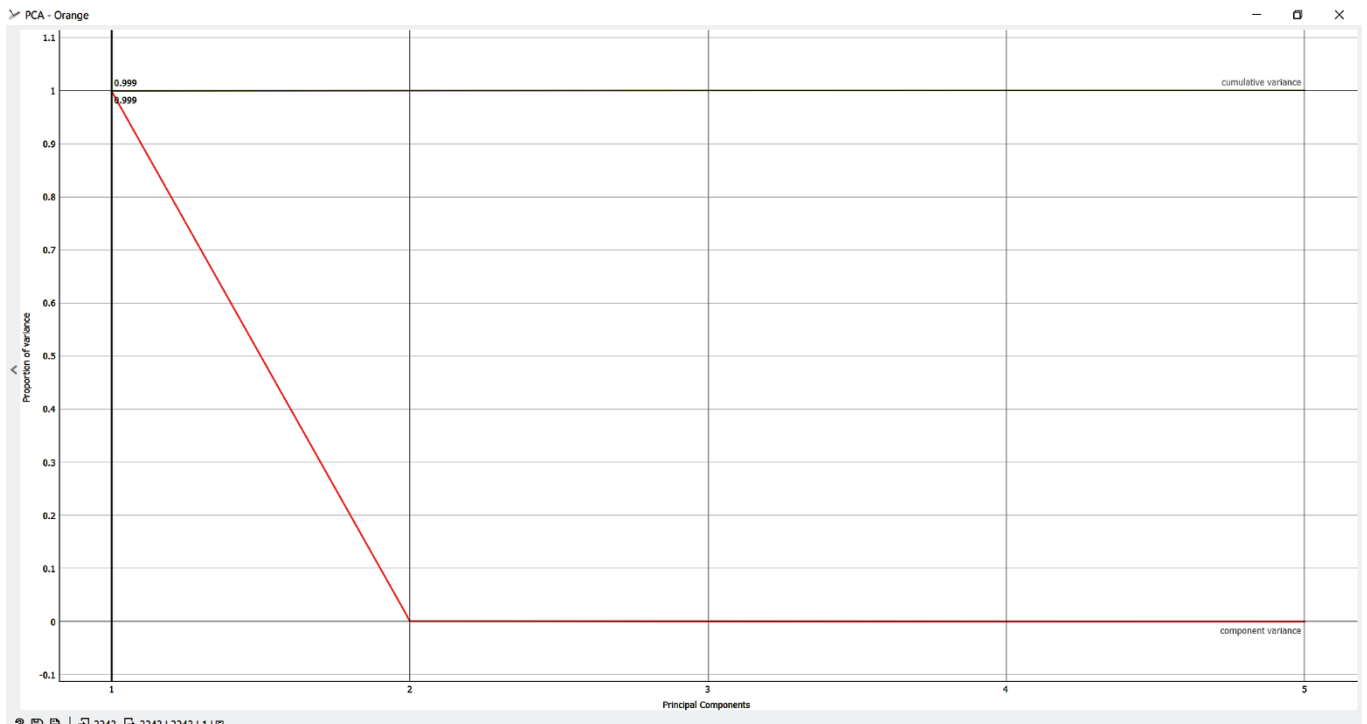
Figure 4 An initial step – PCA (Variance of PCA)

These two figure are sample illustration of the obtained results. Fig. 5 has clusters C1, C2, and C3 and Fig. 6 is self-organizing map of silhouette.
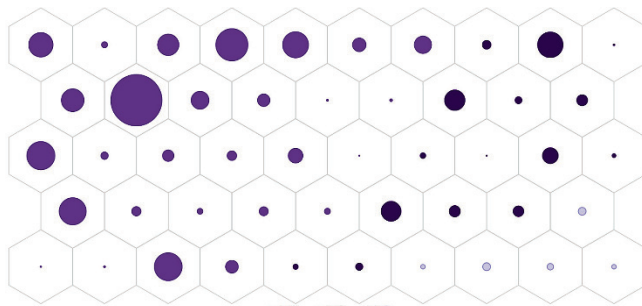
Figure 5 K-means followed by PCA
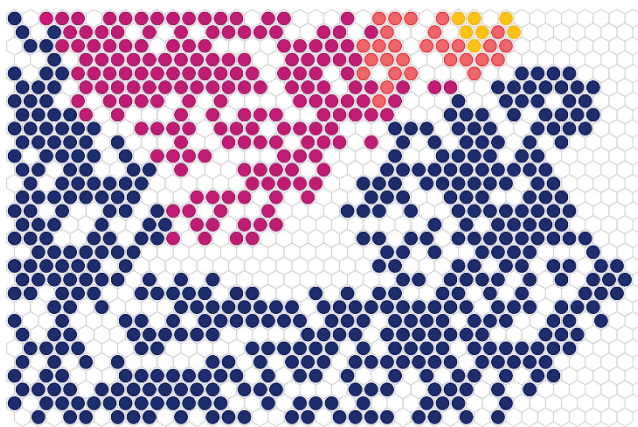
Figure 6 SOM using k-means

3.1 Implementation

To demystify the purpose of prediction and analyses, here it is applied a trend analysis using a dataset of bitcoin. The business intelligence and knowledge management concepts are applied in the example of bitcoin. These concepts are used to find out the current trend of the bitcoin in the business environment using an attribute called "demand" [29]. This involves the following steps:

- **Requirements Reporting** – the recipient would prefer to conduct an examination on the development of Bitcoin business, with the help of numerous particulars as conceivable [9].
- **Requirements are Broken Down** – this is the second step in the business analysis this has different sections for the process such as the findings of yearly transactions, the volume of transaction, the globalization of industry and the vital information on current posters about the industry [18].
- **Prioritization** – The most relevant attributes are to be considered for the analysis. In this case it is suggested as: High price, low price, open price, close price and transaction volume. These attributes are important for the upcoming steps.
- **Data Gathering and Validation** – this procedure will include the training of all obtainable basis for statistics,

be they authorized foundations, or on open-sources that give statistics about the Bitcoin usage.

- **Analysis** – the entire results will be utilized completely in this step. The data will be cleaned and organized to put together for an accurate result. These results will be used to improve the annual production as well as supports to take proper business decisions. Separately from the "data analysis preparation", specialists might spread over numerical proprieties so that they have statistics appropriate info and have suitable pictorial constituents to represent to the consumer. This might effect in polls, trends, explanations for the change in price and all the associated illustrations [12].
- **Results Presentation** – this is the concluding phase that characterizes the tendering of the consequences to the end client. This analysis will help the entrepreneurs to have an improved picture of the current Bitcoin marketing, its expansions and conceivable forthcoming progresses [24].

3.1.1 Dataset

Table 1 Sample rows of the taken dataset

Date	Open	High	Low	Close	Volume
Jun 18 2019	9335.47	9348.37	9004.9	9081.76	15848210536
Jun 17 2019	8988.92	9416.41	8988.92	9320.35	15562951919
Jun 16 2019	8841.44	9335.87	8814.56	8994.49	23348550311
Jun 15 2019	8689.75	8859.13	8618.4	8838.38	18371033227
Jun 14 2019	8230.9	8710.64	8183.39	8693.83	19831162906
Jun 13 2019	8145.55	8311.57	8087.06	8230.92	18669407147
Jun 12 2019	7925.43	8196.65	7862.36	8145.86	19034432883
Jun 11 2019	8004.24	8026.39	7772.8	7927.71	17107279932
Jun 10 2019	7692.28	8031.91	7586.73	8000.33	18689275118

The dataset (Tab. 1) is taken from the website https://www.kaggle.com/. The dataset contains different columns such as date, Open Price, Highest trading price of the day, Lowest trading price of the day, Close price of the day, Trading volume and Market cap of bitcoin.
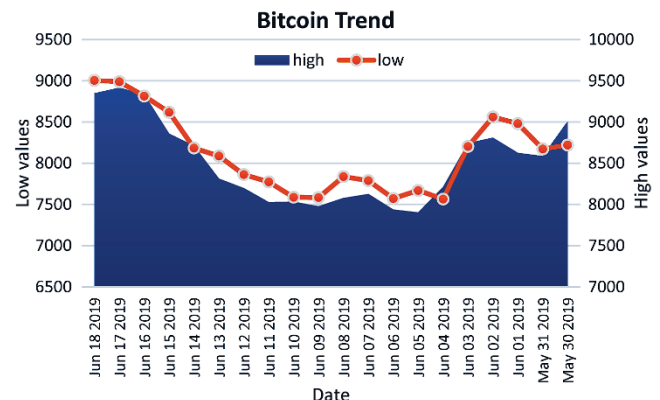
Figure 7 Sample plot of bitcoin trend

Fig. 7 explains the highest trading price of specific dates which is given in the right side of the graph and lowest trading price on the left side. The first twenty values are taken from the dataset to plot this graph. From the plotting one can easily understand the difference between the lowest price and the highest price in a date [17].

Table 2 The first twenty values of the dataset (column: date, high and low)

Date	High	Low
Jun 18 2019	9348.37	9004.9
Jun 17 2019	9416.41	8988.92
Jun 16 2019	9335.87	8814.56
Jun 15 2019	8859.13	8618.4
Jun 14 2019	8710.64	8183.39
Jun 13 2019	8311.57	8087.06
Jun 12 2019	8196.65	7862.36
Jun 11 2019	8026.39	7772.8
Jun 10 2019	8031.91	7586.73
Jun 09 2019	7975.97	7583.22
Jun 08 2019	8076.89	7837.61
Jun 07 2019	8126.15	7788.37
Jun 06 2019	7937.34	7571.47
Jun 05 2019	7901.85	7668.67
Jun 04 2019	8210.99	7564.49
Jun 03 2019	8743.5	8204.19
Jun 02 2019	8809.3	8561.24
Jun 01 2019	8625.6	8481.58
May 31 2019	8586.66	8172.55
May 30 2019	9008.31	8221.27

This is a part of the dataset where this contains only three columns such as date, high and low. Tab. 2 have the highest price of the bitcoin per date. From this table the analyst can have a clear picture on the value of bitcoin [2].

4 RESULTS AND DISCUSSIONS

The study model of the system is appropriate for this paper since it increases the accuracy and efficiency of the results. The section contains the plots and figures obtained from the analysis. Initially the data is processed from the PCA and then after filtering the noisy data it is applied with the k-means. And finally for the representation SOM (Self-Organizing Map) is used.

The over-all variance here is 99% which is the totality of variances of all independent principal components (Fig. 8). This figure has three components thus the line lies on the component three on the x-axis and that line is parallel to y-axis.

The k-means is a clustering algorithm which is commonly used for various predictive analysis (Fig. 9). Here three clusters are illustrated with three distinct colors as pista green (C1), cyan (C2), and blue (C3). Cluster 1 i.e., C1 is having large number of data points.

This type of size variance is obtained by choosing, size by number of instance. These feature will enable the diagram to have a clear understanding picture of the analysis. In this, the large circles denote the greater values in the close price of the bitcoin (Fig. 10).

The PC2 denotes the second most important direction along with the samples (Fig. 11). PC2 is also known as second principal component which is focused in such a way that it reproduces the second largest cause of variation in the data while being immaterial to the PC1.

This is the silhouette representation in the Self Organized Map (Fig. 12), silhouette is defined as one of the mechanism in machine learning for understanding and justifying of constancy inside the clusters of the data.

The silhouette can have multicolor for catchy looks, in the SOM there exists an option to choose the initialization (Fig. 13). This structure was obtained by initializing with PCA. As the PCA is the root of this predictive analysis.
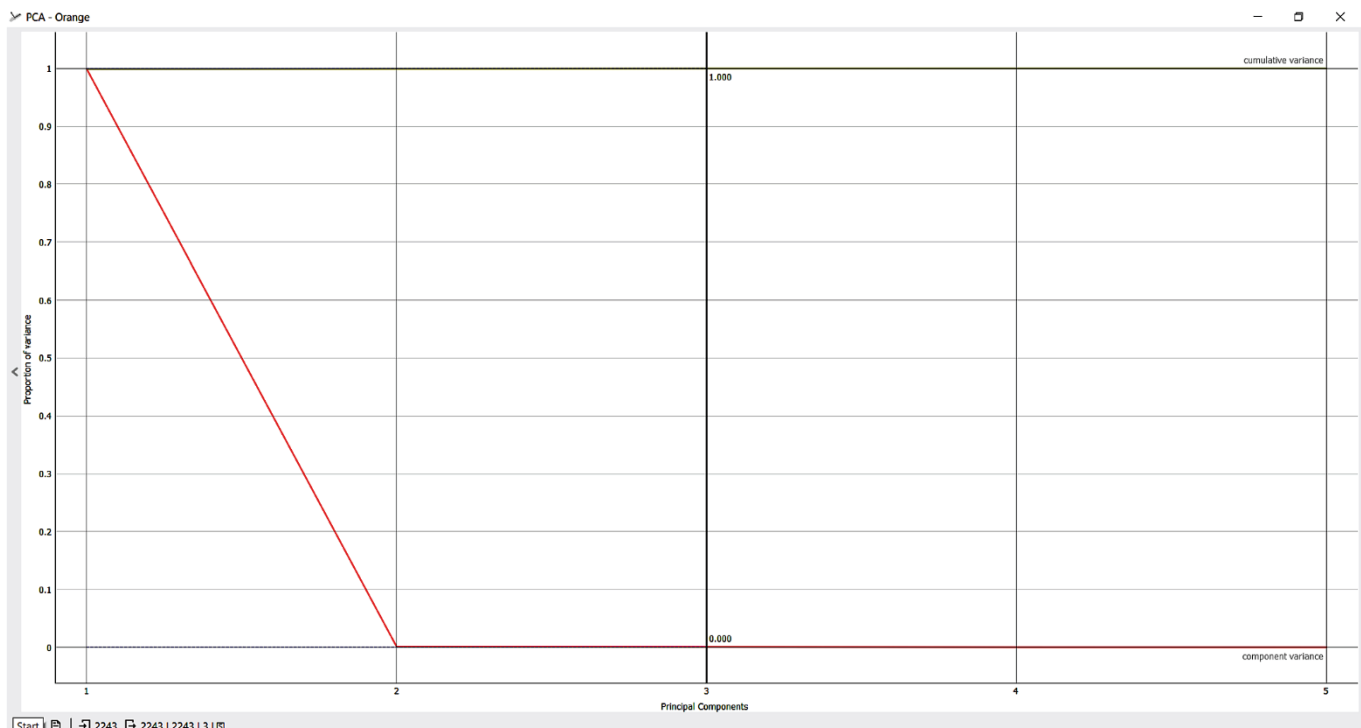
Figure 8 PCA with 99% of variance
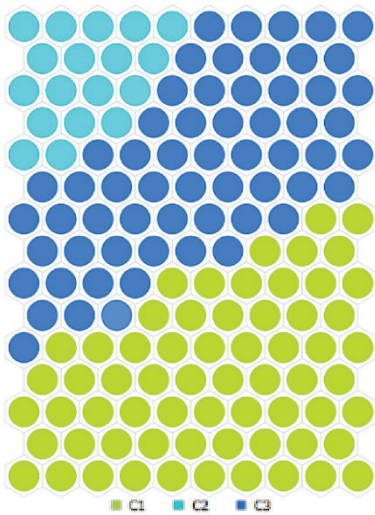
Figure 9 K-means using SOM (Self-Organizing Map)
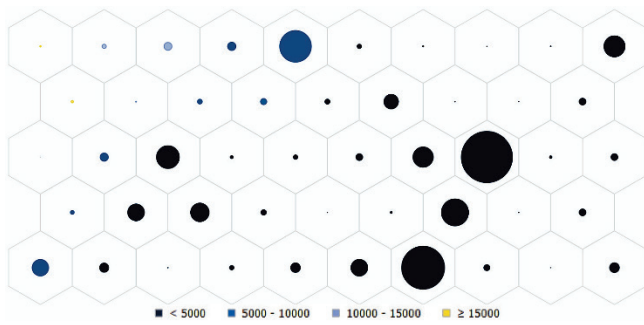
Figure 10 SOM of close price of the day
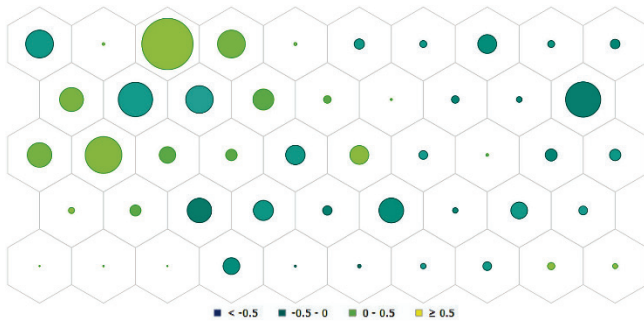
Figure 11 SOM of PC2 component
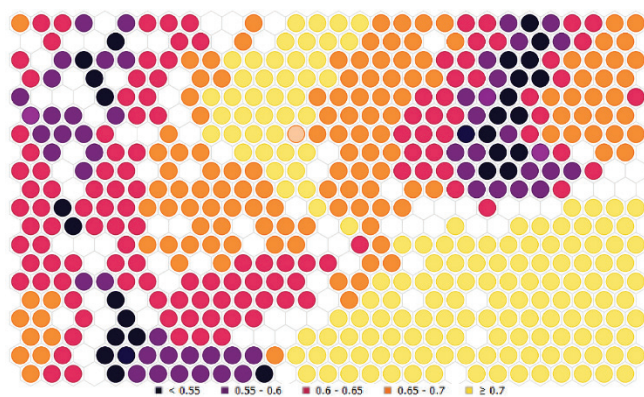
Figure 12 SOM of silhouette
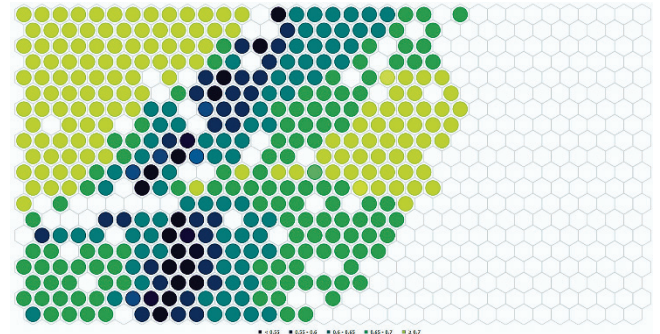
Figure 13 SOM of silhouette in different shade

5 CONCLUSION

As a conclusion, there are a number of challenges in the business field. But even those challenges solving or finding the demand can provide many major solutions for the business problems [30]. If an enterprise analyzes the demand of the customers the future sale of the production is secured. Demand of the product is the only key off the product for an example the progression of bitcoins is used for analysis, the people use their bitcoins extremely. Bitcoin is also known as one of the volatile investment. Bitcoins do have challenges still it can be prevented by the analysis [5].

Similarly, any production can be secured from falling by performing proper analysis by using accurate information. For the analysis, PCA (principal component analysis) is applied initially for handling an analysis problem termed as high dimensionality [4]. "Dimensionality reduction" includes depleting the count of columns or input variables in data modelling. PCA is a procedure as of linear algebra which could be applied to execute dimensionality lessening automatically [29]. PCA also helps to reduce noisy data from the pre-processed data. PCA is calculated by discovering the components that clarify the highest count of variance, it records the signal from the data and neglects the noise [7].

After applying PCA, the clustering algorithm called k-means is implemented to improve the accuracy of the analysis. The k-means clustering algorithm is best suitable with large dataset. The efficiency of k-means generally based on the silhouette of the obtained clusters. Thus k-mean has an efficient result. For the illustration of k-means, SOM (Self Organizing Map) is used which has a capability to characterize clustering perception by joining the same kind of data together. Finally, the knowledge management supports the business environment to evade the redundant work. Business intelligence and knowledge management helps to set richer goal for the employees by managing the organization info, spreading the opportunity of employee learning, betterment in "intra-company communications".

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Examining E-Commerce Satisfaction and Sales Growth Considering the Role of Trust in Social Commerce

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Abstract: In this study, e-commerce satisfaction and sales growth by considering the role of trust in social commerce are examined. In a trust-based environment, tools such as coercion to secure trades lose their effectiveness. Instead, people are willing to pay back and believe in honesty. Trust fosters market work, increases the willingness of individuals to interact and collaborate with groups, and provides a thriving network of voluntary gatherings. Trust, on the other hand, affects a person's satisfaction, purchase intention, and buying behavior. This study is conducted to examine e-commerce satisfaction and sales growth by considering the role of trust in social commerce. Therefore, a model is proposed to achieve the main goal using structural equation modeling (SEM). The hypotheses are then tested using Amos and 22spss software. In the inferential statistics section, the normal distribution of the variables is first examined using the Smirnov-Kolmogorov test. Since the significance level of all variables is higher than 0.05, it can be claimed that all variables are normally distributed. In the factor analysis section, the sample adequacy is examined using KMO and Bartlett's test. The hypotheses are then tested using Amos software and regression in SPSS software.

Keywords: e-commerce; sales growth; the role of trust in social commerce

1 INTRODUCTION

Nowadays, a good platform for business and economic communication has been provided due to the access of a large number of people around the world to the World Wide Web and the expansion of electronic communications between different individuals and organizations through the virtual world. E-commerce is the main achievement of using ICT in economic fields [7]. Among the essential tools for the realization and expansion of e-commerce are e-services that facilitate e-commerce activities in line with global systems. It can be argued that the realization of e-services is a prerequisite for the implementation of e-commerce. Therefore, the use of electronic systems and the number of users of electronic services are rapidly expanding [9]. E-commerce has provided the basis for quality improvement, faster access to customers, and reducing the cost of customer access. Moreover, the use of e-commerce in business will bring several benefits such as globalization of trade, job creation, expanding market coverage, improving productivity, significantly reducing transaction costs, and increasing sales [2]. The issue of e-trust has become more prominent because of the advent of e-commerce and the conduct of large exchanges through it. E-marketing holds that trust is the main determinant of long-term relationships in online and offline settings [4]. Trust is one of the most important aspects of human relationships that enable participation and cooperation among members of society. Trust accelerates exchanges in various economic, social, and cultural fields, promotes market function, increases the willingness of individuals to interact and collaborate with groups, provides a thriving network of voluntary communities, and affects the development of satisfaction, purchase intention, and buying behavior [6]. In this study, developing e-commerce satisfaction and sales growth is examined by considering the role of trust in social business.

2 THEORETICAL FOUNDATIONS

E-commerce refers to conducting business transactions through the network, especially the Internet. E-commerce goes beyond having a website and includes ordering, job search, recruitment, and information exchange using information technology. In e-commerce, money can be paid both traditionally and electronically [10]. Satisfaction is a person's positive feeling after purchasing a product or service through e-commerce. The desired feeling is due to the confrontation between customer expectations and supplier performance. The customer feels satisfied if the goods and services received by the customer are evaluated at the same level of expectations [8]. Trust is the core of e-commerce. Trust is a major issue in most social and economic interactions, especially in cyberspace where there are process ambiguities [14]. Trust plays an important role in the adoption of e-commerce and SNSs. The need for trust to reduce the risk of both parties in interactions is seen as social technologies such as SNSs and social media spread (Ming et al., 2009). Trust is the result of an organization fulfilling its promises. Furthermore, trust is increased by the openness of an organization to receiving data from others. Key factors of consumer trust and factors affecting the intention of social commerce should be examined due to the increasing popularity and application of social commerce and its important role in online commerce [15].

3 LITERATURE REVIEW

In a study titled the Effect of Social Media Information on Trust, Purchase Intention, and Word-of-Mouth in Social Commerce (Case Study of Instagram Social Network), Mozari Lang (2016) found that content and source of information have a significant positive effect on the credibility of the source and the quality of information at the 95% confidence level. Source credibility has no significant effect on trust. Besides, the quality of information has a

significant positive effect on trust, and trust has a significant positive effect on purchase intention and word-of-mouth. In a study titled The Effect of E-Commerce on Customer Loyalty, Satisfaction, and Trust, Ebrahimi (2015) [3] concluded that e-commerce has a significant positive effect on e-loyalty and e-commerce and there is also a direct relationship between e-commerce (dependent variable) and e-loyalty of customers (independent variable). Bajelani et al. (2017) [1] conducted a study titled The Effect of Social Commerce Characteristics on Trust in Social Commerce (Case Study: Customers of Digi Kala Sanandaj Store). The results showed that there is a significant positive relationship between social commerce characteristics and willingness to participate. The results of multivariate regression also indicated that social commerce characteristics affect trust in social commerce. In a study titled Consumer Behavior in Social Commerce: Results from a Meta-Analysis, Mou and Benyoucef (2021) [11] found that interpersonal trust is more closely related to social commerce than organizational trust. In a study titled The Role of Social Commerce in Online Purchase Intention: The Mediating Role of Social Interactions, Trust, and Electronic Word-of-Mouth, Monfared et al. (2021) [13] concluded that emotional support

affects trust and that trust significantly affects electronic word-of-mouth. Electronic word-of-mouth also significantly affects purchase intention. Attar et al. (2020) [12] conducted a study titled Investigating the Antecedents of E-Commerce Satisfaction in Social Commerce Context and found that trust significantly affects e-commerce satisfaction leading to purchase intention.

4 MATERIALS AND METHODS

This is a descriptive-survey study in which data are collected using questionnaires. The statistical population includes all Digi Kala customers in Tehran, and the sample size is determined using Morgan's Table. Since the study is conducted to examine e-commerce satisfaction and sales growth by considering the role of trust in social commerce, a suitable model is proposed using structural equation modeling (SEM). The hypotheses are then tested using Amos and 22spss software.

5 THE CONCEPTUAL MODEL

The conceptual model is shown in Fig. 1.
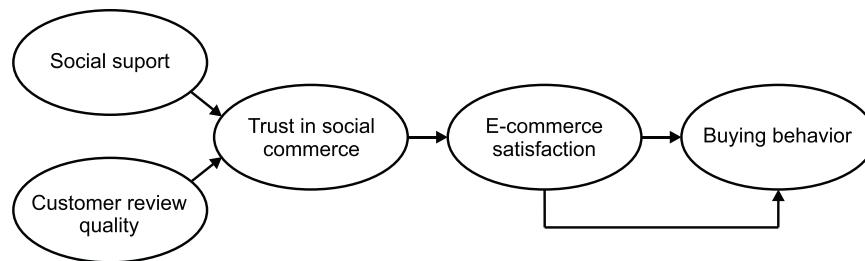
Figure 1 Conceptual Model [5]

6 HYPOTHESES
6.1 The Main Hypothesis

There is a significant positive relationship between trust in social commerce with e-commerce satisfaction and sales growth.

6.2 Sub-Hypotheses

1) There is a significant positive relationship between trust in social commerce and e-commerce satisfaction.
2) There is a significant positive relationship between trust in social business and buying behavior.
3) There is a significant positive relationship between e-commerce satisfaction and buying behavior.

4) There is a significant positive relationship between social support and trust in social commerce.
5) There is a significant positive relationship between customer review quality and trust in social commerce.

7 DESCRIPTION OF VARIABLES

This section provides statistical indicators including mean, standard deviation, and percent error (independent and dependent variables). These indicators can help to better understand the variables.

According to Tab. 1, the maximum mean value belongs to the buying behavior and the minimum mean value belongs to customer review quality.

Table 1 Descriptive statistics of the variables

	Min	Max	Mean	SD	Variance	Skewness	Kurtosis
Social support	1	5	2.6211	0.62293	0.388	1.224	0.841
Customer review quality	1	4.83	2.2878	0.77691	0.604	−0.177	0.617
Trust in social commerce	1	5	2.7491	0.61162	0.374	1.608	0.368
E-commerce satisfaction	1	5	3.1165	0.98484	0.970	−0.423	−0.538
Buying behavior	1	5	3.2439	1.33087	1.771	−1.116	−0.268

8 MODEL EVALUATION

As a first step in performing confirmatory factor analysis (CFA), factor loadings are standardized and significance is checked to ensure that markers are involved in measuring their latent structures, or in other words, are significant. Significant coefficients outside of –1.96 and –1.96 are acceptable for markers, and the standard factor loadings are the same as the regression coefficients of the latent variable path to the marker, which must be greater than 0.3. However, some references consider the minimum acceptable value to be 0.5.
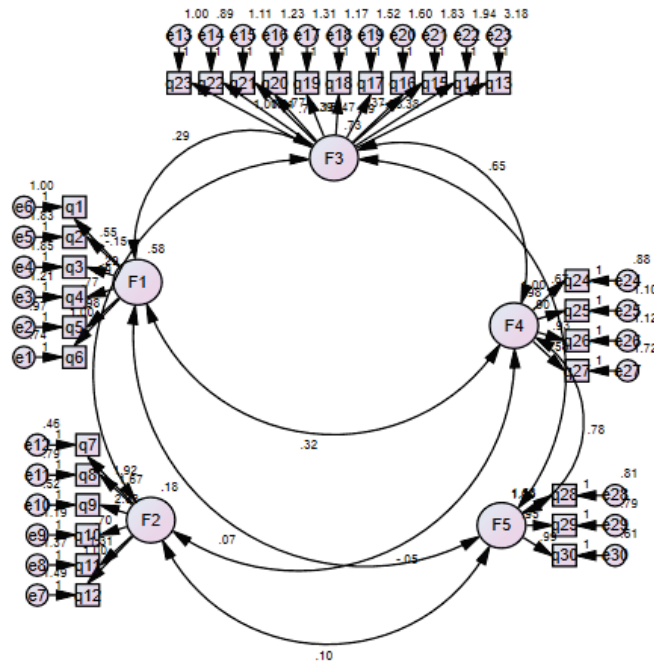
Figure 2 Standard coefficients of measurement model variables

There must be a significant correlation between the index and the dimension to achieve validity. The standard estimation model is obtained by matching the two-covariance matrices of the data model and shows the actual estimation of the model parameters. In this model, the degree of correlation between the index and the dimension and vice versa is shown. The standardized coefficient measurement model (Fig. 2) indicates that there is a significant correlation between latent variables and their corresponding indices. Standardized coefficients represent standardized path coefficients or factor loadings between factors and markers. The coefficients between the questions and the variables are the standardized coefficient, indicating the degree of ability to measure each index in the variable.

Significance coefficients indicate the significance of the relationships between variables. If these coefficients are between –1.96 and 1.96, they indicate the inability of the index to measure the corresponding variable. Tab. 2 shows the factor loading values along with their significance values.

As can be seen in Tab. 2, the values of the significant coefficients (t-value) for all items are out of range (1.96, –

1.96). Therefore, markers are involved in measuring their latent structures, or in other words, are significant.

Table 2 CFA results

Variables	t-value	Significance
Question 1	5.620	0.000
Question 2	2.358	0.000
Question 3	2.511	0.000
Question 4	6.492	0.000
Question 5	7.428	0.000
Question 6	7.068	0.000
Question 7	5.873	0.000
Question 8	5.632	0.000
Question 9	5.900	0.000
Question 10	3.824	0.000
Question 11	4.970	0.000
Question 12	5.006	0.000
Question 13	3.104	0.000
Question 14	6.858	0.000
Question 15	3.984	0.000
Question 16	5.438	0.000
Question 17	5.329	0.000
Question 18	5.077	0.000
Question 19	2.019	0.000
Question 20	8.209	0.000
Question 21	8.609	0.000
Question 22	10.443	0.000
Question 23	5.006	0.000
Question 24	6.159	0.000
Question 25	10.968	0.000
Question 26	11.104	0.000
Question 27	6.989	0.000
Question 28	5.113	0.000
Question 29	16.544	0.000
Question 30	17.360	0.000

9 FITTING THE STRUCTURAL MODEL AND TESTING THE HYPOTHESES

Fig. 3 shows the structural model in which the estimated regression coefficients between the structural model variables are displayed.

Tabs. 3 and 4 summarize the results of the structural model fitting.

According to Tab. 4, all fitted indices of the model are in the desired range.

Hypothesis 1: There is a significant positive relationship between trust in social commerce and e-commerce satisfaction.

H0: There is no significant positive relationship between trust in social commerce and e-commerce satisfaction.

H1: There is a significant positive relationship between trust in social commerce and e-commerce satisfaction.

According to the table above, the standard regression coefficient is 0.294 and the t-value is 5.238, indicating that trust in social commence has a significant direct effect on e-commerce satisfaction at a significant level of 5 (because the significance level is less than the test level of 0.05 and the sign of regression coefficient is positive). It can be argued that since the significance level is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is confirmed. In other words, there is a significant positive relationship between trust in social commerce and e-commerce satisfaction.

Hypothesis 2: There is a significant positive relationship between trust in social commerce and buying behavior.

H0: There is no significant positive relationship between trust in social commerce and buying behavior.

H1: There is a significant positive relationship between trust in social commerce and buying behavior.

According to the table above, the standard regression coefficient is 0.673 and the t-value is 7.474, indicating that trust in social commence has a significant direct effect on

buying behavior at a significant level of 5 (because the significance level is less than the test level of 0.05 and the sign of regression coefficient is positive). It can be argued that since the significance level is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is confirmed. In other words, there is a significant positive relationship between trust in social commerce and buying behavior.

Figure 3 The values of the standard coefficients of the relationships between the variables in the structural model

Table 3 Results of the structural model fitting

Relationships between concepts and indicators in the model	Standard coefficient	t-value	Significance
There is a significant positive relationship between trust in social commerce and e-commerce satisfaction.	0.294	5.238	0.000
There is a significant positive relationship between trust in social commerce and buying behavior.	0.673	7.474	0.000
There is a significant positive relationship between e-commerce satisfaction and buying behavior.	0.781	7.842	0.000
There is a significant positive relationship between social support and trust in social commerce.	0.099	2.688	0.000
There is a significant positive relationship between customer review quality and trust in social commerce.	0.315	5.008	0.000

Table 4 Model fit indices

Index	The desired range	Reported value
The goodness of fit index (GFI)	0.9 or higher	0.90
The softened fitness index (NFI)	0.9 or higher	0.90
The non-softened fitness index (NNFI)	0.9 or higher	0.91
The incremental fit index (IFI)	0.9 or higher	0.92
The comparative fit index (CFI)	0.9 or higher	0.91
The root mean square error of approximation (RMSEA)	Less than 0.1	0.043

Hypothesis 3: There is a significant positive relationship between e-commerce satisfaction and buying behavior.

H0: There is no significant positive relationship between e-commerce satisfaction and buying behavior.

H1: There is a significant positive relationship between e-commerce satisfaction and buying behavior.

According to the table above, the standard regression coefficient is 0.781 and the t-value is 7.842, indicating that e-commerce satisfaction has a significant direct effect on buying behavior at a significant level of 5 (because the significance level is less than the test level of 0.05 and the

sign of regression coefficient is positive). It can be argued that since the significance level is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is confirmed. In other words, there is a significant positive relationship between e-commerce satisfaction and buying behavior.

Hypothesis 4: There is a significant positive relationship between social support and trust in social commerce.

H0: There is no significant positive relationship between social support and trust in social commerce.

H1: There is a significant positive relationship between social support and trust in social commerce.

According to the table above, the standard regression coefficient is 0.099 and the t-value is 2.688, indicating that social support has a significant direct effect on trust in social commerce at a significant level of 5 (because the significance level is less than the test level of 0.05 and the sign of regression coefficient is positive). It can be argued that since the significance level is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is confirmed. In other words, there is a significant positive relationship between social support and trust in social commerce.

Hypothesis 5: There is a significant positive relationship between customer review quality and trust in social commerce.

H0: There is no significant positive relationship between customer review quality and trust in social commerce.

H1: There is a significant positive relationship between customer review quality and trust in social commerce.

According to the table above, the standard regression coefficient is 0.315 and the t-value is 5.008, indicating that customer review quality has a significant direct effect on trust in social commerce at a significant level of 5 (because the significance level is less than the test level of 0.05 and the sign of regression coefficient is positive). It can be argued that since the significance level is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is confirmed. In other words, there is a significant positive relationship between customer review quality and trust in social commerce.

10 CONCLUSION

According to the results, Hypothesis 1 that there is a significant positive relationship between trust in social commerce and e-commerce satisfaction is confirmed due to having a significance level of less than 0.5. As a result, it can be argued that there is a significant positive relationship between trust in social commerce and e-commerce satisfaction. Moreover, Hypothesis 2 that there is a significant positive relati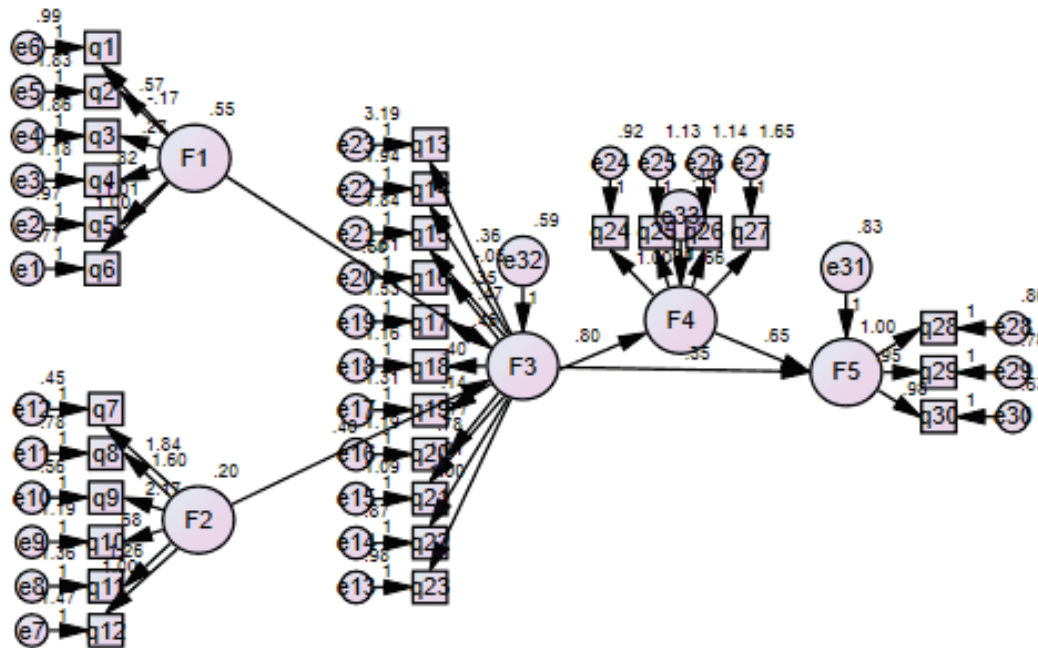onship between trust in social commerce and buying behavior is confirmed. Therefore, it can be argued that there is a significant positive relationship between trust in social commerce and buying behavior. The results also indicate that Hypothesis 3 that there is a significant positive relationship between e-commerce satisfaction and buying behavior is confirmed due to having a significance level of less than 0.05. Therefore, it can be argued that there is a significant positive relationship between e-commerce satisfaction and buying behavior. Based on the results, Hypothesis 4 that there is a significant positive relationship between social support and trust in social commerce is confirmed. Therefore, it can be argued that there is a significant positive relationship between social support and trust in social commerce. Furthermore, Hypothesis 5 that there is a significant positive relationship between customer review quality and trust in social commerce is confirmed due to having a significance level of less than 0.05. Therefore, it can be argued that there is a

significant positive relationship between customer review quality and trust in social commerce.

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Design of Information Visualizations in the Internet of Nano-Things Air Quality Systems

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Abstract: Today's age is characterized by large amount of information that surrounds us in which visual information plays a significant role. Nanosensor air quality measurement systems that use Internet of Nano-Things technology enable the collection of big data. Ease of display and storage of information that the user can easily interpret are imperative in designing a visual interface. Only a good combination of visual elements complemented by data and map display will contribute to the clarity of the processed data. This paper will give an overview of the factors that affect the excellence of the transmission of visual information. Ways of presenting visualizations of air quality data measured by IoNT systems will be discussed through descriptive and empirical analysis of visualizations. A special emphasis is on the review of existing practices and principles, and the possibilities of visual presentation of information in this area will be explained through the discussion.

Keywords: air quality; design; information visualization; IoNT; nanosensors

1 INTRODUCTION

Air pollution rose sharply after the first industrial revolution [1]. Development of new production processes, increased transport of people and goods, and use of energy are the factors that contributed to the rise of this problem [2]. This rough division in a way also speaks about the pollutants that are dominant in the air during these processes. Everything mentioned above led to the need for quantitative and qualitative measurements of air pollutants. As the need for these measurements grew, measurement methods evolved, and new technologies emerged, and are still emerging.

One of the significant technologies in this field is the technology that uses the Internet of Nano-Things (IoNT) system. The mentioned technology uses nanomaterials, which in relation to the traditional ones (materials whose particles are greater than 100 nanometers) have the characteristics of desirable required properties that their size brings them. Materials of molecular or atomic sizes from 1 to 100 nanometers are used which is the main feature of nanotechnology [3-6]. In addition to their specific size after which they got their name, they owe their properties also to their shape and composition [7, 5].

Examples of the special properties of nanomaterials can be observed in nature and phenomena from our environment. Thus, some examples of nanotechnology in nature are the lotus flower that "repels" water, is always clean, and cannot get wet (the so-called lotus effect), a lizard that climbs on a smooth surface, and butterfly wings that change color [5]. Preferred properties for materials used in IoNT are characterized by increased selectivity and sensitivity in the detection of air pollutants. Nano-devices used in the IoNT system are in charge of performing all functional tasks [8].

The idea of IoNT was presented by Ian F. Akyildiz and Josep M. Jornet in the paper *The Internet of Nano-Things* as a combination of a network of physical objects that exchange data through nano-communication [3]. The components of the IoNT network change depending on the context [9]. Nevertheless, we can define elements that are always needed and used frequently. Thus, Akyildiz and Jornet [3] presented the components and architecture of an IoNT system consisting of nano-nodes, nano-routers, nano-links, nano-micro interfaces, gateways, and micro-links.

The most important parts are nano-nodes, nano-routers, nano-micro interfaces, and gateways. Nano-nodes are sensors and at the same time the smallest and simplest nano-devices that perform certain tasks [6]. Nano-routers control the nodes by aggregating the data obtained from them and can control the behavior of the nodes via simple commands (on and off, read values, etc.) [10]. Nano-micro interfaces enable the reception and transmission of information coming from nano-routers and perform a hybrid function by communicating using nano-communication and conventional network communication, while gateways are responsible for controlling the system remotely [11].

The ideal sensor would have features of high sensitivity, dynamic range, selectivity and stability, low detection limit, good linearity, fast response, and long life cycle [12]. The most common classifications of nanosensors are according to the conversion mechanism, recognition principle, and application [13]. According to the conversion mechanism, they are divided into electrical, optical, thermal, piezoelectric, etc., according to the principle of recognition into enzymatic, biological, molecular, etc., and according to the application to environmental, food, medical, etc. [14].

A well-designed graphical interface allows the viewer ease of perception and using and storing large amounts of data collected using nanosensors. The aim of this paper is to present information visualization methods obtained in the field of air quality control and to raise awareness of the importance of the role of information visualization in quality transmission of information. To review the role of visualizations within the IoNT system that measures air quality, a systematic study of the relevant literature and existing solutions was conducted. The keywords used were: nanotechnology, nanosensors, communication, IoT, IoNT, information visualization, data visualization, visual perception, air pollution, and air quality. In the second part of the research, we conducted a two-part research consisting of a descriptive and empirical analysis.

2 APPLICATION OF NANOSENSORS IN AIR QUALITY MEASUREMENT

Air quality refers to the measurement of the state of the air in relation to human needs and is related to health. Pollution is used to describe substances that lower the air quality [15]. Nanosensors are used to monitor and identify air pollution in high concentrations for the purpose of monitoring toxins, heavy metals, and organic pollutants in air, water, and soil [13, 16, 9]. The most common air pollutants that are measured are ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, ammonia, and volatile organic compounds (VOCs) [12].

Detection of air pollution requires the simultaneous detection of oxidizing and reducing gases in the presence of many potentially interfering molecules under stable conditions [17]. Nanonetwork enables air quality control and management [10]. The current problems of air quality sensors are the lack of sensitivity, accuracy, and stability, and the reduction of these problems lies in nanomaterials [14]. In many cases, nanosensors have proven to be an effective alternative to conventional pollution detection techniques, so metals and metal oxides can be used as electrochemical sensors due to their oxidizing form to detect toxins from the environment [12, 13]. For the detection of nitrogen dioxide, a nanostructured sensor based on a metal oxide semiconductor is mentioned in the literature, and a nanostructure-based tin oxide sensor with excellent selectivity, stability, and fast response time is good for the detection of formaldehyde [12].

Many sensors are needed to cover one city and although the costs are low, the implementation potential is demanding [16]. Due to the rapid development of this area, all these items are evolving and improving every day.

3 INFORMATION VISUALIZATIONS USED IN THE IoNT SYSTEM

The human visual system is based on a complex information processing system designed to optimally extract environmental information [18]. Interpretation of visual information with the use of an optimal combination of visual-artistic, empirical-statistical, and mathematical skills enables easier interpretation of the measured data [19]. Using and combining the mentioned skills, the designer creates an abstract visualization of the data that gives the user the ability to detect patterns, groups, gaps, and deviations within the statistical data [20].

William Playfair is considered the founder of graphical methods of statistics because he developed or improved almost all basic types of visualizations [19]. The basic types of visualization are graphs, maps, network diagrams, and composites [21]. Graphs are the most used type of visualization in data analysis, and some of the most used graphs are line graphs, bar graphs, scatter plots, heat maps, etc. [21]. On the graph, the data are coded with symbols that have a different shape, length, width, height, position, slope, area, angle, color, and shade [22, 23]. A typical graphical representation of information provides two spatial and three

dimensions of color [24]. One of the ways of displaying information is through interaction which allows a quick search of the information network, but if the information can be perceived without interaction, then the cognition process will be the fastest [25]. Woods defined cognitive tools that support control and focus attention through accessibility, partial information, and mental economics. Through accessibility, the user perceives information without losing attention, through partial information he decides whether to redirect his attention, and through mental economy he processes information without cognitive effort [26].

Some visualizations have turned into Norman's [27] everyday things, have already existed for centuries, and their functioning has been explained to us in elementary school (line graphs, pie charts, etc.) [28]. Some of the prominent authors within the field of information visualization such as Alberto Cairo, Cole Nussbaumer Knaflic, Ben Shneiderman, Edward Tufte, and Colin Ware, have presented their principles for information visualization which are used today. Thus Cairo [22] emphasizes five qualities of excellent visualizations: truthfulness, functionality, aesthetics, insight, and enlightenment. Nussbaumer Knaflic [29] singles out six key steps in visualizing information: understanding the context, choosing an appropriate visual representation, removing clutter, focusing on specific places, thinking like a designer, and telling a story. Shneiderman [20] presents the Shneiderman mantra of overview first, zoom and filter, then details on demand, while Tufte [19] presents his data-ink ratio, which represents the proportion of ink graphics dedicated to the non-redundant display of data.

Ware [21] divided the visualization process into seven basic steps: description of high-level cognitive tasks, data inventory, analysis of cognitive task requirements, identification of visualization types, recognition and selection of cognitively effective interaction methods, prototyping and application, and evaluation. Through visualizations, we display data, lead the observer to think about the substance, avoid data deformation, display a large amount of data in one place, encourage the human eye to compare different types of information, and discover data through different levels [19]. Only by applying all the above-mentioned parameters can we design a visualization that will be useful and understandable to the observer.

4 EXAMINING AIR QUALITY INFORMATION VISUALIZATIONS IN THE IoNT SYSTEM

Nanosensors collect, accumulate, and transmit data over the Internet to the graphical interface. The interface is a medium through which the user can interpret the collected data and it is therefore important that the data is visualized accurately, and that the user can extract certain insights from them. Users that use air quality interfaces are the commercial users (the public) who are interested in receiving information about the air quality in their environment, but also experts who analyse this information. Our research was conducted in two stages. In the first stage we used a descriptive analysis to analyse existing portals which use air quality data visualizations. In the second stage we conducted an empirical

research in which we examined the visual perception and attitudes of the respondents related to the visualization of air quality data. Data were collected in year 2022 on a sample of 59 respondents, of which 35 (59%) were female, and 24 (41%) male. The age group was diverse, with 17 (28%) of respondents being from age 18 to 25, 18 (31%) from 26 to 35, 18 (31%) from 36 to 55, and 6 (10%) above 56 years old. We used a survey for the data collection process, and a questionnaire consisting of 14 questions (single selection, multiple selection, Likert scale) for the instrument. The goal was to examine the respondents' visual perception of air quality data visualizations. We wanted to examine and define to which extent the participants use these kinds of information and in which way they perceive them. Given all the above, we set two hypotheses:

H1: There is no difference in the degree of agreement with the display of clarity and understandability between visualization.

H2: The colors used in all visualizations are understandable to respondents.

4.1 Descriptive analysis

In the first stage of the research, we analysed six different platforms that use air quality data visualizations. The human visual system is cognitively more effective if there is a particular external artifact such as a map, shown in Fig. 1, rather than just a mental image of certain data [30]. The visual elements shown in Fig. 1 and Fig. 2 show that a combination of a map and different visual elements can provide good pollution measurement information regardless of the size of the area for which the data is displayed, or whether it is a local or global representation of pollution. The differences between the two views are found in the selected visual elements. In the local view, color and geometric shapes were used, while in the global view, only color was used. It is very likely that on the global display the geometric figures would not be legible and would not contribute to the ease of information transfer, which is not the case with local displays.
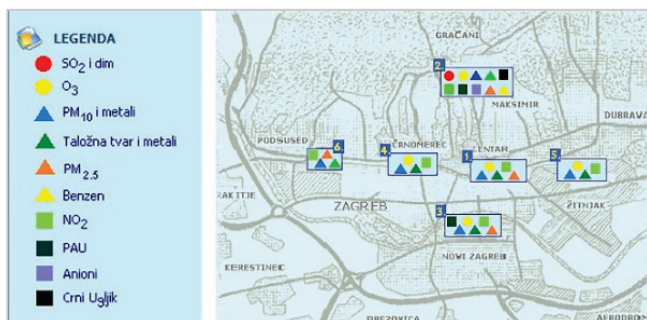
Figure 1 Example of pollution on a map, overview of locations and types of pollutants on permanent measuring stations in Zagreb [31]

Statisticians need to know the structure of certain data before they start applying analytical procedures and techniques, and the graph has proven to be the best tool for exploratory data analysis [33]. The mentioned data

visualization techniques provide visual representations of data that can convey information directly and intuitively to the user [34].
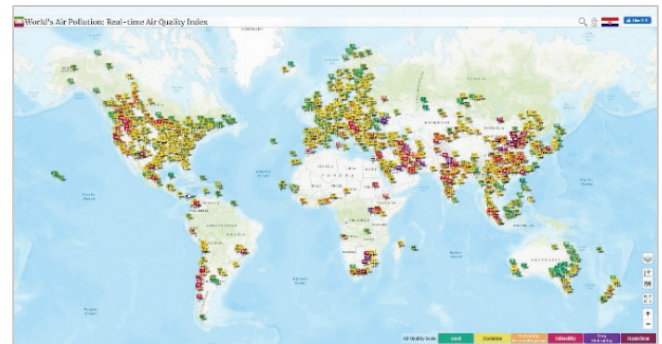
Figure 2 Example of pollution on a map, display of measurement results of pollution in the world on the World's Air Pollution portal [32]
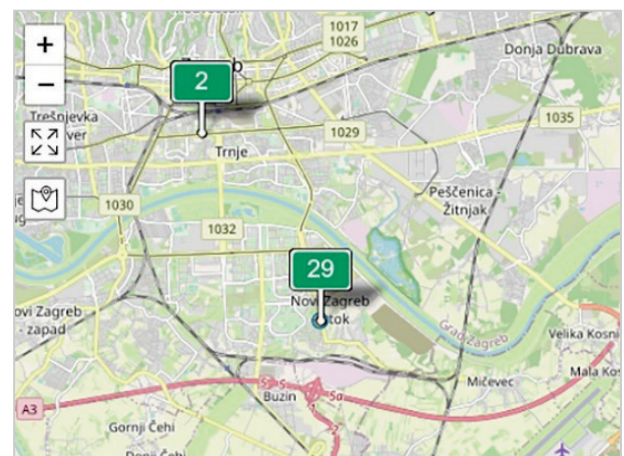
Figure 3 Pollution display in Zagreb, map display with the total pollution index [32]

Sometimes several types of pollutants and their concentrations are measured to assess air quality, such as small particles (PM 2.5), large particles (PM 10), ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, and pollution index (AQI). When representations need to contain multiple variables, displays such as simple numerical representations, line graphs, bar graphs, stacked bar charts, area graphs, maps, heat maps, and scatter diagrams are often used, as seen in Fig. 3 and Fig. 4. In the mentioned representations, a process of visual mapping of information is required, which includes a phase of data pre-processing for cleaning, selection, formatting, and normalization of raw data [34]. This is followed by mapping data objects into visual objects and selecting visual properties that represent data attributes, followed by the user's use of information [34].

Hu et al. [35] designed a *HazeWatch* system based on a portable sensor and communication technologies. The system analyses the data through the visualization of pollution of a certain area on the geographical map and the visualization of personal exposure. A map with the area of pollutant presence is used to visualize the concentration of pollutants, while an area graph was used to show personal exposure, see Fig. 5. By combining the mentioned display modes, optimal visual visibility of the data was obtained.
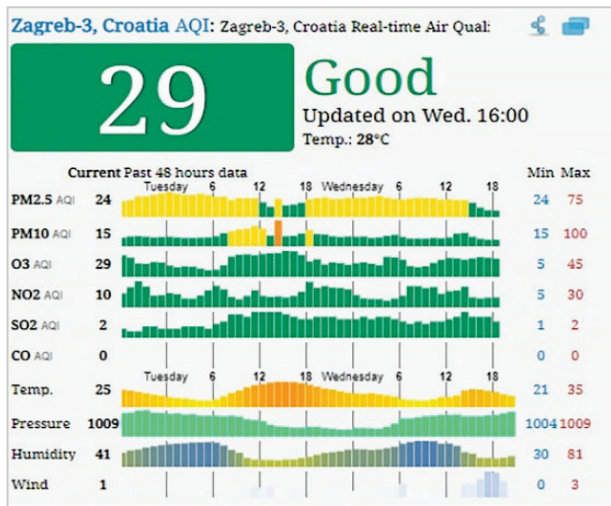
Figure 4 Pollution display in Zagreb, bar graphs of air quality at a particular location [32]
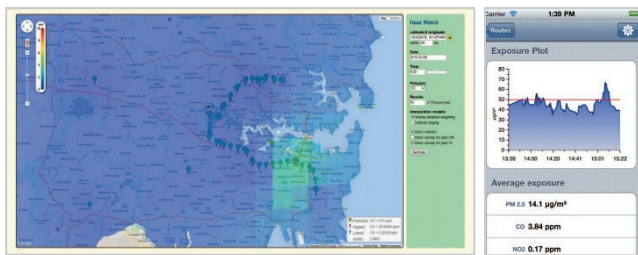
Figure 5 Pollution display in the HazeWatch application, display of pollutant concentration on a map (left), personal exposure display (right) [35]

Table 1 Modified scheme of the hierarchy of perceptual tasks according to the scheme of Alberto Cairo [22]

When choosing in which way to present certain information, it is important to consider the hierarchy of elementary perceptual tasks (coding methods) [22]. Cairo [22] presented a modified hierarchy scheme, see Table 1, originally designed by statisticians William S. Cleveland and Robert McGill in the 1980s. Using a hierarchy scheme, one can define which representation is required for a particular type of data depending on the perceptual task the observer is performing. The displayed table indicates the premise that as the position of the visualization mode within the scheme increases, the observer will interpret the information faster and more accurately [22]. Nevertheless, the use of visualization elements located at the bottom of the table does

not necessarily result in poor visual representation. Cairo [22] points out that the methods in the lower part of the table are appropriate when the goal is not to define accurate estimations but to detect general samples, which is most often the case with air quality measurement displays.

For the analysis of air quality measurement visualizations used in this paper we used visualization available on web-based Croatian platforms such as the portal of the Ministry of Economy and Sustainable Development [36], Eco Map of Zagreb [37], State Meteorological Institute [38], Air Quality Monitoring in the City of Zagreb [31] and World Air Pollution [32]. Also, in addition to these platforms we also analysed the mentioned *HazeWatch* system [35] that has a mobile application.

What is needed for a visualization to be good is reliable information that is visually coded in such a way that the relevant patterns become noticeable, that research is enabled, and that it is presented attractively with clarity in the first place [22]. All the mentioned information visualization interfaces rely on graphically coded device dimensions such as shape, color, size, texture, orientation, and position, and these schemes can be effective in enabling information analysis [39]. Thus, we can observe that in systems in which air quality measurements are visualized, shapes and colors are used as the main visual coding dimensions, as shown in Fig. 6. Shapes and colors give an easy insight into local areas with polluted air, especially when the location can be determined relatively accurately (streets, squares, etc.).

If the data collected by nanosensors are related to entities and their attributes, then graphs that display attributes (on a graph or a map) are suitable for displaying such data, which is visible on the Eco Map of Zagreb portal.
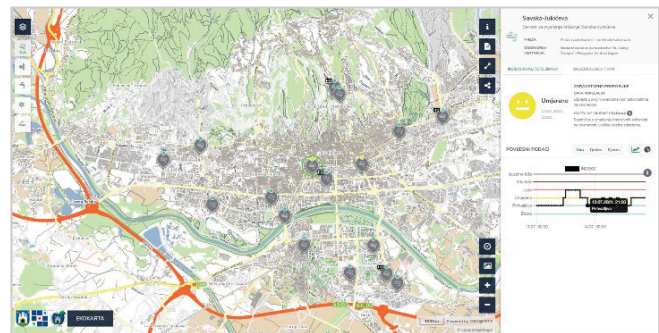
Figure 6 Air quality index display and map on the Eco Map of Zagreb portal [37]

A visual representation such as a map is much easier to use than a textual description when more information needs to be displayed [20]. Displaying data on a map is suitable if spatial data are obtained and it is necessary to define a specific area. An example of such a visualization is visible on the platform of the Ministry of Economy and Sustainable Development, see Fig. 7, in which a map was used as the main presentation medium. The platform can change the way data is displayed through a map, bar graph, line graph, and pie chart. This example provides an insight into the platform in which the user chooses how to display the data and can select the views that he needs at a certain time.

On the map display, a map legend is placed with a description of the gradation of the air quality index through which the information categories are defined (seven terms that are color-coded). It is recommended that no more than eight colors be used to define information categories [39], which was respected in this information visualization. The visual element of color in this example plays an extremely important role and significantly contributes to the ease of perceiving information. Grouping information by color is easy to format, but also clear to the end-user.
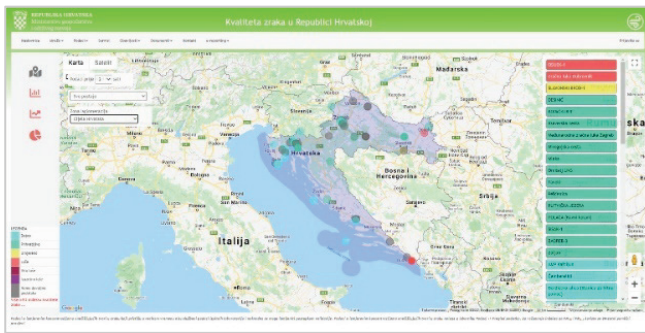
Figure 7 Republic of Croatia air quality display on the Ministry of Economy and Sustainable Development portal [36]

On the map of the Ministry of Economy and Sustainable Development portal, geometrical color-coded shapes were used to display air quality index of certain areas.
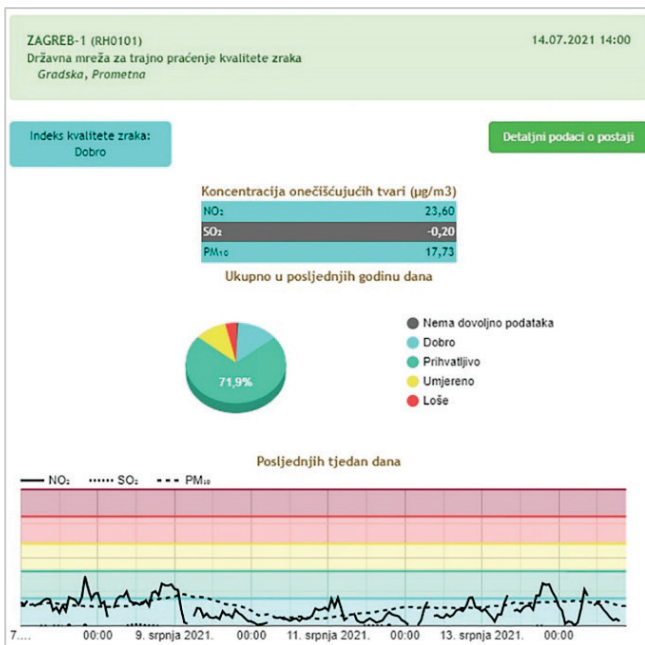
Figure 8 Republic of Croatia air quality display on the Ministry of Economy and Sustainable Development portal [36]

More detailed information can be obtained by clicking the specific shapes, as seen in Fig. 8. This way of presentation is in accordance with the Schneiderman mantra [20]. If the data are time-related, line graphs are suitable for such data display because they display change of data over a period of time. Precisely this way of display was used to display more detailed information about a certain area where the

concentrations of pollutants are shown within a multiple line graph, and certain values are highlighted through a numerical display. It can be observed that in the visualization of information in air quality measurement systems, color is a very important element.

To show the relationship between the data sets on the Ministry of Economy and Sustainable Development portal, pollutant indexes can be viewed through a stacked bar chart, as shown in Fig. 9. The graph shows pollutants and their air quality indexes through five color-coded categories. It can be observed that the use of color leads to a very efficient and fast interpretation of information.
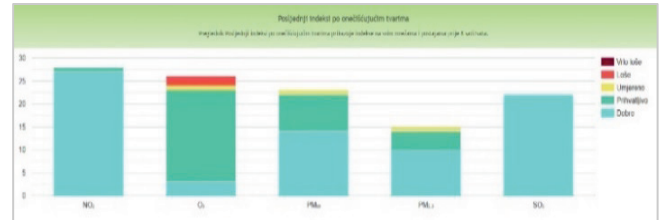
Figure 9 Index display by pollutants on the portal of Ministry of Economy and Sustainable Development portal [36]

If the data obtained from the nanosensors are related to a data network then a line graph or an area graph can be used, as shown in Fig. 10.

Figure 10 Overview of small particles concentration in Zagreb on the State Hydrometeorological Institute portal [38]

Heat maps use color-coding to display categorical data and are also suitable for displaying a data network if one wants to highlight the concentrations of pollutants in the air, see Fig. 11. If multiple types of data need to be displayed, then it is necessary to use complex visualizations (composed of multiple types). Information visualization must possess graphical excellence that refers to a well-designed data display that gives the viewer the most ideas in the shortest time with the least ink in the least amount of space [19]. It is important to emphasize that despite all the guidelines and how well a particular visualization is designed, it cannot withstand the test of being shown to an inattentive, careless, or uninformed viewer [28].
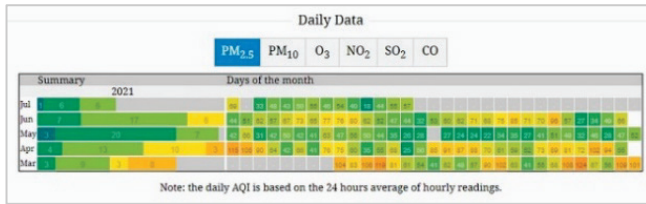
Figure 11 Overview of small particles concentration in Zagreb on the World's Air Pollution portal [32]

4.2 Empirical analysis

In the second (empirical) stage of the research we used a survey that consisted of question regarding the use of air quality information and questions related to five air quality information visualizations. Out of the 59 respondents, 3 (5%) of them stated that they monitor air quality data, 42 (71%) that they sometimes monitor air quality data, while 14 (24%) of them do not monitor air quality data. From the frequency of monitoring air pollution data (AM=1.9) we can conclude that respondents sometimes monitor such data. Also, respondents cite various media through which they monitor air quality data. Most respondents often use web portals (33, 58%), then TV news program (24, 42%), mobile weather forecast applications (16, 28%) and to a lesser extent smart watches (2, 4%) and social networks (1, 2%). From the above results, it can be concluded that the respondents review the data during the review of other general news on web portals or TV. Awareness of the importance of data is evolving, which is confirmed by the following answer, where two groups of respondents are almost equally represented. Those groups are respondents that monitor air pollution data sometimes (23, 40%) and due to warnings about increased concentrations of pollutants (23, 40%), while to a lesser extent they monitor them before external physical activity (4, 7%), daily (2, 4%), or when there is fog outside (2, 4%).

From the data that respondents most often follow, they state that "they do not inspect certain pollutants individually, but cumulatively" (29, 51%), while they equally emphasize the monitoring of carbon dioxide, small particles (PM 2.5),

large particles (PM10), and ozone (7, 12%). Some respondents follow data on sulfur dioxide (5, 9%), and some on nitrogen dioxide and volatile organic compounds (2, 4%). The obtained results indicate that the respondents were not sufficiently informed on how a particular pollutant affects health or the environment, but for now general information on air quality is enough. Respondents rate their competencies for reading and understanding visual representations (visual literacy) as relatively good (AM = 2.9). In the questions related to the visualizations, we used the existing visualizations from some of the mentioned analysed portals, VIZA [32], VIZB and VIZC [36], VIZD [37] and VIZE [40]. Respondents were required to express a degree of agreement with four statements. The statements were: (1) Visual display of data is clear. (2) Information is obtained quickly through the visual display. (3) Air quality data are presented in a clear and understandable way. (4) The colors used in the visual display are understandable. Through these questions we wanted to examine our two hypotheses. From the results, see Table 2, we can conclude that VIZE is the most understandable and clear to the respondents, while VIZC is the least understandable to them. Based on this information we can refute our first hypothesis (H1) that stated that there is no difference in the degree of agreement with the display of clarity and understand ability between the five visualizations. Even though the degree of agreement with the statements is relatively similar for VIZA, VIZB and VIZD, VIZC and VIZE have a different degree of agreement. The reason behind this could be the fact that VIZC is the only visualization that used a bar chart which was less clear to the respondents than the other visualizations. On the other hand, the simplest visualization (VIZE) that used simple color-coded numerical representations for air quality data display was the clearest to the respondents. They also stated that information is obtained quickly in VIZE, that the data are presented in a clear and understandable way and that the colors are the most understandable in this visualization in comparison to the others. If we compare the fourth statement results, we can conclude that the colors used in all visualizations are understandable to respondents and

Table 2 Degree of agreement with the statements (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), comparison of all visualizations (average scale values, arithmetic mean (AM) and scatter (SD))

Statements	VIZA		VIZB		VIZC		VIZD		VIZE	
	AM (1-5)	SD	AM (1-5)	SD	AM (1-5)	SD	AM (1-5)	SD	AM (1-5)	SD
1. Visual display of data is clear.	3.27	1.08	3.47	1.10	2.93	1.36	3.46	1.28	3.90	.96
2. Information is obtained quickly through the visual display.	3.42	1.05	3.53	1.10	2.85	1.31	3.47	1.18	3.83	1.02
3. Air quality data are presented in a clear and understandable way.	3.42	1.09	3.34	1.18	2.80	1.34	3.56	1.22	3.88	.99
4. The colors used in the visual display are understandable.	3.71	1.25	3.58	1.19	3.25	1.29	3.63	1.11	3.80	1.11

therefore we can confirm our second hypothesis (H2). All visualizations show a scattered response, except for VIZE where responds for statements (1) and (3) are not scattered. Finally, respondents to a large extent (51, 86%) believe that it is good to have an overview of the future trend of pollutant concentration available in such visual representations, while a smaller number point out that they do not care (7, 12%) and that it is not good (1, 2%). Based on this result, we believe that such data should be included in the visualizations so that the users can plan their activities.

5   DISCUSSION

Through the presented examples, principles, and analysis of information visualization, ways of visualization of air quality measurement information are explained in the IoNT system. Since the most important aspect in the field of information visualization is the visual perception and understanding of what is seen, we can draw conclusions regarding the interpretation of data related to air quality based on the descriptive and empirical analysis that we conducted. When defining any visualization, it is important to emphasize that while perceiving visualizations, our previous knowledge and expectations play a crucial role [23]. Design of visualizations is not only based on principles, but also on a combination of multiple factors [41]. Prior knowledge and existing mental models are important in any data visualization. Psychologist Stephen Kosslyn presented the principle of appropriate knowledge in which effective communication between a designer and an observer requires a shared understanding of what the graph represents and how the data is coded or symbolized on the graph [23]. The level and degree of understanding certain information visualizations largely depend on the expertise of the visualizations themselves and the viewer. For this reason, we cannot generalize when it comes to understanding data visualizations. Given the type of data related to the measurement of air quality and obtained through nanosensors, it is important to know how to choose the right way to display information.

It can be said that there is no one right way of displaying certain information, but rather that it depends on what should be conveyed to the user. The choice of display depends on how the designer wants to present and communicate certain data. When choosing a display, it is necessary to decide what information needs to be highlighted or displayed and then choose a visualization accordingly. The role of information visualization in systems in which air quality is measured is very important because the user is in direct contact with the visualizations. If the information is not clear to the observer, it will also not be useful to him. It is therefore essential to synthesize the latest research and current practices to provide designers with the knowledge needed to design complex visualizations such as those related to information collected via the IoNT system. Based on the results of the empirical analysis, we can conclude that users perceive simple color-coded numerical representations which display cumulative air pollution data as the most clear and understandable. On the other hand, a stacked bar graph showing different cities

and their pollution index in the span of a year was less clear to the participants who expressed a lower degree of understanding the displayed information. From the results we can see that none of the visualizations have the arithmetic mean equal or higher that four. This means that further research is needed to examine which of the visualization elements can be improved to be clearer the end-user.

The air quality measurement system intertwines the fields of nanotechnology, Internet of Nano-Things, and information visualization. These facts lead to the merging of different disciplines and the need for mutual understanding by all participants involved in the process. In the interdisciplinarity of the field lies the challenge of visualizing complex data that are nowadays increasing more and more. In order not to get lost in the sea of meaningless data, it is the responsibility of designers to present them in a true, clear, and useful way to the users who will then be able to draw their conclusions and ask new questions. Since this field is relatively new, the limitation of this research is the lack of literature which combines all the mentioned fields. Also, previous knowledge and expectations of users, as well as the lack of interactivity of visualizations in the survey, were a limiting factor in the empirical analysis.

6   CONCLUSION

Air quality monitoring has become a global imperative. IoNT systems have greatly contributed to the simple and effective solution of such a complex problem. These systems provide a quick and more parametric insight into air quality that can be applied to all locations on the planet. Problems with IoNT air quality monitoring arise in the processing and visualization of data, which an unqualified user should be able to interpret and use in everyday life. Designers have a significant role in solving this problem by using the knowledge of psychologists, mathematical and environmental engineers and trying to present the information to the general public in a user-friendly way. The information visualization of the mentioned data is complex due to the need to present qualitative and quantitative air quality data that are combined with geographical data. Proper selection of visual elements along with a good visualization process, can enable the user a high level of cognitive perception. The choice of visual display depends on the amount and type of information that needs to be visualized. For further research, we propose a more extensive empirical analysis which would include a test with different variables in specific graphs used in air quality information visualizations (e.g. color used in a bar chart). Also, interactive visualizations would bring us more conclusions regarding visual perception since these visualizations mostly exist inside an interactive environment. Furthermore, it would be interesting to research whether visualizations showed on mobile devices are perceived differently than those on a desktop which is what we focused on in this research. Finally, we recommend developing new types of information visualizations by combining the most successful parts of existing visualizations (based on our empirical research results) or designing fully innovative visualizations.

This will contribute to the clarification of which elements are most effective for perception and understanding of air quality data.

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Detecting Arabic Offensive Language in Microblogs Using Domain-Specific Word Embeddings and Deep Learning

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Abstract: In recent years, social media networks are emerging as a key player by providing platforms for opinions expression, communication, and content distribution. However, users often take advantage of perceived anonymity on social media platforms to share offensive or hateful content. Thus, offensive language has grown as a significant issue with the increase in online communication and the popularity of social media platforms. This problem has attracted significant attention for devising methods for detecting offensive content and preventing its spread on online social networks. Therefore, this paper aims to develop an effective Arabic offensive language detection model by employing deep learning and semantic and contextual features. This paper proposes a deep learning approach that utilizes the bidirectional long short-term memory (BiLSTM) model and domain-specific word embeddings extracted from an Arabic offensive dataset. The detection approach was evaluated on an Arabic dataset collected from Twitter. The results showed the highest performance accuracy of 0.93% with the BiLSTM model trained using a combination of domain-specific and agnostic-domain word embeddings.

Keywords: Arabic Natural Language Processing; Arabic Tweets; Offensive Language Detection; Offensive Language; Word Embeddings

1 INTRODUCTION

Warning: This paper tackles the problem of offensive Arabic language in microblogs. So, it may contain some examples that include offensive or vulgar words. These examples do not reflect the authors' perspective in any way.

Over the last years, online social media platforms have become an essential part that influences everyone's daily life. The widespread use of online social media platforms has changed the way people communicate with each other, exchange information, promote products, and evaluate services. Despite the significant benefits provided by social media platforms to individuals and businesses, they are still vulnerable to harmful activities. One of the most detrimental behaviors in social media platforms is offensive language [1]. These platforms enable their users to communicate online anonymously and to express their opinions without barriers, creating an environment where people have the freedom to misbehave and to use obscene words to offend. Therefore, each social media platform was keen to provide policies and guidelines to determine the content that is permitted to be published. Whenever a user posts any content that violates these policies and guidelines, the content will be deleted, or the user's account will be suspended.

However, some users might cross the limits to post content that may violate these policies and guidelines, such as posting intentionally misspelled offensive words, slang, emoticons, or uninformative words. Thus, to maintain the violations as low as possible and ensure that all users can communicate online freely and safely, social media platforms such as Facebook and Twitter have invested in people, processes, and technology to detect offensive and hateful content. But most social media platforms' legal efforts and policies in detecting harmful content and filtering offensive language still heavily depend on traditional channels of reporting misconduct and monitoring by moderators. The manual tracking of offensive and hateful content will be challenging, especially with the massive volume of content on social media platforms these days. So, the automatic detection of offensive language and hate speech on social media platforms has attracted the attention of many scholars. Several studies and competitions emerged in detecting offensive language domain, which clearly emphasizes the growing importance of this issue. However, most of the research on automatic detection of offensive language has focused on rich resource languages such as English, whereas research on this area in Arabic has been rather limited.

The Arabic language is among the most widely used languages on the Internet [2]. A report about the state of Arabic language in social media released in 2018 [3], stated that the number of Arabic users on the Internet reached 237 million users, 17 million tweets in Arabic daily, and 72% of the tweets in the Arab region are in Arabic. According to the New Media Academy Report [4], social media penetration in Arab countries reached 90% of the population in 2020. The report also showed that the average of social media users in the Arab region is represented by 8% of all social media accounts. In Saudi Arabia, for example, there are 25 million social media users, representing 72% of the population [5]. Further, The Arab Youth survey showed that around 90% of young Arab use at least one social media platform every day [6].

Thus, this paper aims to detect Arabic offensive language in Twitter based on textual and contextual features using deep learning models. This paper describes a new approach for constructing a sizeable Arabic corpus for offensive language collected from Twitter. Following this approach, we compiled a data corpus containing more than 500K tweets to extract a domain-specific word embedding. Using a subset of 30K tweets from the data corpus, we then constructed an Arabic offensive language dataset for classification. It also presents a deep learning-based approach to detecting Arabic offensive language using the Bidirectional Long Short-Term Memory (BiLSTM) model, domain-agnostic word embedding (AraVec), and domain-specific word embeddings extracted from an Arabic offensive corpus. To this end, we can summarize the contributions of this study to the field of

offensive language detection on social media platforms as follow:

1) Present a large cross-domain and multi-dialect dataset up to date for Arabic tweets that embrace a broad range of offensive and non-offensive tweets for detecting offensive language on Twitter.

2) Propose a new approach for constructing and labeling an Arabic dataset collected from Twitter.

3) Build a domain-specific word embeddings extracted from an Arabic offensive language corpus. To the best of our knowledge, this is the first study that that introduces domain-specific word embeddings for an Arabic offensive language domain.

4) Develop a deep learning-based approach to detect offensive Arabic language, the approach combines the bidirectional Long Short-Term Memory (BiLSTM) model with domain-agnostic word embedding (AraVec) and our domain-specific word embeddings.

The following is how the rest of the paper is structured: Section 2 reviews the previous work on offensive language detection. The approach used in collecting and labeling the dataset is discussed in greater depth in Section 3. The proposed model and experiment implementation are described in sections 4 and 5, respectively. The results are discussed in Section 6 of the paper. Section 7 conclude the study and looks ahead to future works.

2 RELATED WORK

Offensive, as a standalone word, is generally understood, but as a concept, it is broad, complicated, and has different forms and types. As a concept, offensive can be described as discourteous and rude words or comments that lack respect and cause anger or harm [7]. Xu and Zhu [8] defined offensive language as any textual content that might be considered offensive on the grounds of religion, society, culture, or morals, such as sexual, racist, or aggressive content. Jay and Janschewitz [9], identified three categories of offensive language. These three categories are 'vulgar' which includes explicit and rude references of a sexual nature, 'hate,' which includes offensive comments or words that attack a group of people based on their race, religion, or nationality, and 'pornographic'.

As aforesaid, the widespread of offensive language in online communication has become an issue especially with the massive increase in using online social communication. Most of this research focused on the issue of offensive language in English and Arabic. However, it's important to note that the research works addressing this problem in the Arabic language are still limited.

2.1 English Studies

Since detecting offensive language in online social platforms is challenging, many supervised machine learning approaches have addressed this problem. Most of these methods extract various types of information from text. Some

research [7-14] employed lexical features such lexicon, Bag of words (BoW), N-gram, and Term Frequency-Invert Document Frequency (TF-IDF). For instance, Vandersmissen [7] used BoW and N-gram to detect just two categories of offensive language – sexual and racist – using the techniques of query expansion and text classification. Query expansion is used to increase the overall efficiency of retrieving the relevant messages from the dataset, while text classification separates inoffensive from offensive (sexual or racist) messages. Naive Bayes (NB) and Support vector machine (SVM) classifiers were applied to detect offensive messages. The SVM method outperformed the Naive Bayes algorithm on the validation set, obtaining a precision of 62% versus 9% for the Naive Bayes. In addition, Gaydhani et al. [10] used supervised machine learning to distinguish and detect offensive language and hate speech on Twitter. To detect offensive and hateful tweets, our method used N-gram and TF-IDF characteristics to train three classifier models (Logistic Regression, SVM, and NB). The results revealed that the Logistic Regression model, with an accuracy of 95.6 percent, outperformed the other two models. Shende and Deshpande [11] also used N-gram, TF-IDF, and tokenization to extract features from a dataset collected from Twitter and Facebook. This study proposed a system to recognize offensive material and identify the potential offensive users using SVM and NB classifiers. The SVM system achieved 91.75% accuracy whereas the NB reached 90%.

Although the lexicon-based approaches disregard the syntactical structure of the entire offensive sentence, they performed well in detecting foul language and showed promising results. However, Razavi et al. [12] designed and implemented a novel approach for automatic flame detection, which applies multi-level machine learning classifiers to extract features, boosted by the lexicon of abusive and insulting words. This study demonstrated that the semantic features without the syntactical structure in detecting offensive messages fail to identify the exact insulting comments in different arrangements. Moreover, Davidson et al. [13] proved that using lexical-based methods to detect and separate offensive language and hate speech in online social networks tends to have low accuracy.

Chen et al. [14] suggested a method for detecting offensive content and identifying probable abusive users based on lexical-syntactic characteristics architecture. Because the offensive message cannot be discovered unless it comprises comparable words or expressions that originated from a dictionary, this approach focuses on lexicon to see unacceptable information. It also distinguishes between the use of derogatives and obscenities in detecting offensive content. Moreover, Chen et al. proposed approach integrates style, structure, and context features to detect the user's potential to post abusive messages. The approach showed a higher precision in detecting offensive content by 94.34% and detecting offensive users by 90.2%.

To identify what offensive content should be removed from user messages, Xu and Zhu [8] proposed a technique for semantic filtering based on words' grammatical relations. This method was only concerned with filtering rather than exact identification of offensive remarks. The inflammatory

term in the phrase was detected using a word matching algorithm and a vast dictionary of harsh words.

2.2 Arabic Studies

The Arabic studies into the field of offensive language detection is relatively emerging and still limited. Most of previous studies used supervised machine learning algorithms to develop classifiers to detect offensive and harmful content in Arabic social media platforms. Abozinadah et al. [15] trained three classifiers, Naive Bayes, SVM, and Decision Tree, with three sets of features obtained from users' accounts, including user profile features, textual features, and social graph features, to detect abusive Arabic accounts on Twitter. The results of the evaluation showed that the Naive Bayes classifier outperformed other classifiers with an F1-score of 90%. Alakrot et al. [16] employed a dataset that included 15K YouTube comments. They trained an SVM classifier to detect Arabic offensive language in YouTube comments using word N-gram features. The evaluation results showed that the classifier was able to achieve the best F1-score of 82% by integrating these N-gram features and data pre-processing techniques. Mubarak et al.[17] used hashtags and controversial user profiles to create a Twitter dataset. The dataset contains 1100 tweets that were manually classified as obscene, offensive, or clean by three annotators. They also created a list of seed words containing 228 Arabic swear words using a pattern-based search strategy. They classified Twitter users based on whether they were clean or profane using the seed word list. After that, they extracted unigram and bigram to generate a new list of potentially profane words used by aggressive users. They used both lists as features in both internal and extrinsic evaluations to identify tweets as obscene or clean. The results revealed that combining the seed word list with the extended list yielded the best F1-score of 60%.

3 DATA
3.1 Data Collection

The first step toward detecting offensive Arabic language is dataset construction. In this study, we selected Twitter as a source for building a new large multi-domain and multi-dialect Arabic dataset of offensive language. Tweets were extracted during two months from August 01, 2019, to October 01, 2019, using the TweetScraper tool. This tool enables the researcher to crawl tweets from the Twitter search engine [18]. To ensure that the dataset will not be biased to a specific type of offensive, dialect, topics, or targets, we used a blended approach combining two searching strategies: keyword-based and profile-based for extracting tweets and building up the dataset. In the keyword-based method, we explored three publicly available sources containing 404 offensive words and hashtags in Arabic to identify the prevalent offensive and obscene words and phrases that will be worked as a seeding list for our search. These sources are DataWorld dataset contained 37 dirty words in Arabic, HateBase lexicon, which included 79 hateful and offensive terms in the Arabic language, and a list

of 288 abusive Arabic words and 127 Hashtags provided by the study Mubarak. et al. [17]. To ensure that the keywords selected from these sources are unbiasedly identifying the offensive language in Arabic tweets, we applied the following criteria: excluding hashtags; terms must be shared between the three sources and written in casual spoken language. Also, terms must not represent a specific Arabic dialect, e.g., the Egyptian or Iraqi dialect. After applying these criteria, we used 81 terms as searching seeds and performed 17 tweets crawling processes, in which we collected 4000 tweets for each crawling. We collected 68k tweets and 38943 users. In the profile-based approach, we randomly selected 1700 unique users who crawled using offensive keywords. One hundred users were selected from each crawling and collected their tweets within the same period that the offensive tweets were collected. We retrieved 525599 tweets after excluding the repeated tweets that were already collected using search seeds. In total, we collect 593599 tweets.

3.2 Data Cleansing

From the extracted data, we randomly sampled a dataset of 30K tweets for cleaning and labeling. In the cleaning stage, we cleaned the dataset by removing the following occurrences:
- Repeated tweets that have the same tweet ID.
- Short tweets that have less than three words, such as 'private'.
- The less informative tweets that have no meaning, such as 'Hhhhh.'

3.3 Data Labeling

After the data cleaning stage, now the Arabic offensive dataset contained 29901 tweets. We utilized Mango DB and Mongo DB Campus to label Tweets manually. Tweets were given one of two classes, offensive and non-offensive.

Offensive: Tweets include explicit or implicit insults, cursing, and obscene words intended to attack someone or a subgroup of people. The offensive label has Vulgar tweets that include explicit and rude references of a sexual nature; Hate tweets that include offensive comments or words that attack a group of people based on their race, religion, or nationality; Tweets that include insult and pejorative terms such as: call a person with an animal name, cursing; Tweets that mock the disabilities and shortcomings; Tweets that attack ethics and morals; and pornographic related tweets.

Non-Offensive: Tweets do not include any vulgar or offensive terms. We noticed that a keywords match method without considering tweet context would fail in some cases because some tweets may contain some harsh words. However, the whole tweet could not be regarded as offensive due to the tweet context and the users' intent. We considered the tweet's context and searched Twitter to find how actual users used terms to annotate the ambiguous tweets. Tab. 1 shows examples of vague tweets.

To assess the reliability of manual labeling, we selected a random sample of 10K tweets to be validated via a

crowdsourcing platform. For this task, we used Appen (formerly known as Figure Eight), a well-known crowdsourcing platform, to collect, improve, annotate, label, and validate the data to make it practical for machine learning training [19]. In the crowdsourcing validation task, contributors will validate whether the tweet represents the assigned label or not. To make the label validation process more accessible, we developed a labeling guideline for offensive Arabic language. We ensured that our approach was compatible with those provided in [20, 21]. The inter agreement average was 83%.

4 THE PROPOSED MODEL

To investigate the detection of offensive Arabic language on Twitter, we proposed a novel model that utilizes a deep learning-based model with domain-specific word embeddings. Using domain-specific word embeddings helps to capture the most terms used in the offensive context and the intentionally spelling mistakes that are undetectable by general word embeddings since they trained on textual data without spelling errors such as Wikipedia. This section describes in detail our proposed model for detecting offensive Arabic language on Twitter. The primary purpose of this detection model is to process the collected tweets and extract a domain-specific word embedding, and then build a deep learning model (BiLSTM) to classify offensive and clean tweets.
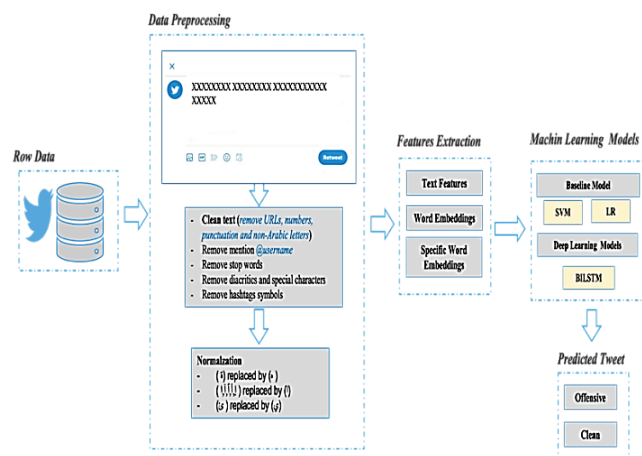
Figure 1 The proposed model for Arabic Offensive Language Detection.

As shown in Fig. 1, the model starts with a dataset labeled as offensive and clean tweets collected from Twitter. Then, we conduct several pre-processing techniques to prepare the dataset for the model. After that, the model extracts text and word embeddings features. Finally, it evaluates three machine-learning models to classify tweets into offensive and clean tweets.

4.1 Data Pre-processing

Text pre-processing is an important stage for text classification tasks. The texts crawled from social media platforms such as Twitter are unstructured and have conversational and noisy nature. So, applying some text pre-processing steps is vital before starting to feed data to the classification models. For Arabic tweets, text pre-processing becomes even more crucial because of the variety of Arabic dialectal used. Arabic tweets usually include tags, punctuations, URLs, symbols, and un-Arabic characters, which we want to remove from the dataset. We performed several pre-processing steps to our dataset. These steps include:

1) **Cleaning:** This step includes removing URLs, non-Arabic letters, numbers, punctuation. The cleaning action also comprises removing the word elongation (kashida), diacritics (tashkeel), and special characters.
2) **Remove Stop Words:** they are the most common words in the data which occur excessively and usually do not provide meaningful information for text classification, such as prepositions, articles, and conjunctions. We used the Arabic stop words list provided by Natural Language Toolkit (NLTK) in this study to remove stop words [22].
3) **Remove Hashtags:** In this step, only hashtags symbols were removed while keeping the keywords because they may represent contextual information.
4) **Normalization:** All Arabic characters that appeared invariants were rendered into a single stat in this step. For example, 'T marbotah' (ة) replaced by (ه), "hamza" on letters (ا ,آ ,أ ,إ) replaced by (ا), and (ى) replaced by (ي).

4.2 Features Extraction
4.2.1 Text Features

For our baseline experiments, we adopted a variety of feature extraction techniques from the text, and we extracted several combinations of word n-gram and character n-gram features. We used the Term Frequency Inverse Document Frequency (TF-IDF) value to normalize all n-gram features. TF-IDF value reduces the effect of the less informative tokens that frequently appear in the dataset.

4.2.2 Domain-Specific Word Embeddings

A domain-specific word embedding is word representations extracted from a data corpus of a specific domain such as sports and politics domains. As mentioned previously, removing word embeddings from the Arabic offensive language domain helps capture the words usually used in offensive contexts. To extract a domain-specific word embedding, we used the corpus of more than 500K tweets, which was described, in section 3.1. After that, we performed some pre-processing techniques to clean the data and remove un-related words. However, we only applied standard techniques to remove the noise, and we did not handle the misspelling mistakes since some words are abbreviated or intentionally misspelled to avoid the detection models. After removing the noise and processing the data, we used the Arabic offensive tweets to train a continuous bag of word (CBOW) Word2Vec model to extract the embedding features. The CBOW model uses the neighboring words to detect the target word. We trained the model by using

Gensim library with a five-word window and a 300-vector size. We refer to our domain-specific embedding in this study as Arabic offensive Word2Vec (ArOffW2V).

The differences between our domain-specific word embeddings model (ArOffW2V) and the AraVec embeddings model [23]. The analysis results showed that the word's similarities that the AraVec model provides have more general meaning, while our domain-specific word embeddings model provides words that tend to be more related to offensive context. For example, the term ' كلب dog' in the AraVec embedding model referred in general to the name of an animal while in domain-specific embedding model, we noticed that words like "يا ابن الك*لب son of a dog " appeared which mostly tend to be used in an offensive context. Moreover, it can be shown that the intentionally misspelled words such as (عبيد- nig*er) appeared in the domain-specific embedding model while didn't appear in the AraVec model.

4.3 Supervised Machine Learning Models

In this study, we adapted two supervised machine learning classifiers as baseline models: Support Vector Machin (SVM) and Logistic Regression (LR).

4.3.1 Support Vector Machin (SVM)

It is one of the most popular supervised machine learning classifiers that can be used for classification or regression. So, it can classify both linear and non-linear data. SVM algorithm outputs the best decision boundary, which is known as hyperplane, to separate n-dimensional space into classes using different kernel functions. For 2-dimensional space, the hyperplane is represented by a straight line dividing the plane into two parts, wherein each class place on either side [24]. The Linear kernel was applied in this study, which can be calculated as shown Eq. (1) where x_1, x_2 are the input of space vector.

4.3.2 Logistic Regression (LR)

It is another supervised machine learning algorithm used for binary classification tasks. It is a statistical model used to measure the correlation between the dependent and independent variables. It transforms the class (dependent variable) from categorical to numeric.

4.4 Deep Learning Model (BiLSTM)

We conducted a set of experiments to build the most suitable deep learning-based model for the Arabic offensive language detection task. From our experiments, we employed a Bidirectional LSTM (BiLSTM), a sequential processing model containing four layers [25]. The main reason that the BiLSTM is suitable for this task is that the model runs the input sequence in two ways, backward and forward, unlike LSTM, which only runs the input sequence backward. So, it's able to understand more information about the context. Fig. 2 shows the construction of our BiLSTM model; the model consists of four layers: embedding layer, bidirectional CuDNNLSTM, dense layer, and dropout layer.
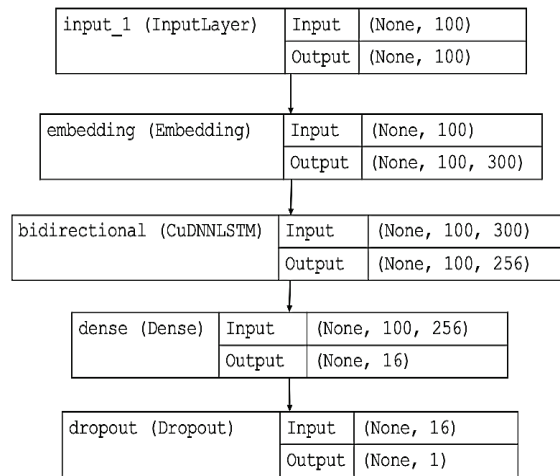
Figure 2 The Structure of BiLSTM Model

5 EXPERIMENTS

Many experiments have been conducted on our created dataset to obtain strong classification results for offensive Arabic language on Twitter. We used a binary classification task in all our experiments to classify tweets into offensive and non-offensive classes (clean). The dataset, baseline models, and performance evaluation measures are all described in the following sections.

5.1 Dataset

In all experiments, we used a random sample from our created dataset. The data sample contains almost 30k tweets labeled manually, either offensive (offensive) or non-offensive (Clean). The dataset sample was described in section 3.2 and section 3.3.

$$K(x_1, x_2) = x_1 \cdot x_2 \tag{1}$$

Since our data sample is relatively imbalanced, we used the Stratified sampling method to prepare our data for the binary classification task. When splinting the dataset into training and testing sets, this sampling method ensures an equal class distribution. As a result, we used this strategy to divide our data into 70% training and 30% testing sets. Tab. 1 shows the distribution of offensive and clean tweets in training and test datasets.

Table 1 Offensive and Clean Tweet in Training Set and Test Set

Class	Train	Test
Offensive	11,720	2939
Clean	12,199	3032

5.2 Baseline Models

As a baseline, we employed the Support Vector Machine (SVM) and the Naive Bayes (NB) classifiers from supervised machine learning. We tested the two classifiers with distinct n-gram features on a word and character level. Supervised machine learning models utilizing word n-gram and character n-gram features performed remarkably well in

Arabic offensive language detection tasks, according to various research investigations [7, 18]. The results of our experiments showed that the character n-gram ($n = 2 - 5$) achieved the highest F_1-score. Because this feature can detect alternative spelling which are common in online communication, it also helps detect a word's morphological makeup.

5.3 Evaluation Metrics

For performance evaluation, we computed true negatives (TN), true positives (TP), false negatives (FN), and false positives (FP) by comparing predicted and actual classes. Then we calculated average precision (P), recall (R), F-measure (F), and accuracy (A) as in the following equations:

$$Recall\,(R) = \frac{TP}{TP + FN} \tag{2}$$

$$F_1\,Score\,(F) = \frac{2 \times (P + R)}{P + R} \tag{3}$$

$$Precision\,(P) = \frac{TP}{TP + FP} \tag{4}$$

6 RESULTS

In this section, we discuss the experimental results of our models. It shows the performance results of the baseline models and the deep learning based-model (BiLSTM) with domain-specific word embeddings. The results are presented in terms of precision, recall, F_1-score. Moreover, we evaluated our BiLSTM model on two different datasets for the offensive Arabic language to generalize our results. We used Mubarak et al. Dataset [17], and abozinadah et al. Dataset [15].

6.1 Baseline Performance

As we mentioned previously, we evaluated two supervised machine learning models on word-n-gram and character n-gram features. From Tab. 2, we can observe that LR on the char n-grams ($n = 2 - 5$) performed the best overall performance of 92% and is also the best macro precision. On the other hand, SVM was trained on the same set of features and achieved an overall performance of 90%. In terms of features, we can see that the word n-gram (1-4) reached the second-best performance among all models on detecting Arabic offensive tweets.

Table 2 Evaluation Results of The Supervised Machine Learning Models

	SVM			LR		
	P	R	F_1	P	R	F_1
Char n-grams (2-5)	0.90	0.90	0.90	0.92	0.92	0.92
Word n-grams (1-4)	0.89	0.90	0.90	0.90	0.90	0.90

6.2 BiLSTM Model Performance

In Tab. 3, we present the performance of our proposed model from a feature perspective of three embedding models (AraVec, ArOffW2V, blending model of AraVec, and ArOffW2V) under the same classifier (BİLSTM).

Table 3 Evaluation results of BiLSTM Model

Dataset	Features	BiLSTM		
		P	R	F_1
OUR Data	ArOffW2V	0.91	0.91	0.91
	AraVec (CBOW)	0.90	0.90	0.90
	Blend Embeddings	0.93	0.93	0.93
Mubarak Dataset [17]	ArOffW2V	0.81	0.81	0.81
	AraVec (CBOW)	0.89	0.89	0.89
	Blend Embeddings	0.90	0.90	0.90
Abozinadah Dataset [15]	ArOffW2V	0.86	0.85	0.86
	AraVec (CBOW)	0.87	0.88	0.87
	Blend Embeddings	0.90	0.89	0.90

Among all embedding models, the blending model of AraVec and ArOffW2V achieved the best performance in detecting Arabic offensive tweets on our dataset. However, ArOffW2V performs better than AraVec on the same dataset.

$$Accuracy\,(A) = \frac{TP + TN}{TP + FP + TN + FN} \tag{5}$$

The performance of all embedding models on our datasets was very close to each other. Moreover, we can perceive that training the BiLSTM model with domain-specific embeddings on other datasets achieved high-performance results. These results were consistent with the results obtained when we trained the model in our dataset. To this end, we can conclude that using a specific domain word embeddings model could improve the performance of the Arabic offensive language detection model.

6.3 Error Analysis

This section presents an analysis of the top misclassification errors of the Arabic offensive language detection model. In this study, we were interested in achieving a high detection model accuracy for the Arabic offensive language detection task. Besides that, we were interested in detecting all the offensive Arabic tweets. Thus, we are trying to find misclassified tweets by our model and understand why the model failed at classifying these tweets.

We found that our model misclassified a total of 375 tweets. Most of the misclassified tweets were offensive tweets mis-predicted as clean tweets.

The tweets context and dialects are the reasons for the classification error in these tweets. These tweets have offensive terms in a natural context and dialectal terms that might confuse the classifiers and cause classification errors. However, we can conclude that detecting Arabic offensive language is still challenging and highly dependent on the context.

7 CONCLUSION

Offensive language has grown as a significant problem with the increase in online communication and the popularity of social media platforms. The main purpose of this study is to develop a deep learning-based model to detect Arabic

offensive language. In this study, we built a multi-dialect and multi-domain Arabic dataset for detecting offensive language on Twitter. From this dataset, we extracted domain-specific word embeddings from the Arabic offensive language domain to capture the intentionally misspelled phrases that are usually used in offensive contexts. Combining the domain-agnostic word embeddings model with domain-specific word embeddings provides the best performance with the BİLSTM classifier.

For future work, we can explore the type of offensive by labeling the dataset with multi-classes. In addition, it would be interesting to utilize the domain-specific word embeddings with other neural network models for Arabic offensive language detection.

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Knowledge Sharing in International Business: A Literature Review Study

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Abstract: In an era where global trade has developed along with the massive number and expansion of knowledge, the necessity of exchanging knowledge and international business has continuously increased. This is in light of international business organizations' intellectual capital, which propels them into global competition and provides them with a competitive advantage if utilized properly. The purpose of this research is to examine and assess two topics, namely, knowledge sharing and international business, as well as their location in research studies, importance, definitions and histories of those terms, and research interests for each one of these two dimensions. The review focused on the topic of knowledge sharing in international business organizations, with analysis and discussion of the most important research, studies, and trends along three axes: knowledge sharing, international business organizations, and earlier studies. The study concluded that knowledge sharing is an essential aspect of knowledge management since it connects the previous processes of acquiring knowledge capital to the subsequent processes of application and practice, which is especially important for international business organizations that need to benefit from knowledge in a variety of ways. In addition to the scarcity of studies that coupled knowledge sharing and international business, there is a great scope for developing models and applications in this field of study. We were unable to find studies that combined the two themes through research, but they were implicitly addressed within the research to highlight the importance of knowledge sharing in international business, and this is what motivates more research in this field due to the shortcoming of studies on the subject. It seemed to be that the essential element to organizational innovation is knowledge development and sharing.

Keywords: business administration; knowledge; knowledge management; knowledge management operations; knowledge sharing

1 INTRODUCTION

Organizations create value from their intellectual elements based on knowledge to achieve best practices. "Peter Drucker," an American management scientist, argues that the world is already dealing with knowledge businesses whose products are ideas, whose raw materials are data, and whose tool is the human mind, to the point where knowledge has become the most important component of the contemporary economic and social system [16].

Whenever knowledge is invested in any company, it becomes the intellectual capital and adds value that offers this company a great opportunity for competition and success against its competitors. We might argue that, among other material considerations, the factor of progress in the sphere of knowledge has become the most significant and valuable in life.

Knowledge management has a series of operations that may increase or reduce depending on the opinions of researchers, but the essence remains the same, and some sub-processes may increase. We will use the Fraunhofer IPK, 2001 model, which was used by [34] in their survey study on European organizations, which comprised six core knowledge management procedures, including the following:
1) Knowledge diagnosis
2) Knowledge objectives determination
3) Knowledge generation
4) Knowledge saving
5) Knowledge sharing
6) Knowledge application.

Knowledge sharing is considered as the strategic mediator of knowledge operations, as it connects the previous processes' valuable efforts to the next, and it is the application of knowledge in the company and its persistence, making it the most important in operations. International business organizations share knowledge in a variety of ways, either in structured ways that derive from an understanding of the value of knowledge management in businesses or through specialized practices and applications to share knowledge among each other.

The most relevant research, studies, and trends for knowledge sharing in international business will be evaluated and discussed in this review, and the focus will be the topic of knowledge sharing in international business.

1.1 The Methodological Framework for the Review

The researcher used the Literature Review Methodology and will be committed in this review to include the most important terms in the fields of knowledge sharing and international business, as well as the first appearance of these terms in studies and research that focused on the two areas under review and tracking the historical development of the field. However, some digital indicators for the terms of knowledge sharing and international business in some Arab and foreign databases shall also be included. This is in addition to evaluating a set of studies that dealt with the terms knowledge sharing and international business individually, as well as studies that combined the two themes together and extracting patterns for those studies and research that were interested in the two topics under review and discussion.

First Axes: Knowledge Sharing

1.2 Important Terms and Concepts in the Domain of Knowledge Sharing
1.2.1 Knowledge

Knowledge is a wide notion that refers to the act of creating, sharing, and/or applying knowledge through a variety of ways that are appropriate for the content, purpose, and participants involved [19].

Nonaka, believes that knowledge is simply a "flow of messages," whereas knowledge is based on knowledge and the accuracy of its interpretation is dependent on the individual's experience and awareness [41]. Other researchers believe that all knowledge is considered as knowledge, but true knowledge is more than just knowledge, that is, knowledge includes both knowledge and know-how [53].

1.2.2 Knowledge Management

Knowledge management (KM) is defined by Skyrme as "the explicit and methodical management of essential knowledge, as well as the accompanying procedures of invention, organization, publication, usage, and exploitation" [48]. Knowledge management principles have been examined and utilized in a variety of organizational and professional settings [28].

Knowledge management is defined as "a planned and organized approach to managing, creating, sharing, acquiring, and benefiting from knowledge which is considered as an asset of the organization, that enhance its ability and speed up its effectiveness in the delivery of products or services that benefit customers," [43].

1.2.3 Knowledge Management Operations

Lindvall et al., (2001) [32] defined knowledge management operations as "knowledge acquisition, saving, distribution, and application". Knowledge operations are represented in "sharing, storage, development, application, extraction, and classification of knowledge", according to [27]. It is expressed by [8] as how to manage knowledge by obtaining and analyzing it, as well as the consequences of constructing and synthesizing knowledge, codifying model knowledge, and structuring knowledge.
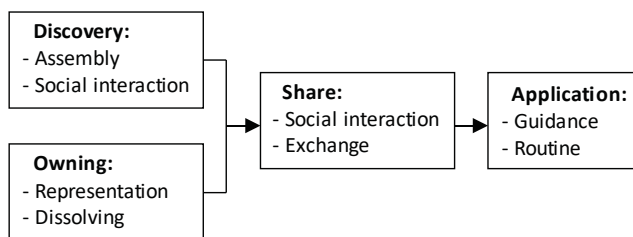

Figure 1 Knowledge management operations

Knowledge management, according to [40], consists of four primary processes: knowledge discovery, acquisition, sharing, and application. This is in addition to the other sub-processes mentioned in Fig. 1 (Fernandez, I. B. & Saberwal, R. (2014). Knowledge Management: Systems and Processes, 93).

1.2.4 The Concept of Knowledge Sharing as a Knowledge Management Operation

It is the process of passing explicit or tacit knowledge to others. The sharing of knowledge is defined by three factors, which are as follows: First, effective knowledge transfer, which means that the future of this knowledge does not find it difficult to understand to a sufficient degree of trust and usefulness [24]. Second, knowledge is shared of itself, rather than recommendations based on knowledge, because in the first situation, the ability to do activities based on this knowledge is included, whereas in the second case, knowledge is used without embodiment. Third, knowledge is shared among various entities such as individuals, groups, departments, and organizations [4]. Knowledge sharing concept is described by Jasser and Ghoneim as "the process by which explicit or tacit knowledge is conveyed to other individuals through contacts between them" [3].

1.2.5 The Origin and Evolution of the Term "Knowledge Sharing" in Scientific Research and Studies

Although knowledge transfer and sharing were not directly discussed in Ikojiro Nonaka's article in 1991, he claimed that; "Because explicit knowledge is formal and methodical, it can easily be communicated and shared" [41]. Nonaka argues in another section of the same article argues; "This aids in the development of a shared knowledge base among employees and, as a result, facilitates the transfer of tacit knowledge" [41]. Following Nonaka's article, several other writers tackled the two terms of knowledge transfer and sharing, and the article became a jumping-off point for this theme [41].

Since then, the two phrases have steadily evolved and are now used interchangeably [20], but there has been a clear distinction between them in recent years.

In the year (1996), Appleyard [5] used the term knowledge sharing alone in the context of comparisons, such as (by contrasting semiconductor sector knowledge sharing with steel industry knowledge sharing) or (by comparing knowledge sharing in countries such as Japan and the United States) [17], were other researchers who followed in the same footsteps. They discovered that Toyota's competitive advantages in manufacturing are largely due to its ability to develop and maintain a network of knowledge-sharing operations.

In 2002, Cabrera & Cabrera [10] discussed various study views in the psychological and social aspects of knowledge sharing. For example, the study looked at how people think about social challenges while examining people's willingness to share knowledge with others, even if their organization has invested in specific technologies to make this possible.

In 2003, Ipe [23] investigated the topic of knowledge sharing within organizations' individuals, identifying four primary characteristics that influence knowledge sharing: 1) the type of knowledge, 2) desire for sharing, 3) sharing opportunity, and 4) culture and work environment.

An in-depth analysis of recently published articles has been presented on knowledge sharing at the individual level [49]. This article is the first comprehensive examination of individual knowledge sharing, whereas earlier studies have concentrated on technological challenges associated with knowledge sharing or knowledge transfer across institutions or organizations, or within inter-organizational networks.

1.3 Knowledge Sharing in Databases

The term "knowledge sharing" was tracked in the titles of studies and research from 2010 to 2020 by searching in some Arab and foreign scientific databases, yielding the following results:

First: The EcoLink the Arabic database.

Between 2010 and 2020, researchers looked for the term "knowledge sharing" in the titles of research and scientific papers, and came up with the Fig. 2.

Figure 2 Repetition of the term knowledge sharing in the EcoLink database

Second: International Scientific Indexing (ISI)

Between the years 2010 and 2020, the term "Knowledge Sharing" was searched in the titles of research and scientific papers, and a significant difference in foreign publication was noticed, with a noticeable rise from the Arabic database, which increases each year compared with the year before. Fig. 3 shows a graphic illustration.

Figure 3 Repetition of the term knowledge sharing in ISI

Second Axes: International Business Organizations.

1.4 Important International Business Terms and Concepts
1.4.1 Business Administration

Business administration is what is carried out of the administration's policies to help in the determination of the tasks that result in the desired outcomes from the work [9]. According to [42], business administration is defined as a set of actions and processes used within a company to meet management's objectives. Business administration is described academically as the areas of study based on the understanding of management principles in the business sector, which includes gaining different university degrees, ranging from bachelor's to postgraduate studies [11].

1.4.2 International Business

According to Boddewyn and others (2004) [7], international business is defined as "Work that crosses national borders," or "the comparative study of business as an organizational structure in different nations, business activities of companies across borders, and business interactions with the international environment" [17].

1.4.3 International Business Management

According to Muhammad Khattab (2018) [38], international business management entails economic transactions coordinated by organizations and carried out beyond the regional borders of many countries to fulfill the desired and planned goals of these companies or individuals.

International business organizations

As stated in the previous definition by [38], the description of international business organizations encompasses economic transactions organized by organizations and carried out across regional borders of various countries to achieve the desired and planned goals of these organizations or individuals. Hence, it appears to us that organizations are one of the parties that can use international business management in their transactions, according to the definition of international business management made by [46].

As a result, we define international business organizations as entities that have commercial activities within countries and have branches in other countries to manage their commercial activities of various sizes and strengths, and as a result, they must consider those differences, as well as temporal and spatial differences, as well as different cultures and customs, to compete and obtain a good share of the market in various countries.

1.4.4 Origination and Development of the Term "International Business Management" in Research and Scientific Studies

At the end of the 1960s and the beginning of the 1970s, American exports began to deteriorate, prompting concerned to seriously think about studying international business administration to learn more about the causes of this decline. Studies at the time revealed a gap in dealing with international markets due to a lack of interest in other languages, resulting in a lack of awareness of global markets and a drop-in export.

The curricula of the American business schools featured aspects of international business administration, emphasizing the importance of the international components of business administration in the country's economy. The study of languages and cultures began with the establishment of many cultural centers and the teaching of languages to strengthen the cultural position of the

American companies in global markets, which will be reflected in their ability to understand the nature of demand in foreign markets and to successfully make dealing with them and reaching them easier [38].

During the 1960s, each year, between fifteen and thirty worldwide business research projects were issued. An essay titled "Trends in International Business Research" was published in the JIBS editorial [39]. One of the article's main recommendations, which was highlighted twenty-five years ago, was that, despite the increasing pace of research in functional areas, more research in the field of international business is needed, with attention and focus on differences in cultures between countries and comparisons between nations. Since then, international business research has grown considerably to incorporate numerous elements and contemporary trends [51].

The concept of international business has altered considerably over the previous twenty-five years, and globalization has become a reality rather than a fad.

There was not enough awareness of the relevance of international business management at the end of the 1980s, but in the early 1990s, Melin (1992) [33] defined and raised three main topics in this framework: 1) The globalization phases model 2) Researches of the relationship between multinational corporations' strategy and structure 3) Researches on the administrative processes of multinational corporations and their existing organizational forms.

Melin's (1992) [33] model was utilized as a framework for analyzing 102 research papers in the early stages of international business, and it was revealed that the majority of the research is focused on the process of firm internationalization or globalization (63 papers). There were 22 articles devoted to internationalization strategy. Several researches explored transactions and technology transfer, including 13 papers addressing transaction costs, agency theory, foreign direct investment (FDI) decisions, and networks. As a result, scholars have focused on the globalization of family businesses, as we mentioned at the beginning, while many other areas remain unexplored.

Until the emergence of networks as a modern phenomenon [18, 25], global corporations [29], modern international corporations, and multinational corporations in emerging countries [13, 26], few theories emerged at the end of the 1980s.
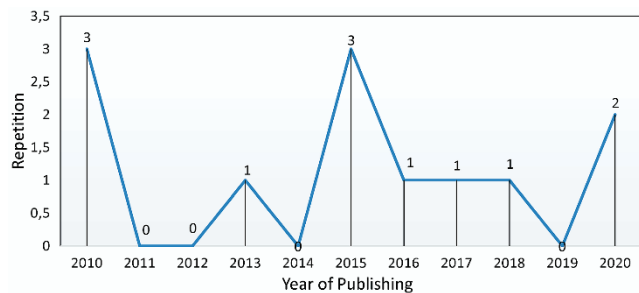
Figure 4 Repetition of the term (International Business) in the EcoLink The Arabic database

These operations spawned the appearance of international firms, stimulated the growth of new markets,

and aided the expansion of many family businesses into foreign markets, resulting in the formation of multinational family businesses.

The term (International Business) in the Databases

The term "international business" was traced in the titles of studies and researches from 2010 to 2020 by searching in some Arab and foreign scientific databases, yielding the following results:

First: The EcoLink the Arabic Database

Between 2010 and 2020, researchers looked for the term "international business" in the names of researches and scientific papers, and came up with the following visual illustration:

Second: International Scientific Indexing (ISI)

Between the years 2010 and 2020, the term "International Business" was searched for in the titles of research and scientific papers. The considerable rise in the international publications, which increases each year, was observed as a significant difference when compared with Arabic publications in the Arabic database. The following Fig. 5 is a graphic illustration.

Figure 5 Repetition of the term (International Business) in ISI

Third Axes: Previous Research

A) Some Specialized Studies and Researches Interests and Trends Related to the Term Knowledge Sharing

Many studies and research projects have looked into the various aspects of knowledge sharing, including but not limited to:

Mubarki Safaa, (2019) [37] studied "Knowledge sharing as an introduction for developing learning skills: an exploratory study for a sample of graduate students (Algeria)", aimed to focus on self-learning skills for the purpose of development. It also aimed to shed light on the theories that have been circulating in the context of knowledge sharing behaviors as well as learning of the most important skills that graduate students have to acquire and then set of proposals that contribute to the quality of students' learning skills after graduation.

The study came up with a number of conclusions, the most important of which is that knowledge sharing is a planned procedure for ensuring the transfer of both tacit and explicit knowledge to concerns via communications. Knowledge sharing also confirms an increase in organizational loyalty, as well as enhancement in individual bonding and knowledge expansion.

Razmerita, Kirchner, and Nielsen (2016) [31] investigated; "What factors have an impact on organizational knowledge sharing? From the viewpoint of the whirlpool of social media." The study's purpose was to find out what factors inspire employees to share their knowledge, as well as the factors that prevent them from participating in their employers' social media.

The findings of the study revealed the motivations and barriers that limit knowledge exchange within organizations. The study discovered major incentives in enjoying assisting others, monetary rewards, management support, behavior modification in knowledge sharing, and recognition with the same. Changes in behavior, distrust, and a lack of time are all barriers to knowledge sharing.

Uqti, (2013-2014) discussed "The Impact of Strategic Leadership on Knowledge Sharing". The study's purpose was to find out how strategic leadership approaches affect knowledge-sharing behavior and strategy. In addition, to investigate the indirect effects of these strategies on knowledge sharing behavior through internal marketing, marketing orientation, and organizational learning culture.

The study concluded with the most crucial finding: that one of the most important indirect benefits of strategic leadership practices is the performance and plan of knowledge sharing through internal marketing. Training is also crucial in encouraging knowledge-sharing behavior and the adoption of a knowledge-sharing plan by pushing leadership practices aimed at human capital and balanced control. In his study, the researcher discovered that the adoption of an incentive and reward strategy plays an important role in developing a strategic vision and creating an organizational culture that is considered as essential support for encouraging knowledge-sharing behavior and a commitment to implementing related strategies.

B) Research Interests and Trends for the Term International Business in Some Specialized Studies

Many studies and research have been conducted on the axes of international business, including but not limited to:

Al-Fahal, Hussein, and Zarzour, Ibrahimi (2015) [1] argued "Protecting International Business: An Introduction to Political Risk Management" addressed one of the major issues that has arisen as a result of the political and economic rapprochement that has occurred in our world today, namely the internationalization of companies that are affected by the political conditions of the countries in question required for investing in. One of the priorities that must be thoroughly explored before entering into investment and the risks it encounters is the process of protecting the foreign business.

According to the findings, multinational corporations' negotiation abilities and skills, as well as the tactics and procedures they employ to manage political risks, must be backed up by a significant influence of political leaders in the company's home country on the host countries. This is accomplished by putting pressure on these host governments to change their policies in favor of foreign commercial corporations, allowing them to manage and control strategic assets in the sites where they are located. As a result, risk is an inherent aspect of the investment, and political risk management is a critical concern for multinational corporations.

Jormanainen and Koveshnikov (2012) [26] investigated the internationalization of emerging market foundations (EMFs) in fourteen international management journals (IM) between 2000 and 2010, using an inductive approach and qualitative content analysis technique.

The study was concerned with the phenomenon of emerging market foundations (EMFs) internationalization as another "research laboratory" that allows researchers to validate their current theoretical approaches and develop new ones that are likely to be useful to the largest number of companies of all origins and shapes operating globally in the contemporary business environment. To attain these objectives, academics must maintain regular communication with international business practitioners and be ready to provide timely advice to businesses. (Bartunek, Rynes, & Ireland, 2006)

Czinkota & Ronkainen (2009) [14] examined "Trends and Indicators in International Business", pointed out that forecasting with changes in business environments is critical for policies, companies, and academia as well as for an appropriate response by policymakers and corporate decision-makers. Most experts agree that recent (business) trends are more important to business strategy than they were a few years ago.

The results of the study indicate that issues of terrorism and corruption have increased in importance while trade negotiations have declined, and the researcher believes that corporate strategies need a major reform to fulfill the promises that lead to globalization, and since trends have become multidimensional, opinions from stakeholders become more important than any time before.

Hill, Charles (2008) [21] investigated "International business: Competing in the Global Market Place," which stated that international business is defined as "business activities that entail the transfer of resources (raw materials, capital, and people), goods (assembled and end products), services (business consulting, financial services, insurance, education, and so on), knowledge (databases, networks), and knowledge and skills (administrative skills or intellectual property rights), beyond the national borders in reality".

The research discusses cultural differences in international business in some of its sections, and this topic is also recognized in other important international business manuals such as that mentioned by [15] and [47]. The study is noteworthy, as it covers all aspects of international business in-depth, from the principles through theories of international trade, finance, accounting, international operations, human resource management, and marketing. The study serves as a comprehensive academic resource and

reference in this regard. The research also looked into market access strategies.

C) Research Interests and Trends of the Term International Business in Some Specialized Studies

We will look at a number of studies that combined the terms of the first dimension, which is knowledge sharing, and the second, which is an international business and discuss them from various perspectives. We discovered a scarcity of research that combined the two dimensions, especially Arabic ones. Furthermore, there is also a scarcity of foreign research that has brought the two terms together, and we will review a number of studies that have been reached, focusing on the topics of those studies, what they aim for, and the most important results they have revealed, and we will also draw attention to the fact that we did not reach conferences, workshops, or associations interested in both themes together, through our research.

Rungsithong and Meyer (2020) [45] examined "Trust and Knowledge Sharing in the Business Environment: A Study of International Relations between the Buyer and Supplier in Thailand". In emerging markets, trust between organizations and individuals is a critical factor in the knowledge exchange between the buyers and suppliers. This study investigates whether the positive correlation between trust and knowledge sharing is stronger or weaker in an emerging market setting.

The study's findings suggest that the distance between customers' and suppliers' human resources may act as a natural barrier to the relationship between trust and knowledge sharing [36]. However, these barriers can be overcome via intensive communication and cross-cultural awareness training, as well as the encouragement of informal communication and greater behavior transparency [30]. The development of similar values and standards for buyer-supplier interactions is aided by interpersonal relationships [22; 35].

Evans & Qureshi, (2015) [44] investigated " Obstacles of Knowledge Sharing in the Pharmaceutical Sector: A Case Study" which intended to discuss the barriers to knowledge sharing in the pharmaceutical industry. One of the most important aspects of promoting knowledge assimilation is effective knowledge sharing.

The findings show that major hurdles to knowledge sharing exist in the corporation, both within and across organizations. The lack of knowledge sharing has a number of cascading repercussions, according to the study. In addition, despite the challenges, there appears to be a desire to share knowledge and learn from others. Finally, the study stated that the organization is not an educational institution and that the industry sector should seek to foster a friendly and voluntary knowledge culture between individuals and organizations.

Abdullah, Halim, and Loo, (2013) [2] studied "Knowledge sharing between the headquarters and its global companies: the impact of the manager's function, compensation structure, and cultural differences". The study's goal was to examine the impact of branch

managers' roles in knowledge exchange, as well as branch managers' compensation and motivation systems, and the degree of cultural differences between the home country and the host country and their impact on knowledge exchange between headquarters and multinational companies.

According to the findings of this study, all three criteria have an impact on the degree of knowledge sharing between subsidiaries and head office. The strongest link between knowledge sharing and senior management compensation and cultural differences has been discovered. According to the findings, multinational firms should provide rewarding benefits to branch managers who share valuable knowledge or business knowledge that can help improve the company's performance and competitiveness, such as promotions, bonuses, and better wages.

As per the results of this study, cultural differences in Malaysia may enable more knowledge exchange between headquarters and subsidiaries. One possible explanation for this outcome is that the wider the cultural divide, the greater the necessity for communication and knowledge and knowledge exchange between the two parties to fill the gap.

Wendling, Oliveira, and Maçada (2013) [50] discussed "Knowledge sharing barriers in global teams. Journal of Systems and Knowledge Technology", which aimed at determining the challenges that knowledge sharing in the international work teams may encounter.

The findings of this study offer a fresh viewpoint and a better understanding of how barriers to knowledge sharing interact and interrelate with one another. These findings may be useful to academics and organizations since they add to the conversation on knowledge sharing among members of international work teams and show the reality of two technological businesses on the topic. Further research on the impact of different software development techniques on knowledge sharing, as well as how swift technique might enhance knowledge sharing, is recommended to continue this type of research. More research and quantitative analysis of the relationship between knowledge-sharing barriers and enabling factors is also recommended in the study.

Carrillo, Ortiz Fournier, and Rogelio (2009) [12] argued "Improving innovation and knowledge sharing by overcoming cultural barriers", aiming to identify potential cultural barriers that impede knowledge production and sharing within the corporation as well as between organizations with regional or international character and different branches, to find effective ways to overcome these barriers.

This study stated that knowledge generation and sharing are critical to innovation, and it's crucial to understand how different cultures interact, especially in international firms, because this has a big impact on knowledge sharing and exchange.

One of the study's findings is that in international business organizations, management must deal with the organizational environment and emotional intelligence,

which would remove barriers between employees within the organization. The study recommends the formation of a specialized team of employees whose primary task is to manage knowledge in each branch of the organization in coordination with the main office. This group is entitled to remove barriers to knowledge sharing and timely delivery amongst branches to gain a competitive advantage for the organization.

The Fig. 6 shows the relationship between the cultural axes and the elements of knowledge sharing, as stated in the study.
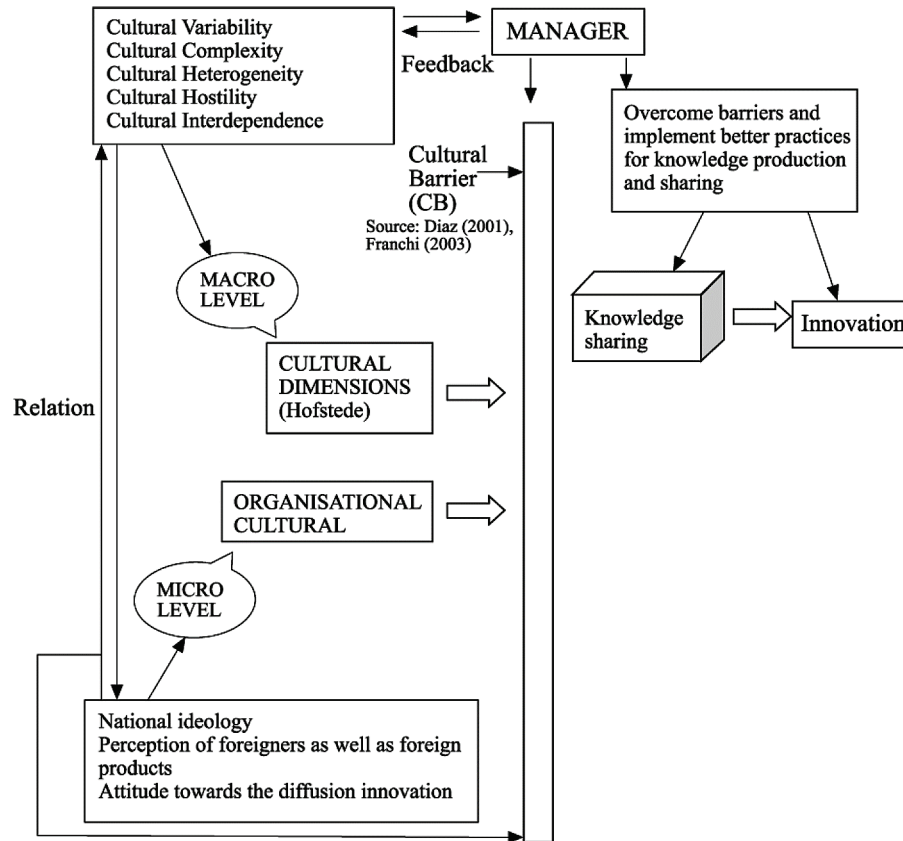
Figure 6 The relationship between the cultural dimension and the knowledge-sharing elements for the study

Xiong, Song and Deng, Hepu (2008) [52] examined "Critical Success Factors for Effective Knowledge Sharing in Chinese Joint Ventures". The study analyzes the impact of culture on knowledge sharing in Chinese joint ventures using a multiple case study method. According to this study, efficient communication shared attitudes, training, and leadership are all critical success factors for effective knowledge sharing in joint Chinese firms. These findings also aid in the formation of a distinct company culture that promotes knowledge sharing leading to improved organizational performance in an economy of progressive globalization.
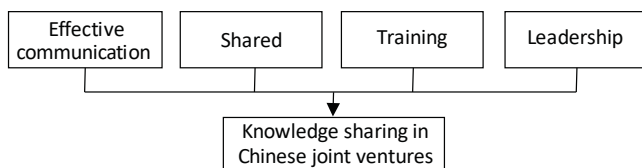
Figure 7 Effective Knowledge Sharing Model in Chinese Joint Ventures

The findings show that the creation of diverse organizational cultures can help international joint ventures share knowledge. The results also illustrate the study's multiple effects on the function of culture in knowledge exchange in a multicultural setting; First, national culture and organizational culture influence knowledge exchange in Chinese joint ventures. Second, the study demonstrates that in Chinese joint ventures, unique organizational cultures can be formed to mitigate the detrimental effects of the general culture of knowledge sharing among people. Third, effective communication, shared mindsets, training, and leadership, among other critical success factors identified for effective knowledge sharing in Chinese joint ventures, all play a key role in assisting the development of specific organizational policies and strategies for knowledge sharing in joint ventures.

Anna Jonsson and Thomas Kalling (2007) investigated the "Challenges of knowledge sharing across national and organizational boundaries: a case study of IKEA and SCA Packaging". The study's goal is to figure out how institutional pressures and the organizational environment, as well as knowledge issues, influence knowledge sharing within multinational companies (MNCs). Furthermore, the purpose is to demonstrate the distinctions across industries,

by contrasting a retail company with a manufacturing company.

The study's findings revealed that knowledge factors alone, as explanatory elements, would not be able to affect knowledge sharing across national borders or within an organization. The success of knowledge exchange depends on institutionalization. As a result, when institutional pressures promote knowledge sharing, industry and organizational structure distinctions are lost or, at the very least, play a secondary role in determining the variables that drive knowledge sharing. The two case studies demonstrate that institutional pressures, as well as the structure and management of organizations, have a significant impact on the willingness to share and understand knowledge.

2 STUDY FINDINGS

Several findings were taken from the themes and earlier studies that highlight the relationship between knowledge sharing and international business. The following are the most important concluded points:
- We noted a dearth of studies, particularly in Arabic, that combined knowledge sharing and international business. During our search, we were unable to locate any study that has collected the two themes for research.
- By tracing the two terms in Arabic and foreign databases, we discovered that there were few studies in Arabic for the two terms individually, whereas the number of studies in foreign databases increased over the last ten years for the two subjects individually, as shown in Figs. 8 and 9, while we found no titles of studies that combined the two terms together in Arabic or foreign databases, and we came across few studies that dealt with the two terms in another way within the study.
- Based on the research we have done, we have determined that the organizational culture is the most important aspect in spreading a suitable culture of knowledge sharing.
- Furthermore, the external culture that employees bring from their communities and countries may create barriers to knowledge exchange, especially if the company has branches in other countries, making it more difficult to understand cultural, spatial, and linguistic differences.
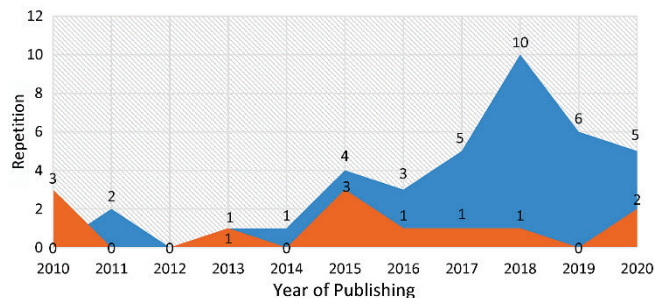
Figure 8 Repetition of the terms knowledge sharing and international business in the EcoLink the Arabic database
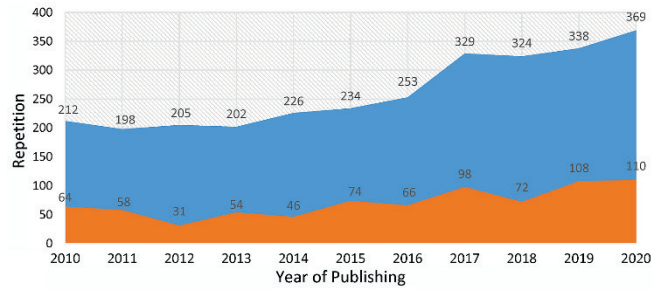
Figure 9 Repetition of Knowledge Sharing and International Business in the foreign database (ISI)

- As previously stated by Möller and Svahn (2004), practical experience in a variety of cultural circumstances is also an appropriate medium.
- A natural impediment to the relationship between trust and knowledge exchange may be the distance between customers and suppliers' human resources [36].
- Cultural differences may encourage headquarters and branches to share knowledge.
- Management must address the organizational environment as well as emotional intelligence to break down barriers between employees
- it is important to establish a specialized knowledge department in the firm's branches, or at the very least within the parent company.
- Institutionalization is essential to the success of knowledge sharing.
- Organizational innovation requires knowledge development and exchange [12].
- Effective communication, participative mindsets, training, and leadership have all been identified as critical success factors for effective knowledge sharing in Chinese joint ventures [52], as illustrated in the Fig. 7.

3 DISCUSSION

- The shortage of studies integrating the two concepts necessitates and provides an opportunity for additional studies and research.
- Individually, the two terms are uncommon in Arab and international databases, but their use in foreign databases has increased over the last ten years for the two themes. In terms of collectively, no Arabic study has compiled them, while only a few foreign studies have mentioned them, showing that there is a broad area for research in knowledge sharing in international business to maximize the influence and profit of international organizations.
- The organizational culture is so significant enough because it should include policies and legislation that enable the organization to manage this process and spread a culture of knowledge sharing within it through codified mechanisms and procedures, to maximize the organization's knowledge assets and reap the benefits in all of its local and international branches.
- Employees' external cultures from their communities and countries can obstruct knowledge exchange.

Recognizing these cultural, physical, and temporal barriers becomes much more challenging if the organization has branches in other countries. As a result, creating an organizational culture to overcome these barriers encourages the most effective use of knowledge to gain a competitive advantage.

- Practical experience in various cultural contexts is also an appropriate medium, as it should improve individuals' ability to understand cultural cues and provide them with a better foundation for communicating across cultures, and organizational culture is another important mediator and part of the solution, so field experts should not be overused and the organization should get benefited from them to the greatest extent possible.
- Human resource distances between buyers and suppliers are a hindrance that can be overcome by extensive communication and cross-cultural awareness training, encouragement of informal communications, and more transparency in behavior [30].
- Cultural differences may make knowledge transfer between branches easier. One possible explanation for this result is that the greater the cultural distance, the more communication, knowledge, and knowledge exchange between the two parties is required to bridge the gap.
- Having a knowledge management system in place in the company's branches, or at the very least in the parent company, aids in organizing the process of sharing knowledge in a way that is appropriate for the company, allowing it to retain and capitalize on its knowledge capital to gain a competitive advantage. As a result, establishing a dedicated knowledge management department in a company, especially one that is worldwide, is crucial.
- The organizational climate and emotional intelligence. According to research, forming a specialized team of employees whose main goal is to manage knowledge at each branch of the institution in collaboration with the parent organization's head office is recommended. This is for the company's benefit to have a competitive advantage.
- Institutionalization is critical to the success of knowledge exchange. When institutional pressures promote knowledge sharing, industry and organizational structure distinctions are lost or, at the very least, play a secondary role in determining the variables that drive knowledge sharing.
- Effective communication, participatory mindsets, training, and leadership, all of which have been identified as critical success factors for effective knowledge sharing in Chinese joint ventures [52], all play a key role in the development of specific organizational plans and practices for knowledge sharing in common projects.
- Because of cultural and geographical barriers among their various branches, organizations need greater knowledge exchange among themselves [12], and

international organizations are singled out here because they require more knowledge interchange.

4 CONCLUSION

The prior discussion of the two dimensions, knowledge sharing and international business, including their importance, their role in research studies, the definitions and histories of these terminologies, and issues for each of the two dimensions, show their significance. Especially in this era, when global trade has expanded in tandem with the expansion of information, with the vast amount of information available at all times, and the knowledge capital held by international business institutions, which exposes them to global competition and provides them with a competitive advantage if it is well exploited.

Knowledge sharing is a vital aspect of knowledge management because it connects the processes that lead to owning knowledge capital to the actions that contribute to its application and practice, which is especially important for international business institutions that need to benefit from it in a variety of ways, and the field is excellent at developing models for that and applications alike.

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Process & Software Selection for Robotic Process Automation (RPA)

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Abstract: Robotic process automation (RPA) is a technology for office automation to imitate human behaviour when interacting with computers to perform digitized tasks manually, such as opening and closing applications, reading documents, entering data, and sending e-mails. As with any new digital technology answering the question of where to start and what is the right software, is challenging. In the case of RPA, the question of where to start depends on the selection of the business process to be automated and optimized. There are approaches for process selection in research, but they are relatively complex and have not been validated in practice. To fill this gap, we have simplified the process selection method and validated it on a practical example. We also present a simple method to select the appropriate RPA software. The criteria selection and evaluation were done with the Pairwise Comparison and Benefit Value Analysis method. This approach is relatively easy to follow and to apply in practice and thus also closes a gap in applied research.

Keywords: assessment; office automation; process selection; RPA (Robotic Process Automation); software selection

1 INTRODUCTION

The changing global economy driven by the development of new technologies requires organizations to become more reliable and agile in responding to customer needs [23, 31]. In addition, competitive and financial pressures force organizations to seek out new technologies and methodologies that will help them to be more productive, efficient, and cost-effective [30, 31].

One of the emerging technologies is robotic process automation (RPA). RPA is a software-based robot for office automation that imitates human behavior in interacting with computers [30]. RPA enables organizations to shift the employees from repetitive tasks in the office to high-value-added tasks [5, 29]. Unfortunately, it is still constrained by the inability to select which business process is profitable to be automated and what software is suitable for the process [6, 32].

The Research on RPA has been done a lot, but only a few have raised the topic of RPA software and process selection, which is essential before the implementation, and none has simplified and verified these approaches with practical examples. Therefore, this research is triggered by the questions as follows:

- How simply select the best business process to automate with RPA?
- How to simply and transparently select the best software for that process?

To answer these research questions and to clarify the understanding of process and software selection, we present a use case study at Technische Hochschule Ingolstadt (THI). In the *first step*: we identified potential tasks in THI where RPA could be successfully implemented. *Second step:* we chose the best and most suitable process to be automated. And the *third step*: we choose the best RPA software on the market today and compare them with each other.

2 STATE OF KNOWLEDGE
2.1 The Overview of Robotic Process Automation

The Industrial Revolution 4.0 is a combination of a physical and digital system that changes the way humans live. It is supported by various technologies such as the Internet of Things, Automation, Simulation, Big Data Analytics, Vertical & Horizontal Integration, Augmented Reality, Cloud Computing, Additive Manufacturing, and Cyber Security. I4.0 uses the principles of Interoperability, Modularity, Service Orientation, Real-Time Capability, Decentralization, and Virtualization [23].

In the context of automation, the area consists of automation in the offices and factories. The development of office automation is not as fast as automation in the factory. Since 1980, the factory's degree of automation has risen by 75%, while automation in the office just increased by 3 % [18]. Currently, there are several office automation technologies. One of the most promising is RPA, which has a growth rate is around 30% annually [16].

RPA consists of three types, the attended robot, unattended robot, and a combination of them (hybrid robot). The attended robot works directly on the user's computer and acts as a personal assistant, thus requiring the user to trigger or start the process. In contrast, unattended robots work on the company's server and run without or less human interference. The hybrid robot is a combination of attended and unattended robots [5, 30].

The advantages of RPA, such as increased efficiency, productivity, and accuracy, have been described in previous studies [5, 26, 33]. Unfortunately, those have not immediately attracted the companies. One of the obstacle factors is a lack of knowledge about RPA and its future opportunities [4]. Therefore, this study will provide objective information about RPA and how to simply evaluate it.

2.2 RPA Software

There are three major RPA providers currently on the market; UiPath, Automation Anywhere, and Blue Prism [25].

UiPath, or the previous name Desk-Over, was established in 2005 in Bucharest, Romania. It develops an efficient, robust and stable, robotic workforce controlled anytime and anywhere (cloud-based) [12, 29]. Automation Anywhere (AA), or the previous name Tethys Solutions, LLC, was founded in 2003. It has operated more than 1.5 million bots (bots are the other name of RPA robot) in 20 countries [29]. The latest version of this software is Automation Anywhere Enterprise A2019, which uses a web or cloud-based platform and IQ bots as the artificial intelligence feature to recognize documents [4]. Blue Prism was developed in 2001 in Warrington, United Kingdom. The initial goal of Blue Prism was to eliminate manual data entry processes with low returns and high risks. Blue Prism currently offers intelligent and responsive bots that handle various data types in the complete automation process [8, 28].

2.3 RPA Process Selection

Process selection in automation projects is a challenging task as it relates to project success [26]. A project is called "Success" if the effort or resources sacrificed by the organization is far less than the benefits achieved [27]. Therefore, the organization must be able to identify any repetitive process and sort it into the priorities and interests of the organization.

In process selection of RPA, Assatiani & Penttinen (2016) explain that processes or tasks that are high in repetition and have a fixed processing standard must be automated first [3]. While Wanner et al (2019) believe that six parameters influence process selection:

- Execution frequency: the number of repetitive processes.
- Execution time: the duration of each process.
- Standardization: streamlined process and not easy to change.
- Stability: the process is not changed or interrupted.
- Failure rate: the process result tends to deviate from the target.
- Automation rate: the process that is already good, without automation.

Furthermore, Wanner et al. (2019) emphasize that the selection process must also refer to the profitability concept or economic benefits, where the fixed and variable costs of human labour (without automation) are compared with the fixed and variable costs of robots (with automation) [32]. The higher gap between the costs of robots and humans means the greater opportunity for the process to be automated [3, 32]. In a conclusion, the best-selected process is a profitable, stable, and standardized process, with high repetition, long-duration to execute, and tends to fail due to human error.

The approach of this study is to revisit Wanner's parameter, which may be difficult to apply in real-life cases, considering that Wanner built the parameter based on a literature study. Besides that, Wanner's parameters are too broad and rather complicated for process selection. The organization will have difficulties finding data and therefore evaluate and compare one process to another. The Research will simplify Wanner's parameters and provide a real example in this process selection.

3 RESEARCH METHODOLOGY

There are two methodological approaches for process and RPA software selection in this research. The pairwise method is used to weigh the criteria. While the benefit value analysis is carried out to select the alternative solution such as the best process to be automated or the best software. The weighing of the criteria with the pair wise comparison and the rating within the benefit value analysis is done by a team of students which have experience and expertise with RPA [2] and supported by a grey literature review [15].

3.1 Pairwise Comparison

Pairwise comparison generally is any method of comparing entities in pairs to judge which of each entity is preferred or has a greater amount of some quantitative property, or whether or not two entities are identical. It is a great tool to visualize similarities and differences between products, services, and technologies, or even better between more complex and abstract concepts like strategies and ideas. The comparison helps us to organize and classify the elements in which we are comparing [10, 13].

The features and characteristics of each element are evaluated according to a set of criteria (C1, C2, …, C6), enabling the easy recognition of their advantages and disadvantages to facilitate the decision-making process. Then these criteria are tabulated into a paired matrix and weighted from 0 to 2 where "0" means for less important, "1" means equally important, and "2" means more important. The result is a weighting of the criteria in percent. An example of a pairwise comparison template is shown in Tab. 1. In this study, pairwise comparison was used to compare the criteria of RPA software selection, based on the needs of the organization.

Table 1 The Example of pairwise comparison

No	C1	C2	C3	C4	C5	C6	Sum	Rank	%
C1		1	1	0	2	2	6	2	20
C2	1		1	2	2	2	8	1	27
C3	1	1		1	1	1	5	3	17
C4	1	0	1		1	2	5	3	17
C5	0	0	1	1		2	4	4	13
C6	0	0	1	0	0		1	5	3

3.2 Benefit Value Analysis

Benefit analysis is a process of economic analysis that was originally developed for the public sector and has gradually become established in the industry. This method is used to compare various alternatives in future investment projects. The advantage of value analysis is that it can be used when the investment project is not based solely on hard factor comparisons, such as the acquisition of value or profit. The benefit analysis also included qualitative factors in the evaluation [17].

In this research, the benefit analysis method is not used to compare various alternatives in future investment projects but is used as a tool to select RPA software and business processes to be automated. The criteria of benefit analysis are based on (*1*) *What are the main goals of automation, and (2) What is offered by RPA software to achieve the goals of automation.*

The individual criteria are then weighted with the help of pairwise comparisons to obtain meaningful results (see Tab. 1). Once the criteria are weighted, the different RPA software can be evaluated in a value-benefit analysis, in which the RPA software is ranked, and each rating is multiplied by the weight of the criteria to obtain the final result. The result of each RPA alternative is called a score and the alternative with the highest score is selected.

4 USE-CASE STUDY
4.1 Process Selection at Technische Hochshule Ingolstadt

During the identification of potential processes, direct observations to several respective departments at the Technische Hochschule Ingolstadt were carried out [2, 7]. Brainstorming with relevant stakeholders generated many ideas. Unfortunately, these ideas had to be eliminated due to data privacy and regulation issues. The remaining ideas are as follows:

- **The Course Feedback Process:** It is the process followed at THI at the end of every semester to improve the quality of the system. This entire process starts from email rollout to students and ends with report generation for employees.
- **LinkedIn Post Management Process:** At THI, the LinkedIn Posts are managed by a team manually on regular basis. It involves posting open job positions, events, news, etc. The proposal was to automate the process of posting Job positions and events whenever a new Job or event is planned in each department. The post is normally pasted twice, on THI Page and social platforms like LinkedIn.
- **Moodle Study material upload and notification Process:** At THI, Moodle is the portal used for the upload and notification of course-related content by faculty for any particular subject. Often, the course content is updated at regular intervals by including lecture notes, quizzes, and other links for meetings, etc. The notification when new content is uploaded is often send as a group mail to students. This is repetitive work for the course faculty which involves no strategic decision-making process.
- **Buddy Matching Process:** The buddy program provides an opportunity to the international students and exchange students to ask for a buddy. The buddy will act as the first point of contact when the student arrives and gets started at THI. Students who are already in their higher semester of bachelor's or master's program will be assigned a buddy. Currently, buddies are matched to students manually, and is very tedious. Manual matching is done by International Office of THI and the Network & International Culture Exchange (NICE) organization

and has to be repeated every semester for a new set of students and buddies.

The assessment process includes the following steps: Understanding the Process in detail
1) Interviewing or meeting end-users/ customers from respective departments
2) Summarizing the inputs and details provided during the interview/meeting
3) Brainstorming internally with other Project members
4) Rating the RPA potential based on Process knowledge and end-user feedback

The four processes above were then assessed in more detail with several parameters from the Wanner et al. (2019) study. It was the goal to select the most important criteria but at the same time simplify the assessment. The simplification is the efficient way to get the assessment result as soon as possible. Wanner parameters seem complicated because in some real cases, the parameter of failure rate and standardization are not the main considerations for automating processes. For example, a manual process with a high failure rate will not be automated with RPA, as long as it is an occasional or infrequent process [1, 3, 14, 22].

Table 2 Process Selection Matrix

Processes	Course Feedback Process	LinkedIn Post Management Process	Moodle Study Material Upload Process	Buddy Matching Process
Parameters				
Execution Frequency	2	3	2	2
Execution Time	1	2	1	3
Stability	1	1	3	2
Automation Rate	3	1	1	3
Sum	7	7	7	10
Selected				√
1 = low, 2 = medium, 3 = high rating				

The Matrix consists of the potential processes that are given a weight based on the following parameters: *execution frequency, execution time, stability, and automation rate*. The weights are rate 1 to 3, where 1 means low, 2 means medium, and 3 means high. According to the selection matrix (see Tab. 2), the buddy-matching process has the highest score, meaning that automating this process will provide greater benefits than any other process.

4.2 Use Case: Buddy Matching Process

Every year the international office of THI engages in organizing buddies for international students who require assistance in orienting at the university. This organizational process is strenuous and time-consuming because there exist multiple criteria for the matching process, and because it is done by manual repeatedly.
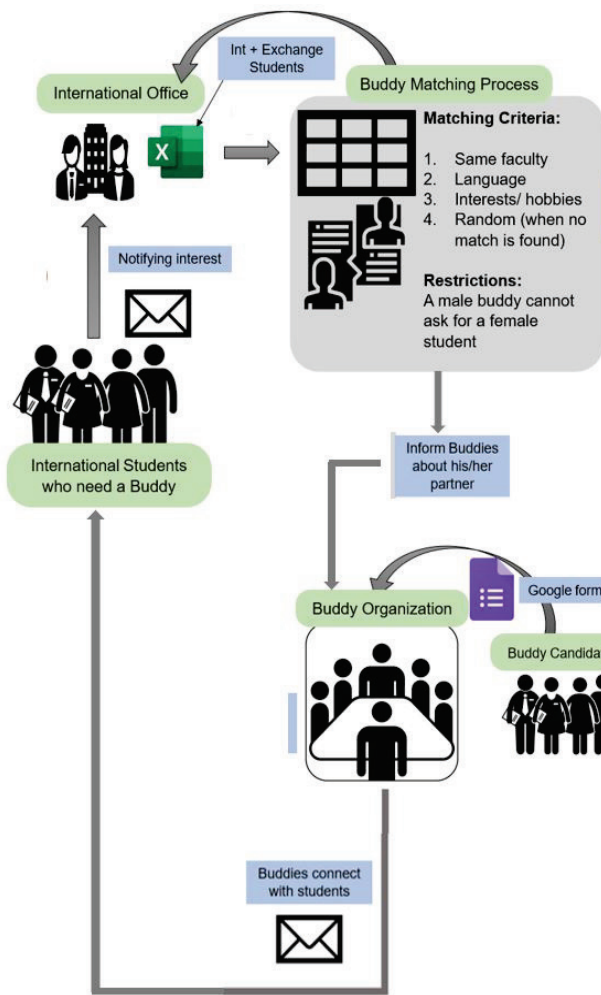
Figure 1 Buddy-Matching Process

As illustrated by Fig. 1, the current process is such that the international student notifies the international office about their interest in having a buddy via email soon after receiving admittance to the university. Afterward, the international office sends the interested students a PDF form to fill out basic information which would later be utilized for the buddy matching process. The international office then registers the student information in an excel sheet and compares it with a list of buddies. The buddy candidates must fill out a google form to be a candidate for assisting the international students. The current matching criteria are as follows:

- Degree – Masters, Bachelors or PhD
- Faculty
- Language
- Interests or hobbies.

In exceptions, the buddy is selected randomly when no similarities are found. The only restriction the international office has by experience is to avoid a male buddy requesting a female international student. Soon after the matching process is complete the international office informs the buddy students about their matched partner students in the form of an email. Through the buddy organization, the buddy

then contacts the international student whom they were partnered with. Although the process seems straightforward, the current process entails a few loopholes. For example, when the Buddy or international student backs off or in other words withdraws from the program, the international office has to take care of such an exception.
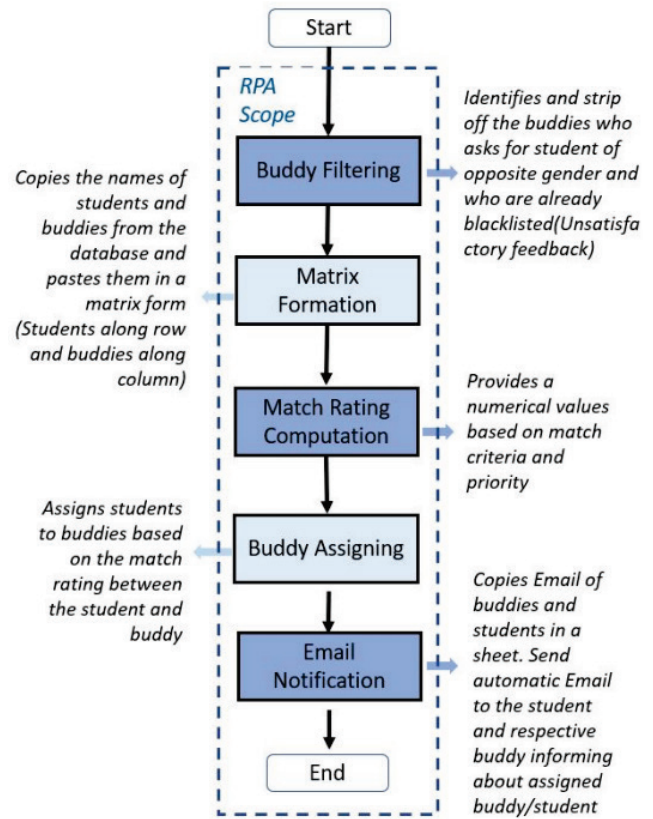
Figure 2 RPA Scope on Buddy-Matching Process

In order to implement the buddy-matching process in RPA, one of the initial steps is to convert the process to a logic flow chart. The program is initially visualized as the chart and then implemented in software. The entire process is converted to the following five subroutines (see Fig. 2)

- Blacklist routine for buddy filtering
- Matrix creation routine
- Match computation routine
- Scoring routine/match rating
- E-Mail notification routine.

Blacklist routine: The target of this routine is to filter out individuals with the below conditions and move them to a separate sheet called the blacklist sheet. The conditions are:

- The buddy requested a student from their opposite gender.
- The buddy details are there in the previously blacklisted individuals list.
- The buddy has a German level less than B1 (This person will not be blacklisted but be deleted from the current list).

The result of this step is a filtered in the buddy sheet and updated in the blacklist sheet.

Matrix creation routine: This routine aims to create a base matrix for pasting match-ratings and performing calculations. The outcome of this routine is an empty matrix with student's names in rows and buddy's names in columns.

Scoring routine: This routine aims to calculate the numerical equivalent of the compatibility between Students and buddies' preferences. The condition of this routine is every matching feature is given a unique prime number to multiply the match rating with. This helps us in the further routines to analyse the data easily and assign the best buddy to the student. The outcome of this routine is a filled matrix with a match-rating for every student-buddy pair.

Match computation routine: Depending on the match-rating, a best buddy is chosen for the student. Here the highest value isn't considered but rather the priority and the preferences chosen are put in combinations to choose the best pair. This is done using If conditions and Mod arithmetic operators as illustrated below.

The conditions are:
- Degree (D), Gender (G) and Priority (P) are given weightage for matching.
- DGP means all three Degree, Gender and Priority are matching.
- The order of priority for matching is - DGP, DG, DP, D, GP, G.
- After every matching is done, the flag count is incremented by 1. Buddies cannot have more than 2 students and students cannot have more than 1 buddy.

The Result of this routine is achieved, when the best buddy is assigned to the student. The student and buddy details are moved to a separate sheet with their e-mail addresses.

Email notification routine: This routine aims to send emails to the student and buddy regarding their respective partners from the results of the match-computation routine. The result of this routine is achieved, when the template emails are send to the student and buddy with details of their respective partners. Once it is done, a flag is assigned in the excel sheet indicating completion of the activity.

4.3 RPA Software Selection

Once the Buddy matching process is selected and the RPA scope plan for that process has been determined, the next task is to determine what software is suitable for the selected process and brings maximum benefit to the organization.

4.3.1 Determination of Selection Criteria

The first step of RPA software selection is to define the criteria by which the RPA providers will be selected. Before the brainstorming about the criteria started, it was fundamental to get an overview of the RPA providers and their products. The aim was to see what the offer of the RPA market is like, how similar the products are and how much information do the companies share online. After extensive research and brainstorming, at least there are seven important criteria for selecting RPA software:

- **Required Programming skills**: The Software should require no coding or just basic level coding, so that person without programming expertise is also able to use it.
- **Ease of use**: If there are too many fields requiring data or the application is difficult to understand, it might be difficult to get efficiency during the use of the software.
- **Product Availability**: The product should be available as a free version or trial version to satisfy the basic need of automation or at least to get the experience of the user interface.
- **Pricing**: The pricing is considered as a cost of the software license in a certain period.
- **Integration**: The Software should integrate easily with other management tools or applications, as well compatible with the existing information systems.
- **Reliability & Security**: Depending on the importance of data, users want to set different permissions based on user accounts or groups. Some tools allow organizations to define who can edit what in the application.
- **Operational Scalability**: Depending upon the scale of the project, the software should be able to perform the task without getting crashed.

4.3.2 Determine the Weighting of the Criteria

Since not all selected criteria are equally important for the particular project, the next important step was to determine an appropriate weighting of each criterion. One of the most common methods for determining a weighting of criteria is the pairwise comparison. To make this comparison more transparent and understandable, a rating of 0-2 to the criteria are given, which "0" means vertical criterion more important, "1" means both criteria are equally important "2" means horizontal criterion more important (see Tab. 3)

Table 3 The Pairwise Comparison of Criteria to Select RPA Software

	C1	C2	C3	C4	C5	C6	C7	Sum	%
C1		0	0	0	0	0	2	2	4.8
C2	2		1	0	1	1	2	7	16.7
C3	2	1		1	2	1	2	9	21.4
C4	2	2	1		1	1	2	9	21.4
C5	2	1	0	1		1	2	7	16.7
C6	2	1	1	1	1		2	8	19
C7	0	0	0	0	0	0		0	0
Sum								42	100

C1	Required programming skills	C5	Integration
C2	Ease of use	C6	Reliability and security
C3	Product availability	C7	Operational scalability
C4	Pricing		

In this pairwise comparison, after calculating the total rating of each criterion, the weighting for each criterion will be gained. The weighting is used to perform a benefits analysis of the different RPA software.

4.3.3 Benefit Analysis of Different RPA Software

Product Availability: UiPath Community edition is available for all to use but the bots created cannot be distributed. Enterprise edition is available on 60 days free trial, while Automation Anywhere gives one month trial is available in enterprise edition whereas community edition is available to use with only Bot Creator rights. Microsoft Power Automate also provides a community version and enterprise version without advanced features, but Blue Prism does not provide a community edition, but it provides a one-month free trial of the product [20, 24].

Pricing: Pricing for Microsoft Power Automate is around 7,000 USD Annually [24], while for Automation Anywhere is approx. 20,000 USD annually, for UiPath, is approx. 18,000 USD annually, and for Blue Prism is Around 15,000USD annually [2, 9, 11].

Reliability & security: UiPath comes with incomplete security standards and certifications that creates business and compliance risks and to enhance the security features the user has to put in extra efforts and bear the costs. However, Blue Prism offers complete security features for the enterprise level. The encryption feature ensures data protection and also offers easy additional encryption features. Automation Anywhere is the only RPA platform that consists of a Bot security framework, and the highest compliance and security ratings [2, 21].

Ease of Use: UiPath is a clear winner as it offers a user-friendly dashboard with simple drag-and-drop functionalities. And Automation Anywhere is developer-friendly and is completely script-based. While Blue Prism is much easier than Automation Anywhere and is a visual designer based but not completely like UiPath [11]. While Power Automata's user interface has a familiar feel like the UiPath as it mimics most of Microsoft's Office UI [2, 9].

Integration: UiPath, Automation Anywhere, and Microsoft Power Automate are easily interactable with other applications including word, excel, Email with easier identification of objects on screen while Blue Prism is also easily interactable with other applications including word, excel, Email but a bit complex to the identification of object on the screen [2, 19].

Required Programming Skills: UiPath doesn't require any programming language knowledge. It provides RPA functionalities in a much simpler way than any other RPA tool. Blue prism needs a basis of programming to manage the business objects and Automation Anywhere does require a little knowledge of coding to use the activities [11]. While Microsoft Power Automate also required some basic programming knowledge [2, 9].

Operational Scalability: Microsoft Power Automate is a newcomer so not suitable for enterprise [24] while UiPath also lacks scalability features and often crashes while working on medium projects. Automation Anywhere Offers limited deployment in large-scale robot integration, while Blue Prism has good operational scalability with high execution speed [21].

The benefit analysis is used to prioritize the software that is efficient and useful for the use-case implementation. The prioritization is done amongst four RPA software: UiPath, Automation Anywhere, Blue Prism, and Microsoft Power Automate. To make this analysis more transparent and understandable, a rating from 1 to 5 for each criterion has been given. "1" means lowest benefits, and "5" means highest benefits. The rating value is based on literature review and user experience (use-case study)

Table 4 The Benefit Analysis for Selecting RPA Software

RPA Software	Weighting (%)	UiPath		MS Power Automate		Automation Anywhere		Blue Prism	
Criteria		Rating	Benefit Value	Rating	Benefit Value	Rating	Benefit Value	Rating	Benefit Value
C1	21.4	5	1.07	4	0.86	4	0.86	3.5	0.75
C2	21.4	4	0.86	5	1.07	3	0.64	4	0.86
C3	19	4	0.76	4	0.76	5	0.95	4.5	0.86
C4	16.7	5	0.84	4.5	0.75	4	0.67	4.5	0.75
C5	16.7	5	0.84	5	0.84	5	0.84	4.5	0.75
C6	4.8	5	0.24	4.5	0.21	4.5	0.21	4	019
C7	0	4	0	3.5	0	4.5	0	5	0
Sum	100	32	4.61	30.5	4.49	30	4.17	30	4.16

RPA Software	Total Rating	Total Benefit Value	Rank
UiPath	32	4.61	1
MS Power Automate	30.5	4.49	2
Automation Anywhere	30	4.17	3
Blue Prism	30	4.16	4

Furthermore, the benefit value of each software is a result of multiplying the weighting value and rating. This benefit value shows the gained benefit of RPA software for each criterion for buddy-matching process implementation.

Tab. 4 concludes that UiPath has more benefits compared to Microsoft Power Automate, Blue Prism, and Automation Anywhere for particular this buddy use case implementation. So UiPath will be used for RPA implementation and with UiPath, a second beneficial RPA software Microsoft Power Automate also will be used to get some overview of this newcomer RPA software.

4.4 The Results of RPA Implementation

For use-case, the selected software, UiPath has been proved to reduce the process time by nearly tenfold. It has also been observed that the operational reliability and customer satisfaction have been improved [7]. Deploying RPA is also expected to increase intangible benefits like enhanced student satisfaction and reduction in non-value-adding activities. RPA also offers the ability to free up some of the time of the employees to undertake more investigative and value-adding tasks. RPA is not necessarily replacing any of the organizational roles but making their work more interesting and value-adding.

From the use-case implementation, it can be understood that the NICE and International Office of THI now can focus on more important tasks than spending days on performing the matching process and notifying the students [7]. The implementation has attained maximum accuracy leading to heavy cost savings for the customer. Additionally, the

automation solution saves 85% of the time, save 85% of cost and 100% accuracy.

Time savings and accuracy are obtained from the comparison between manual and robot processing time to 100 data of student and buddy. In a manual process, the data is processed by different skill operators. The high skilled operator can process 100 data in 9 hours, the intermediate skill operator in 11 hours, and the beginner skilled operator in almost 14 hours. So, on average the operators can process 100 data in 11 hours with an accuracy of around 70%. While the RPA robot (UiPath & Power Automate) can process data in an average of 1,5 hours with an accuracy of 100%. From this calculation, it is seen that RPA can reduce the processing time by up to 85 %.

The cost-saving is determined by comparing cost components in the manual process and RPA process, as seen in the Tab. 5.

Table 5 The Cost-saving of RPA Process

100 Buddies × 100 Students Data		
Cost Involved	Manual	Robot
Total saving time is converted to Euro	693,90	55,68
Cost of operating computer	2657,64	213,27
Internet charge	2,63	0,21
Labour cost	138,78	11,14
Cost for OS	99	99
Hosting cost (clouds)	0	0
Software licence (Community edition)	0	0
IT support	60	240
Total Cost	3651,95	563,40
Saving Cost	**85%**	

5 CONCLUSIONS

Many companies and organizations are just beginning to explore the use of robotic process automation as a part of their digital transformation strategy. Careful planning and implementation of RPA can pave the way to achieve cost and operational efficiencies in companies.

This paper presents the selection process for potential software implementation of RPA at THI. From the observations, there are four potential processes to be selected using the modified parameter of Wanner. The Modification is to simplify and speed up the decision-making process in the organization.

The selection of RPA software involves four software: UiPath, MS Power Automate, Automation Anywhere, and Blue Prism. It consists of three stages:
- Determination of selection criteria using literature study and brainstorming
- Determining the weighting of criteria using pairwise comparisons
- Selection of software using value-benefit analysis.

Finally, the body matching process with UiPath software was selected to be automated in Technische Hochschule Ingolstadt. In the future, the implementation of RPA in THI can be more broadly, given the many potential processes that can be automated within organization. However, guarantee of data protection and privacy must be ensured first by RPA providers.

Notice

The paper was presented at MOTSP 2022 – 13th International Conference Management of Technology – Step to Sustainable Production, which took place in Primošten/Dalmatia (Croatia) on June 8–10, 2022. The paper will not be published anywhere else.

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Linear Displacement and Straightness Measurement by Fabry-Perot Interferometer Integrated with an Optoelectronic Module

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Abstract: This research develops a three degrees of freedom (DOF) measurement system by integrating Fabry-Perot interferometer and photoelectronic inspection module to determine linear displacement, horizontal and vertical straightness geometric error parameters simultaneously. The interferometer and the photoelectronic inspection module in a three DOF measurement system share the same light source, and the two structures are used to measure linear displacement and straightness errors. The experimental results are utilized to calculate the relevant error parameters according to ISO standards and numerical analysis. They show that after the machine error compensation, the positioning deviation of the system is reduced from 55 µm to 19 µm, corresponding to the reduction of 65%. The accuracy is promoted from 65 µm to 31 µm, about the improvement of 52%. The horizontal and vertical straightness errors of the machine are 4.30 µm and 5.71 µm respectively.

Keywords: interferometer; linear displacement; optoelectronic module; straightness measurement

1 INTRODUCTION

Precision machinery is one of the most important industries in worldwide. And the linear guide is a key component for high precision machine tools and coordinate measuring machines. Due to the deviation in the manufacturing and the assembly of the part, multi-degree-of–freedom geometric errors may occur during the linear motion. The assembly of multiple linear guides also possesses the squreness and the parallelism error. Therefore, the development of a high-precision inspection system is a critical issue. It can be utilized to evaluate the performance of the precision equipment and to be a reference for the subsequent error compensation [1].

The laser interferometric technologies have the advantages of large measuring range, noncontact measurement and high resolution performance. Laser also can trace to the definition of length [2]. Because of those features, Laser interferometers are widely applied to many fields which need high accuracy measurement and calibration [3-5].

The usual commercial interferometer based on a non-common optical path structure is sensitive to environmental disturbances and mechanical vibrations. To eliminate these errors, the proposed Fabry-Perot interferometer system arranged with the common optical path bears the characteristics being more insensitive to such fluctuations. And by the integration of an optoelectronic module, the measurement of the linear displacement and straightness can be achieved.

In order to verify the feasibility of the optimized system, comparison measurements between the proposed Fabry-Perot interferometer and a commercial interferometer have been conducted. According to ISO230-2 norm can reveal that the difference in bidirectional system positioning deviation, repeatability and accuracy. It can prove that the proposed system can be employed for high-precision displacement measurements or the calibration of machine tools.

2 PRINCIPLE AND THEORY

In this chapter, a three degree of freedom (DOF) measurement system has been introduced. The mechanical and an optoelectronic module are integrated into the whole system to measure the linear displacement and straightness error synchronously. This investigation used the He-Ne laser as a light source whose wavelength is 632.8 nm. The signal processing system includes the signal amplification circuit, a low-pass filter circuit and an automatic gain control module. The detail of the fundamental principle and theory reveal as follows.

2.1 Fabry-Perot Interferometer

In this research, the Fabry-Perot interferometer (FPI) serves as the measurement system. FPI is a kind of interferometer with the common path optical structure where the displacement measured is precisely defined by the distance in the optical cavity. For this reason, the effect of the environmental disturbances will be obviously minimized [6] [7].

The amplitude of the transmitted beam can be presented in Eq. (1) to Eq. (4), where A_0 is the amplitude of the incident Laser, R and T are the reflectance and transmittance of the plane mirror, T' is the resultant transmittance of the optical components in the cavity [8], and n is the order number of the transmitted Laser beams.

$$A_1 = A_0 TT'^{1/2} R^0 \tag{1}$$

$$A_2 = A_0 TT'^{3/2} R^1 \tag{2}$$

$$A_3 = A_0 TT'^{5/2} R^2 \tag{3}$$

$$A_n = \frac{\sqrt{2}}{2} A_0 TT'^{(2n-1)/2} R^{n-1} \tag{4}$$

The relevant electric field of the s-type and p-type can be illustrated in Eq. (5) to Eq. (12). In this optical design, δ is

the phase difference of the optical cavity which is $2\pi d/\lambda$, where d is the distance of the optical cavity of FPI

For the electric field of s-type transmitted Laser beams:

$$E_{s1} = \frac{\sqrt{2}}{2} A_0 T T'^{1/2} R^0 \cos(\omega t + kx + \delta) \tag{5}$$

$$E_{s2} = \frac{\sqrt{2}}{2} A_0 T T'^{3/2} R^1 \cos(\omega t + kx + 3\delta) \tag{6}$$

$$E_{s3} = \frac{\sqrt{2}}{2} A_0 T T'^{5/2} R^2 \cos(\omega t + kx + 5\delta) \tag{7}$$

$$E_{sn} = \frac{\sqrt{2}}{2} A_0 T T'^{(2n-1)/2} R^{n-1} \cos\left[\omega t + kx + (2n-1)\delta\right] \tag{8}$$

For the electric field of p-type transmitted Laser beams:

$$E_{p1} = \frac{\sqrt{2}}{2} A_0 T T'^{1/2} R^0 \cos(\omega t + kx + \delta + \frac{\pi}{4}) \tag{9}$$

$$E_{p2} = \frac{\sqrt{2}}{2} A_0 T T'^{3/2} R^1 \cos(\omega t + kx + 3\delta + \frac{3\pi}{4}) \tag{10}$$

$$E_{p3} = \frac{\sqrt{2}}{2} A_0 T T'^{5/2} R^2 \cos(\omega t + kx + 5\delta + \frac{5\pi}{4}) \tag{11}$$

$$E_{pn} = \frac{\sqrt{2}}{2} A_0 T T'^{(2n-1)/2} R^{n-1} \cos\left[\omega t + kx + (2n-1)\left(\delta + \frac{\pi}{4}\right)\right] \tag{12}$$

In order to obtain the intensity distribution of the FPI, the summation of the electric field for s-type and p-type are determined by Eq. (13) and Eq. (14).

For the summation of the electric field (s-type):

$$E_s = \frac{\sqrt{2}}{2} A_0 T e^{i(\omega t + kx)} \times \frac{T'^{1/2} e^{i\delta}}{1 - T' R e^{i(2\delta)}} \tag{13}$$

For the summation of the electric field (p-type):

$$E_p = \frac{\sqrt{2}}{2} A_0 T e^{i(\omega t + kx)} \times \frac{T'^{1/2} e^{i\left(\delta + \frac{\pi}{4}\right)}}{1 - T' R e^{i\left(2\delta + \frac{\pi}{2}\right)}} \tag{14}$$

The intensity distribution of s-type and p-type can be denoted by Eq. (15) and Eq. (16).

For the intensity of s-type transmitted Laser beams:

$$I_s = E_s \times E_s^* = \frac{\frac{1}{2} A_0^2 T^2 T'}{1 + R^2 T'^2 - 2T' R \cos(2\delta)} \tag{15}$$

For the intensity of p-type transmitted Laser beams:

$$I_p = E_p \times E_p^* = \frac{\frac{1}{2} A_0^2 T^2 T'}{1 + R^2 T'^2 - 2T' R \cos\left(2\delta + \frac{\pi}{2}\right)} \tag{16}$$

The resultant transmittance of the whole optical cavity and the reflectance of the plane mirror are substituted into the equation Eq. (15) and Eq. (16). The simulated intensity distributions are illustrated in Fig. 1.
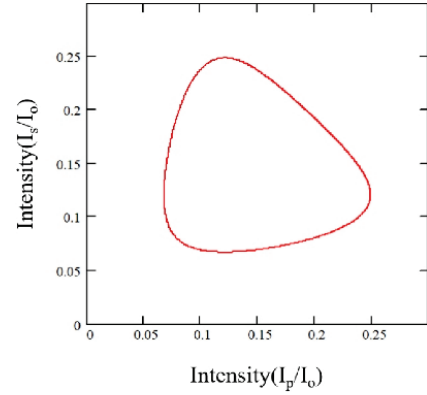

(a) R=25%, T'=87%
Figure 1 Simulation results of signal distribution

2.2 Straightness Measurement

The straightness measurement principle of this system is shown in Fig. 2. This system is combined with a laser light source, a corner cube retroreflector (CCR), a beam splitter (BS) and a 2D-PSD.
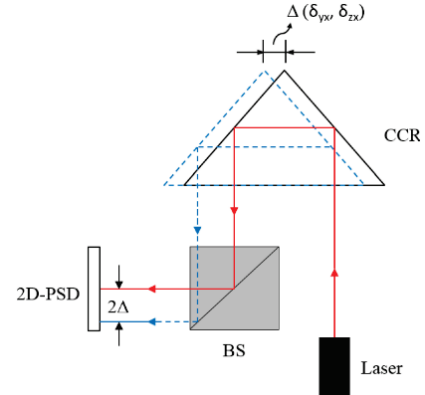

Figure 2 Straightness measurement principle

When the laser beam is incident to the CCR, the beam will be reflected back to the BS, then split to the 2D-PSD which determines the lateral displacement of the laser beam in two directions. For a lateral displacement $(\delta_{yx}, \delta_{zx})$ of the CCR, the corresponding offset of the laser spot detected by the 2D-PSD will be 2 times $(2\delta_{yx}, 2\delta_{zx})$. Therefore, the measurement sensitivity can be enhanced doubly.

The analysis method of straightness error in this research is based on the least square method. And the theoretical equation can be expressed by Eq. (17) to Eq. (19).

$$Y_c = a_0 + a_1 x \tag{17}$$

$$T = \sum_{i=1}^{m} (v_i - y_{ci})^2 \tag{18}$$

$$T = \sum_{i=1}^{m} \left[y_i - (a_0 + a_1 x_i) \right]^2 \tag{19}$$

When the minimum value of T occurs, its partial differential operation is equal to 0, denoted as Eq. (20) to Eq. (22). Solve the simultaneous equations (Eq. 23, Eq. 24) to obtain a_0 and a_1, and then substitute them into Eq. (20) to obtain the theoretical equations.

$$\mathrm{d}T = \frac{\partial T}{\partial a_0}\mathrm{d}a_0 + \frac{\partial T}{\partial a_1}\mathrm{d}a_1 = 0 \tag{20}$$

$$\frac{\partial T}{\partial a_0} = -2\sum_{i=1}^{m}(y_i - y_{ci}) = 0 \tag{21}$$

$$\frac{\partial T}{\partial a_1} = -2\sum_{i=1}^{m}(y_i - y_{ci})x_i = 0 \tag{22}$$

$$\sum_{i=1}^{m} y_{ci} = \sum_{i=1}^{m} y_i \tag{23}$$

$$\sum_{i=1}^{m} y_{ci}x_i = \sum_{i=1}^{m} y_i x_i \tag{24}$$

The straightness error ($E_{\text{straightness}}$) shown in Fig. 3 can be expressed in Eq. (25), where E_{max} and E_{min} are the maximum and minimum difference between the measured curve and the fitted line [9].
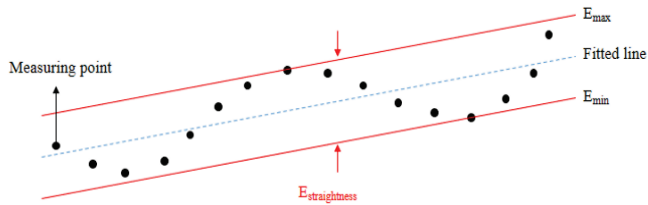

Figure 3 Evaluation of straightness error

$$\sum_{i=1}^{m} y_{ci}x_i = \sum_{i=1}^{m} y_i x_i \tag{25}$$
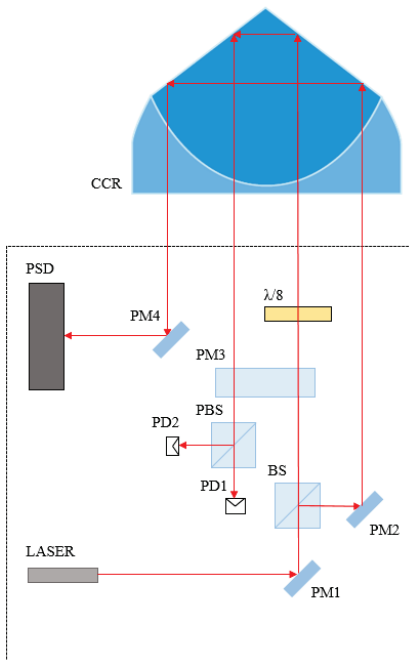

Figure 4 Optomechantronics design of FPI

3 DESIGN OF PROPOSED MEASUREMENT SYSTEM

In this section, the concept and design of this research have been described as follow. The proposed measurement system is based on FPI which is shown in Fig. 4 and Fig. 5. The interferometric signals are recieved by two Photodiodes (PDs). After the signal amplification processing, the signals will be processed with the high-pass filter circuit to eliminate the DC offset and avoid the signal leakage due to the DC drift.
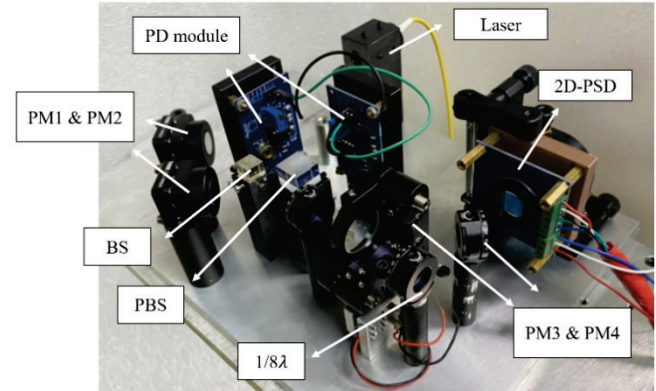

Figure 5 Optical structure of FPI measurement system

4 EXPERIMENTAL RESULTS

In order to verify the ability of the proposed measurement system, a measuring experiment was implemented. The displacement and the straightness error can be measured in this system. And the experimental results are demonstrated as follows.

4.1 Linear Displacement Measurement and Compensation

Fig. 6 is the experimental interference signal of FPI. The reflectance of plane mirrors are about 20%, so the signal pattern is similar to a sinusoid.
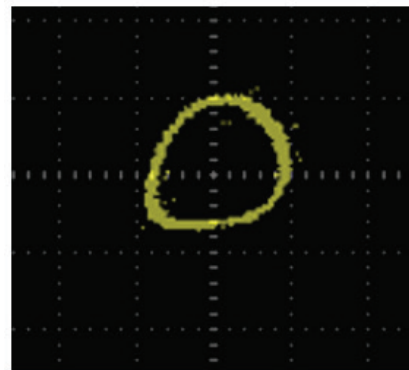

Figure 6 Experimental signal of FPI in X-Y domain

In this experiment, the displacement of linear stage are measured by FPI measurement module, shown in Fig. 7. The measuring range is from 0 to 90 mm with the positioning interval of 10 mm, and each cycle is repeated 5 times. In the comparison experiment, the results with positioning compensation and without compensating are demonstrated as

Figs. 8 to 11. The positioning error of the system is reduce from 55 μm to 19 μm and the accuracy is promoted from 65 μm to 31 μm.
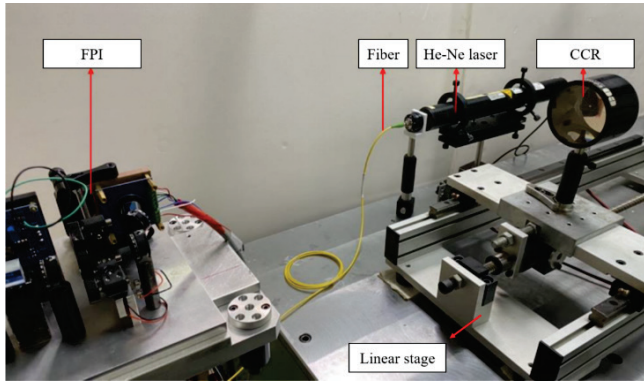

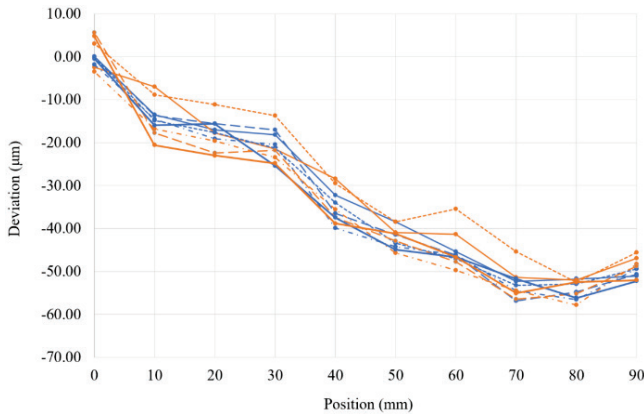**Figure 7** Linear displacement measurement

Figure 8 Displacement measurement without compensation
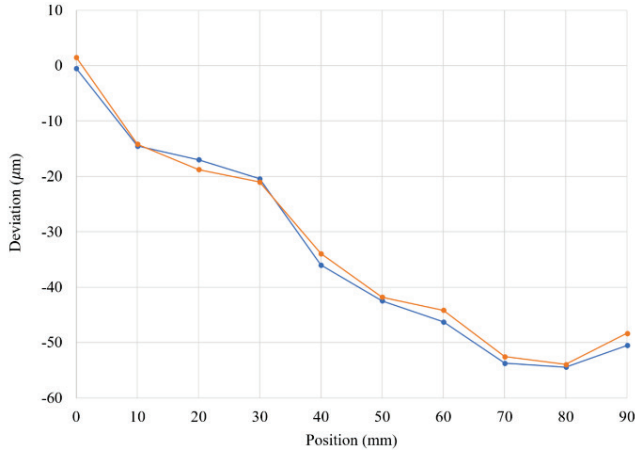
Figure 9 Average displacement deviation without compensation
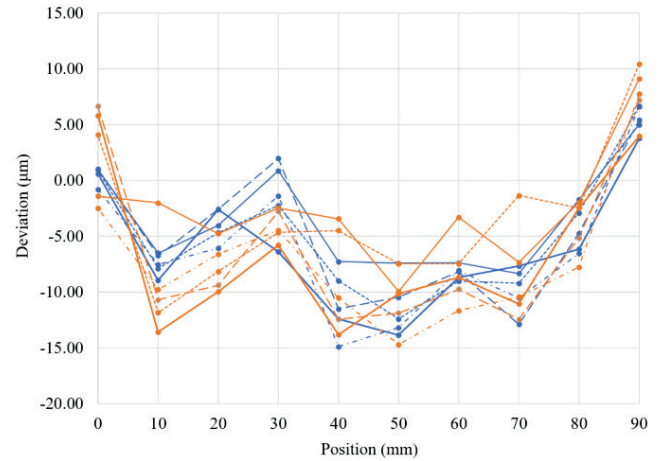
Figure 10 Displacement measurement with compensation

Figure 11 Average displacement deviation with compensation

Figure 12 The non-linearity of 2D-PSD in horizontal direction

4.2 Straightness Deviations

In this research, the straightness error can be detected by 2D-PSD, when the linear stage is moving. According to the calibration experiment of 2D-PSD, the non-linearity of 2D-PSD in horizontal and the vertical directions is about −5.78

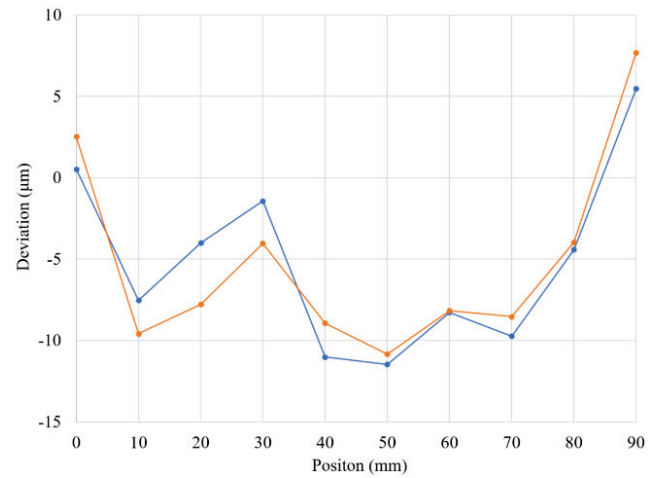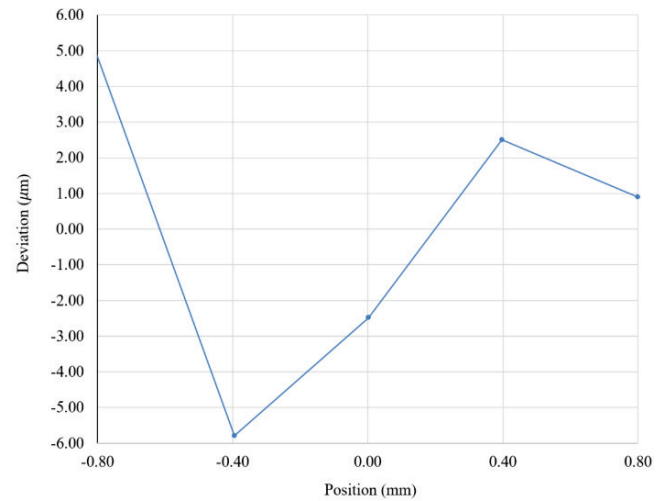μm and 5.03 μm respectively. The calibration curves are shown in Fig. 12 to Fig. 13.

In the straightness experimental results, the horizontal direction straightness error of linear stage is about 4.30 μm. The vertical direction straightness error of linear stage is about 5.71 μm. The results can be shown in Fig. 14 and Fig. 15.
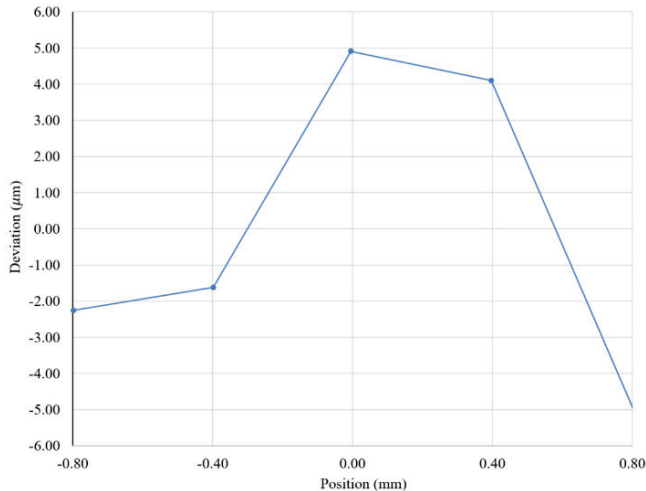

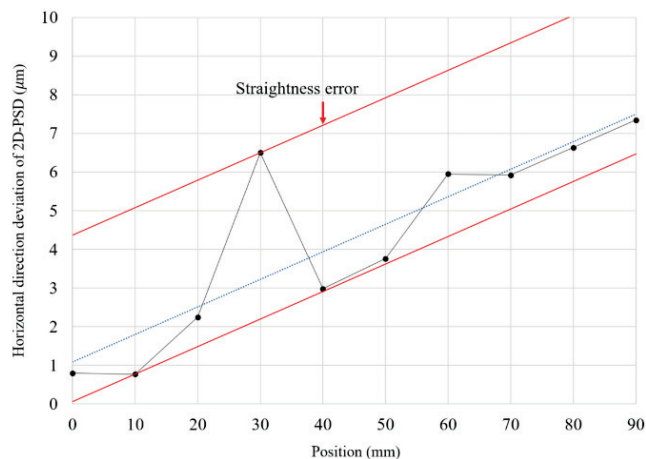**Figure 13** The non-linearity of 2D-PSD in vertical direction

Figure 14 Horizontal direction straightness error of linear stage
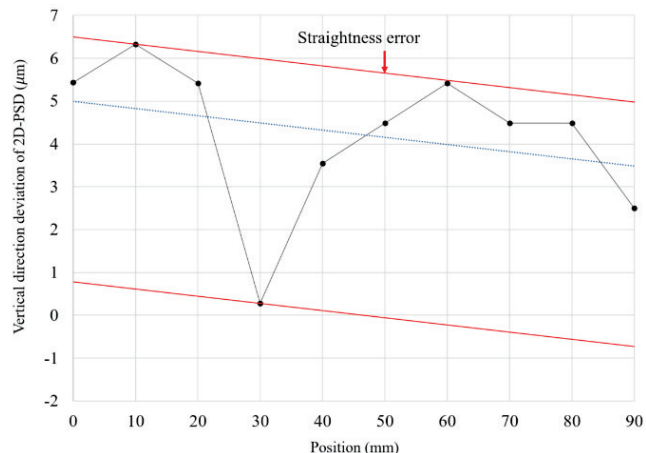

Figure 15 Vertical direction straightness error of movement stage

5 CONCLUSIONS

This article presents a measurement system which can achieve a three degrees of freedom (DOF) measurement by integrating Fabry-Perot interferometer and photoelectronic inspection module to determine linear displacement and straightness errors.

According to the experimental results demonstrated that the positioning deviation of the system is reduce from 55 μm to 19 μm, corresponding to the reduction of 65 %. The accuracy is promoted from 65 μm to 31 μm, about the improvement rate of 52%. The horizontal and vertical straightness errors of the stage are 4.30 μm and 5.71 μm respectively.

Notice

The paper was presented at MOTSP 2022 – 13th International Conference Management of Technology – Step to Sustainable Production, which took place in Primošten/Dalmatia (Croatia) on June 8–10, 2022. The paper will not be published anywhere else.

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Design and Establishment of a Learning Factory at the FMENA Zagreb

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Abstract: Accelerated technology developments caused by Industry 4.0 create problems in its implementation. One of the most important factors that hinder the transition of companies is ignorance and, therefore, the fear of new technologies present among employees. Learning factories have proven to be one of the best solutions for introducing employees to the technologies of Industry 4.0. Croatia is significantly behind in implementing the features of Industry 4.0, especially compared to more developed countries. To facilitate the transition of the Croatian industry to Industry 4.0, it is necessary to acquaint existing and future employees with its technologies through learning factories. There is currently only one learning factory in Croatia, which is too few. This paper presents the process of design and establishment of a learning factory at the Faculty of Mechanical Engineering and Naval Architecture in Zagreb, which facilitates research work and education of students and employees with Industry 4.0.

Keywords: Industry 4.0; learning factory

1 INTRODUCTION

Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet of Services (IoS), and Smart Factory are the main components of Industry 4.0, which has been developed and implemented for more than ten years [1]. The most significant features that this latest industrial revolution brings to manufacturing companies are interoperability, virtualization, decentralization, modularity, customization, and real-time capability [2]. Implementation of Industry 4.0 in manufacturing companies is carried out by creating Smart Factories that contain all the components of Industry 4.0 along with the technologies and services that enable the operation of these components [1]. Rapid technological advances present in Industry 4.0, together with high initial costs and the need for highly educated workers, create difficulties with its implementation in manufacturing companies, especially in less developed countries [2].

There is a lot of research conducted to determine the readiness or current performance of countries in relation to Industry 4.0. Readiness or performance index are most often based on several criteria which consider the use of Industry 4.0 components within a company's business processes. Looking at the results of such research, it can be noticed that more developed countries such as Germany and Denmark are in the upper half of the order, while less developed countries are located at the bottom [3], [4]. A study conducted in 2015 by Veža et al. [5] showed that Croatian industry is between the second and third industrial revolution with a score of 2.15. Atik and Ünlü [3] ranked Croatia 18th in the European Union, while according to Hejdukova et al. [4] Croatia was in 22nd place in 2011, which has not changed until 2019. The dire situation in Croatia was confirmed by a recent survey conducted by the Croatian National Bank, which showed that only 1.97% of Croatian companies have the potential to introduce Industry 4.0 [6]. One of the main factors hindering the implementation of Industry 4.0 in manufacturing companies is the fear of new technologies present among employees due to insufficient familiarity with them [7]. The best solution for this problem are learning factories which facilitate the education and familiarization of employees with Industry 4.0 technologies [8].

Learning factories are high complex educational environments whose primary goal is to connect learning processes with actual industrial processes by representing the genuine factory as realistically as possible. The first forms of learning factories appeared in Germany in the 1980s [8]. Still, the most important moment in their history was the development of a learning factory at Penn State University in America, when the term "Learning Factory (LF)" was formed [8]. The number of studies in the field is growing with the advancement of Industry 4.0, resulting in an increase from 25 to 120 established learning factories in the last decade [9]. To gather, organize and improve existing and new knowledge in the field, there was a need to network interested researchers, existing learning factories and their founders. For this purpose, associations and conferences such as International Association on Learning Factories (IALF), Collège International pour la Recherche en Productique (CIRP) working group, and a Conference on Learning Factories (CLF) were launched [8].

In order to establish a learning factory, it is necessary to interconnect learning processes with industrial production processes [10], which can be done with the implementation of three pillars of transformation. Three pillars of transformation are the didactic pillar, the integration pillar, and the engineering pillar which represent a set of characteristics that need to be defined in order for a facility to be considered a learning factory [11]. The didactic pillar is focused on the selection of learning factory target users and learning objectives. The integration pillar requires that in addition to the usual activities of learning factories related to production, design, and logistics, activities related to administration, marketing, and economics are introduced. Finally, the engineering pillar covers the technical and technological contents of LF through the choice of engineering goals, strategies, and technologies [11]. There is a large number of characteristics to choose from when establishing a learning factory using the three pillars of transformation, and it mostly depends on the part of an industry that needs to be covered. In addition to adapting to the part of the industry that needs to be covered, the design of learning factories is also influenced by the available financial resources, which will mainly affect the amount and

breadth of technologies that will be used within the learning factory.

There is currently only one learning factory in Croatia, established in Split in 2009, which was established for education in the area of lean management without Industry 4.0 technologies present at this time [12]. To facilitate education and familiarization of students and employees with Industry 4.0 technologies and thus improve the state of Croatian industry, the new learning factory, which includes necessary components and technologies of Industry 4.0, is established at the Faculty of Mechanical Engineering and Naval Architecture in Zagreb.

Following the introduction, the paper continues with Section 2, which describes the methods used in the learning factory design and establishment. Section 3 presents and discusses the results obtained during and after the learning factory establishment. Finally, Section 4 presents the conclusion together with plans for future work and research.

2 METHODOLOGY

The learning factory was designed and established at the Faculty of Mechanical Engineering and Naval Architecture (FMENA) in Zagreb. The design process began in 2019, and a learning factory was established in February 2022. The establishment of the learning factory was carried out using the methodology process shown in Fig. 1, which included 4 phases: (1) Literature Research, (2) Developing a Directory of Learning Factories (DoLF), (3) Cross-referencing with the manufacturing market needs, (4) Developing LF at FMENA.

First step in the establishment process of the new learning factory was a review of the available literature on learning factories. A review of the literature was conducted to collect data on existing learning factories and their characteristics from which current trends in research and the presence of certain technologies within learning factories can be observed. The data collected from the literature review will facilitate the selection of the characteristics of the new learning factory that will be designed to enable the use of as many Industry 4.0 technologies as possible, thus increasing the availability of currently underrepresented technologies. A literature review was conducted by searching the keywords: "Learning", "Factories", "LF", "TLF", "Teaching-learning Factory", "Modules", and "Industry 4.0" in Scopus, Web of Science and Google Scholar databases. Necessary data that could not be found within the scientific literature was identified in other public sources.

To facilitate further research and development of new learning factories, it was decided to develop a directory of learning factories that will contain data on existing learning factories found through a literature review. Data on existing learning factories were analyzed and structured to be used within the directory. Structured data is entered manually for each learning factory within the database that will make up the directory. To accelerate directory development, it was decided that it would be developed using no-code tools selected to meet the required criteria. Selection process and technical details of selected no-code tools are explained in detail by Hegedić et al. in [13]. Statistical analysis of the data entered in the directory determined the current state of learning factories in order to identify which technologies and

areas of learning are most represented. Additionally, the statistical analysis provided insight into the distribution of learning factories according to institution type and country in which they are established.

For the new learning factory to facilitate the implementation of Industry 4.0 in Croatia, it is necessary that, in addition to educating students, it also enables the education of new and existing employees of Croatian manufacturing companies. The analysis of production processes was conducted in three Croatian companies to determine the steps of the production process and the technologies used in them that needs to be improved. Observed processes and technologies will be implemented in the learning factory so that research can be carried out in order to upgrade them on Industry 4.0 level and later educate employees about them.

In the last step, based on previously defined market needs and the current state of the learning factories, the necessary technologies, equipment, and components that will make up the new learning factory have been defined. The last step of this methodology also includes the procurement of the necessary components and the commissioning of the learning factory.
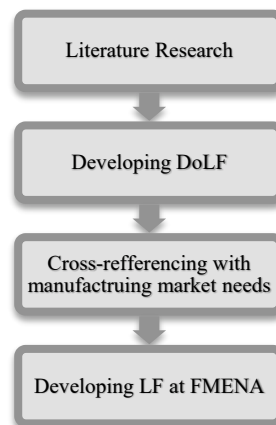
Figure 1 Methodology used for LF design and establishment

3 RESULTS AND DISCUSSION

Through the review of scientific literature and data available from public sources, we found 43 developed and established learning factories. For each learning factory, the data shown in Tab. 1, which describes them, were found, and the learning factories were recorded into the directory database together with their data.

Table 1 Collected information on learning factories

Column name	Description
Operator's name	Name of the company/institution that manages the LF
Location	Name of the country where the LF is located
Initiation Year	The year the LF was initiated
Images	Self - explanatory
Institution type	Academic Institution or Private Company
Functional Modules	Available operations
Areas of Study	Available teaching disciplines
Final product	A product that it produces

The information found about the learning factories was analyzed so that similar data explained in different terms could be clustered to reduce the amount of data for easier statistical analysis and presentation of results. Directory development was done using no-code tools that allow people without coding knowledge to develop software solutions quickly and easily. Different no code tools were used for backend and frontend development which were selected according to the criteria listed in the Tab. 2. The development of DoLF provided easier access to the required data and their statistical analysis, which facilitated the further development of the learning factory. It can be assumed that the developed directory will also facilitate future research on learning factories and enable their comparison and networking.

Table 2 Criteria for no-code tool selection

	Backend	Frontend
Criteria	Most adequate for the needed number of records	Compatible with backend tool
	Functionality for adding attachments	Possibility of adding new entries without login
	Free of charge	
	Good support and maintenance ability	
		Option for custom domains

For the further design of the learning factory, the most interesting data are those about the functional modules included in the existing learning factories and those about the areas of study that they cover. Analysis and clustering defined 13 different function modules that make up individual facilities. All defined function modules are shown in the Fig. 2, from which it can be seen that the learning factories included in DoLF consist mainly of machine tools, robots, and assembly lines.

As in the case of functional modules, after analyzing areas of study included in the learning factories database, 12 different areas of study were identified, the representation of which is shown in Fig. 3. From Fig. 3, it can be seen that in more than 80% of the included learning factories, lean philosophy can be taught, while only 2,3% of learning factories can be used to teach machine learning.

In addition to statistics on functional modules and areas of learning, the developed directory illustrated that 36% of the learning factories included in DoLF are located in Germany and that in 86% of cases, they are based in academic institutions. Although these numbers are not directly relevant to the design of the learning factory, as Germany is in the upper half of most Industry 4.0 implementation ranks, they may indicate the positive effect of learning factories on facilitating the implementation of Industry 4.0 and justify the development of such systems within academic institutions.

A review of the literature and the result of statistical analysis shows that machine learning is poorly represented within existing learning factories, while trends show that it will be an integral part of most industries in the future [14]. In addition to the low representation of machine learning within learning factories, there is a need to create new frameworks and systematize guidelines for the development of machine learning models to facilitate and enable their application in production [15, 16]. To increase the representation of machine learning within learning factories and to enable research aimed at creating frameworks and guidelines for the development and application of machine learning models, it is necessary to implement it within the new learning factory.
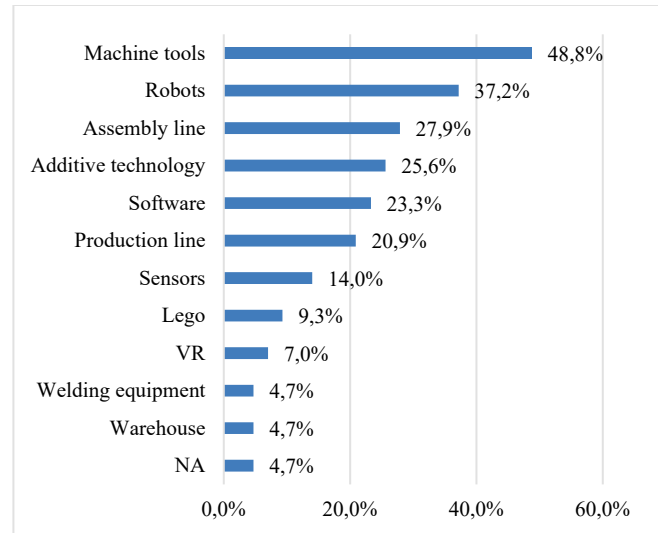
Figure 2 Frequency of functional modules
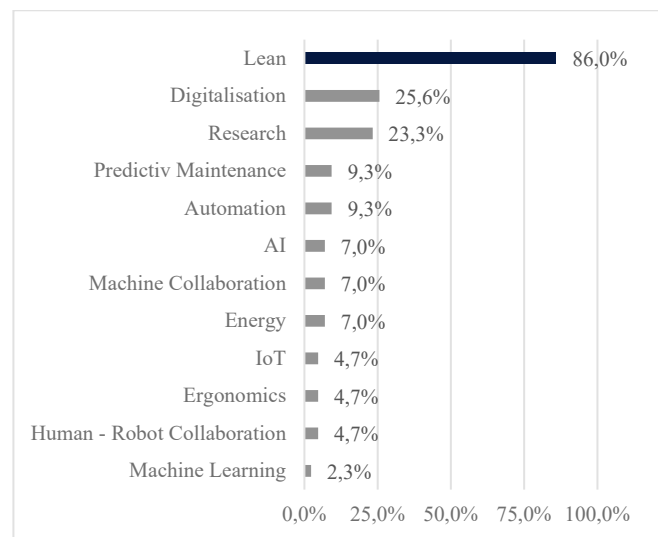
Figure 3 Area of study frequency

The analysis of production processes was conducted within three Croatian companies, one of which is a large company engaged in the production of power transformers, and the other two are SMEs. One of the SMEs is the producer of windows and doors, while the other manufactures fireplaces. The analysis showed that their discrete productions begin with the material processing where particle separation processing such as drilling, turning, and milling and the process of changing properties such as pressing, casting, and tiling are the most used. The second most important process within the analyzed companies is the assembly that is carried out on manual workstations. In addition to the above processes, the need to improve the

connection of manual workstations and the need to conduct inter-phase quality control was noted.

By analyzing the discrete production of the mentioned companies and data on existing learning factories obtained through literature review and directory development, the modules that will make up the new learning factory shown in Tab. 3 were selected.

Table 3 Selected modules for new LF

Module	Description
Properties changing	Simulation of a specific operation from a production process where the workpiece changes its properties (e.g., pressing, casting, tiling).
Particle separation	Simulation of a specific operation from the production process against particle separation procedures (e.g., drilling, turning, or milling).
Warehouse	A module that simulates buffers or final warehouse in the process.
Magazine	A module that stores materials or parts and automatically places them on a production line.
Production line input/output	A module that will simulate the input system of materials into the production line (automatic acceptance and transmission).
Manual workstation	Simulation of manual work in production. This module must also have a system for human-workstation interaction (e.g., industrial tables).
Mobile robot	An autonomous device that simulates the transfer of products (and information) between different operations.
Machine Learning	Machine learning algorithms combined with computer vision for quality control of products and production.
Collaborative Robots	Robotic arms designed especially for collaboration with humans mounted on manual workstations.
Additive technology	System for manufacturing 3D products by depositing materials in multiple layers. (e.g., 3D printer)
Augmented Reality	A system that adds interactive information's to a real word perception via wearable devices such as a smartphone or smart glasses.
Smart Maintenance	A system that includes spare parts warehouse and software for learning factory maintenance control.
Energy Monitoring	System for electrical energy and air consumption monitoring.

Four modules that together form one production line were procured to simulate the above-mentioned material processing in the learning factory. The drilling module allows simulation of particle separation processing, pressing simulates properties changing and assembly of parts using force, the magazine is used to place materials or parts on the production line, and the branch module to enter and exit products from the production line. Each module can be used separately or interconnected into different formations, thus achieving modularity and flexibility of production. Four manual workstations have been designed to integrate the assembly process into the learning factory. One workstation has fixed dimensions, while the other three allow height adjustment to the user, which therefore allows learning and research on ergonomics at work. All workstations are equipped with the necessary tools, equipment, and parts for assembly, as well as with interactive screens that enable more accessible training of employees and education about the lean philosophy in production. Manual workstations are separated

from the rest of the production line, and a mobile robot is used as a connection. Mobile robot, together with collaborative robots located on two manual workstations, enables education and research in the fields of advanced robotics and human-robot collaboration. Two manual workstations are additionally connected with a belt conveyor on which interphase quality control is performed. In addition to interphase quality control, quality control of the final product and management of the work process will be carried out to optimize the operation and ergonomics of work. These controls will be performed using RGB cameras and cameras with depth sensors, and the data obtained will be analyzed using machine learning algorithms. The involvement of machine learning within the learning factory is important for the reasons already mentioned, and in addition to them, it will enable awareness raising and education of students and employees about this technology. In addition to interactive screens, augmented reality will be used for easier acquaintance with the available modules and for obtaining instructions in the assembly process. Implementation of augmented reality into the learning factory will enable education and research on this technology. To enable education and research in additive manufacturing and facilitate the adaptability of production in the learning factory, a device for additive production will be implemented.

Figure 4 Current LF setup

All these modules and systems are interconnected using the Manufacturing Execution System (MES), which allows remote production management, as well as education and research on the system itself. To increase awareness of the need for sustainable and greener production systems, smart maintenance and energy monitoring systems are also included in the learning factory. The learning factory at FMENA was established and commissioned in February 2022 and currently consists of the drilling, pressing, magazine, and branch modules that make up the production line, one manual workstation, a mobile robot, smart maintenance, an energy monitoring system, all connected to the MES and showed in Fig. 4. The characteristics for the rest of the equipment which will make up the complete learning factory shown in Fig. 5 are defined and currently

going through the procurement process. The established learning factory has already made it easier to get acquainted with some of the technologies of Industry 4.0, and once established in its final form will provide education on most Industry 4.0 technologies, from the basics of electrical, mechanical, and computer engineering to complex systems such as MES.
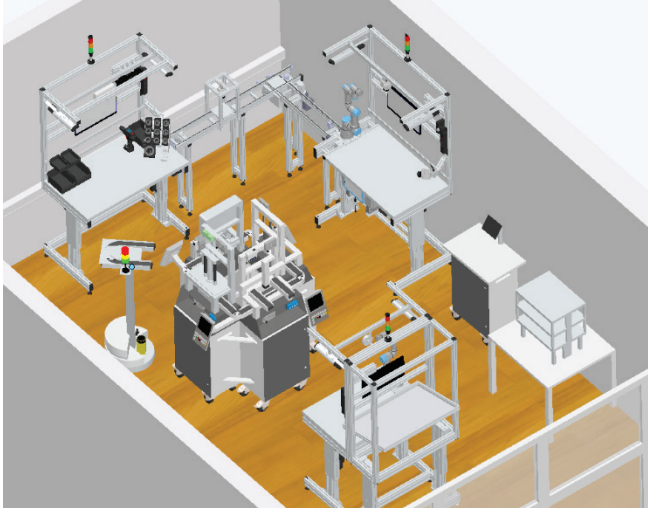

Figure 5 3D model of a complete LF

4 CONCLUSION

The fact that Croatia is significantly lagging with the implementation of Industry 4.0 and that there is only one existing learning factory established more than ten years ago results in need for new learning factories. A new learning factory was designed and installed at the Faculty of Mechanical Engineering and Naval Architecture in Zagreb. The process of design and establishment is described in this paper. The Learning Factory was commissioned in February 2022 in a partial form that will be supplemented with the rest of the equipment upon completion of the procurement process. The new learning factory has already provided knowledge and education about certain technologies of Industry 4.0, so it can be concluded that after establishing in its complete form, this learning factory will significantly facilitate further research and education of students and employees with Industry 4.0 and thus facilitate the implementation of Industry 4.0 in Croatia. A directory of learning factories was developed through a learning factory design process to enable insight into the current state of learning factories and thus the design process itself. Statistical analysis of the data obtained by directory development has facilitated and justified the establishment of this learning factory. Still, care should be exercised when explaining results due to the relatively small sample size.

Further work and research will focus on the establishment of the entire learning factory and development of materials needed for its use in education. Furthermore, efforts will be made to add new features and entries to the DoLF and to keep it up to date.

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Financial Sustainability in Austrian Industrial Companies

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Abstract: The Green Deal published by the European Commission in 2019 pursues the goal of a climate-neutral continent. Its guidelines cover sustainable finance, industry, and energy supply, among other areas. Choosing sustainable investment and finance promotes the shift to a more carbon neutral, circular and environmentally conscious economy and underpins financial stability. Companies that want to remain competitive must embrace sustainable business practices. This means considering sustainable investments and corporate financing along the value chain. In this article, we will show which sustainable forms of financing are available to companies - analysing Austrian industrial companies. Furthermore, it will be worked out when investments are to be judged as sustainable and what kind of sustainable investments are made by the companies surveyed.

Keywords: green debt capital; green equity; sustainable criteria; sustainable forms of financing; sustainable investments

1 INTRODUCTION

Sustainability plays a major role in industry, where the aim is to achieve an ecological transformation of this sector [1]. Examples include a new organization of the value chain by changing the production method, the creation of sustainable consumption with the help of an efficiency revolution and the development of high-quality products [2]. Industrial companies are therefore challenged to address sustainable business practices. The anchoring of sustainability in the management level and its integration into the strategy and innovation processes of the companies is of great importance [3]. Environmentally compatible management also means sustainable financial management. This involves generating sustainable investments by companies and sustainable corporate financing along the value chain [4].

Continuous, sustainable economic growth and the promotion of inclusive, sustainable industrialization play an important role in the goals of sustainable development [3]. By choosing the right financial products, companies can contribute to a sustainable and internationally competitive business location.

1.1 Objectives and Research Method

This paper elaborates when investments are to be judged as sustainable and which sustainable forms of financing are available for companies. Within the framework of a two-stage model, the following research questions will be answered:
- Which sustainable forms of financing are used by Austrian industrial companies?
- Which sustainable investments are made by Austrian companies?

The research questions are addressed in a two-step procedure. First, the most important methods for assessing the sustainability of companies and financial products and the various dimensions of sustainable investment and financing are analysed as part of a comprehensive literature review.

Possibilities of green capital procurement for Austrian companies are identified. Furthermore, evaluation criteria for sustainable forms of financing are elaborated. Since there exist no standardized criteria for evaluating sustainability in the forms of financing, a classification matrix is created as part of a secondary research. This matrix will then be used to assess the extent of sustainable forms of investment and financing for Austrian industrial companies.

For this purpose, industrial companies ranked in the Austrian sustainability index VÖNIX are examined. VÖNIX summarizes all listed companies in Austria that are considered sustainable and serves as a benchmark for sustainable investment on the Austrian stock market. In 2021, a total of 19 Austrian listed companies were included in that index.

Within the framework of a semantic analysis of the sustainability reports from annual reports and homepages of the selected companies, as well as the VÖNIX sustainability rating, green investments and financing forms of the companies are determined.

1.2 Sustainable Finance

Sustainable Finance is the result, or a further development of the agreements adopted by the European Commission, such as the Paris Climate Agreement or the European Green Deal [5]. Companies are encouraged to anchor sustainability in their corporate strategy. The UN Global Compact is used as a basis for transformation and change processes in companies - an agreement between the United Nations and companies that aims to shape globalization in a sustainable, socially and environmentally conscious manner [6]. The lasting ambition is to ensure that sustainability is anchored along a company's value and supply chain [7]. In order to create this transformation process towards corporate sustainability and a predominantly emission-free economic system, certain rules have been laid down on the part of the EU. In addition to R&D and innovation, a decisive role is played by targeted investment. This means that an investment fulfils a specific purpose or has a specific goal, such as environmentally friendly

production or the production of recyclable products [8]. In order to achieve these goals, appropriate financing is necessary. In the course of the transformation process, cooperation with capital providers and credit institutions is necessary. Lenders support entrepreneurs in financing sustainable projects. Credit institutions provide market participants with access to capital for financing sustainable projects [7].

2 EVALUATION OF SUSTAINABLE FINANCE

Sustainable Finance means the provision of financial resources for investments, considering environmental, social and governance aspects [9]. Ref. [10] says the focus of Sustainable Finance is on the development and realization of sustainable finance. Thus, sustainable finance encompasses sustainable growth by channelling financial flows specifically into the transformation of the economy. There are numerous other definitions and terms in the literature. Examples are ethical investment, green finance, sustainable investment, socially responsible investing, or impact investing. Basically, financing approaches consider all three dimensions of sustainability: economic, social and ecological [11]. The definition of Sustainable Finance was derived by the European Commission from the ESG criteria. These are among the best-known methods for assessing the sustainability of companies and financial products. The abbreviation ESG stands for the three areas Environment (E), Social (S) and Governance (G). To finance the transformation of a sustainable economy and the creation of sustainable finance, the European Commission has defined three necessary steps for change: first, redirecting capital flows to sustainable investments to generate long-term growth; second, addressing financial sustainability risks; and finally, promoting transparency and durability in financial and economic activity [12].

Sustainable investments and financing are therefore possible alternatives to conventional financing instruments for a company if, on the one hand, future projects increase the sustainability level of a company (green projects) and, on the other hand, sustainability is integrated into the business activities and the business model of a company (green business models).

There are three different dimensions to sustainable investing and financing [13]:

- type of green project, e.g., renewable energy projects, energy efficiency projects, recycling projects, climate protection projects
- quality of the sustainable project, e.g., project transparency, structure, management
- instrument of financing, e.g., green equity or debt capital

2.1 Sustainability Criteria

According to [12], these include exclusion criteria, best-in-class, engagement, ESG integration, impact investment, sustainable thematic funds, and standards-based screening. Ref. [14] confirms the listed categories and adds that the most frequently used categories are exclusion and negative

criteria, but that positive lists would also be used. The categories exclusion and positive criteria can also be found in the evaluation process of the Austrian sustainability index VÖNIX. Ref. [15] says that the category of exclusion criteria or negative criteria is a first selection in the whole selection process. Positive screenings define the requirements that must be met in order to be a sustainable investment. Best-in-class approaches mean company and country rankings that are carried out and evaluated by rating agencies [11]. The key factor in assessing sustainability is the impact of the project and the company's commitment. This can affect the areas of environment or energy just as much as education or health. To measure the effects of impact and commitment, the ESG criteria are also used here [14].

2.2 Forms of Sustainable Financing

A distinction is made between green debt and green equity. Green debt capital includes, for example, green bonds, green promissory note loans, green bank loans as well as green subsidies [13].

Green bonds are bonds issued by companies or governments. They meet sustainability criteria and are classified as fixed-income securities. To create a uniform framework for issuers of green bonds, the industry has introduced the Green Bond Principles (GBP). These specify the specific purposes of the invested funds, for example how the proceeds of the issue are to be used [14]. *Green promissory note loans* are loan agreements that are mostly offered directly to institutional investors. Specific investment criteria for the capital generated from the loan have not been defined. However, the pricing mechanism is related to the sustainability rating, so that the risk premium decreases when the rating improves and vice versa [16]. *Green bank loans* include traditional bilateral loans. To strengthen sustainability considerations for companies, a company's sustainability performance is assessed, or specific sustainability targets, such as pre-defined CO_2 emissions of the company, are included in the loan agreement [13]. *Green subsidies* are provided for investments that meet sustainability criteria.

Green equity includes green shares, sustainable crowd investing or venture capital.

If companies issue *green shares*, ESG factors are used and evaluated. In this case, the positive criteria are considered and serve to evaluate social, environmental and moral aspects, whereas negative criteria lead to exclusion. If companies have a high value of positive criteria, they are evaluated according to the best-in-class approach. This highlights particularly committed companies that promote environmental protection, employees and sustainable business policies. *Sustainable crowd investing* is a corporate investment consisting of many individual investments. The focus is primarily on investing in young companies and start-ups that are specifically involved in the sustainability sector. There are no criteria in this type of financing that are directly in line with sustainability aspects. With this sustainable crowd investing, it is more about the impact of the project, i.e., what contribution the project or the start-up company

makes to environmental protection and the reduction of CO_2 emissions [14]. ***Venture capital*** is a form of financing in which capital is made available to young, innovative and unlisted companies for a certain period of time. The capital is used for start-ups and growth financing of companies with above-average potential and is mainly used in the Greentech sector [17].

2.3 Evaluation of Sustainable Investment and Financing in Austrian Industrial Companies

As can be seen from the previous sections, there are certain criteria that are used to ensure that the respective investment or form of financing is considered "green". It should be mentioned that there is currently no standardization of the sustainability criteria and therefore different aspects can be included individually, depending on the investment and form of financing. In the classification matrix (see Tab. 1), the sustainability criteria described before are assigned to the financing instruments. The matrix shows which sustainability criteria apply to which financing

Subsequently, the extent to which sustainable forms of financing and sustainable investments are applied in selected Austrian industrial companies is surveyed. The sustainability index VÖNIX from 2021 of the Vienna Stock Exchange is used for this purpose. This serves as a benchmark for sustainable investment on the Austrian stock market. In 2021, a total of 19 Austrian listed companies were included in the VÖNIX. Nine of these companies belong to the industrial sector. Since the focus of this article is on sustainability in manufacturing companies, these nine industrial companies will be used for further analysis. The nine companies considered include manufacturers of chemicals, fibres, printed circuit boards, building materials and metal products, as well as providers of telecommunications services and manufacturers of lifting equipment and special vehicles.

The sustainability level of the selected companies was determined in a semantic analysis based on the respective published sustainability reports in 2021 (annual reports, homepages of the respective companies) and the sustainability rating of VÖNIX. The VÖNIX rating scale of the criteria ranges from –10 (worst rating) to +10 (best possible rating). The evaluation of the respective criteria refers to the significance of the individual company in terms of industry affiliation, regional structure and position in the value chain. The ratings for the individual criteria are used to produce an overall rating for the company, which corresponds to a nine-point scale from A+ to C–. If, for example, too little data is available on the respective companies, the rating is shown in lowercase letters such as a, ab and b to indicate imprecision in the rating.

The companies were ranked alphabetically, the business field was briefly described, the sustainability focus was recorded and the rating of the companies in the sustainability rating of VÖNIX including the exact points were listed. Furthermore, sustainable forms of financing and investments were worked out (see Tab. 2).

3 RESULTS
3.1 Classification Matrix of Sustainable Financing

Tab. 1 shows that among all forms of financing, green bonds apply the most sustainability criteria (10 out of 11 criteria). For green shares, 8 criteria are relevant, which primarily help to ensure the greatest possible transparency for investors. Regarding the sustainability criteria, the criteria for sustainable use of funds and impact and engagement play a decisive role for all sustainable forms of financing. In the field of green financing, the ESG criteria are only relevant for green bonds and green shares, as well as for green investments. In the area of green investment assessment, particular emphasis is placed on the nature and quality of the project and the reporting of its progress.

Table 1 Classification Matrix of Sustainable Financing

	Green Bonds	Green Loans	Green promissory note loans	Green subsidies	Green shares	Sustainable crowd funding	Venture Capital
ESG criteria	X				X		
Green Bonds Principles	X						
Sustainability Rating	X	X	X		X		
Sustainable use of funds	X	X	X	X		X	X
Exclusion criteria	X				X		
Positive critera	X				X		
Best-in-Class					X		
Impact and Engagement	X	X	X	X	X	X	X
Eco-Labels	X						
Certifications	X		x				
Benchmarks (VÖNIX)					X		
Reporting	x				X		

3.2 Sustainable Investment and Financing in Austrian Industrial Companies

During the research, numerous green investments were identified at the nine industrial companies mentioned.

However, the companies hardly show any sustainable forms of financing. Tab. 2 summarizes the data and information collected from the respective companies and lists the companies, their business area and sustainability rating using VÖNIX ratings and score. Those forms of financing of the companies studied that qualify as sustainable have been highlighted in green. If there is no indication of green forms of financing in the company, this is noted in red. In the last column, the sustainable use of funds is mentioned.

The overall result shows that for six out of nine companies, no sustainable forms of financing could be demonstrated. The remaining three companies use for debt financing green revolving credit facility, ESG promissory note loans and ESG loans. Green bonds or sustainable forms of self-financing like green shares were not found at any of the industrial companies surveyed.

4 CONCLUSIONS

In summary, sustainable investing and financing is gaining in importance in the industrial sector. The Austrian industrial companies surveyed can demonstrate through their inclusion in the VÖNIX sustainability index that they operate sustainably and that their activities and performance have been assessed as sustainable. The nine companies examined have received a rating class of B or B+ or ba. In terms of the score value, LENZING AG is the furthest ahead with 3.9 points, which is related to the use of the renewable raw material wood. PALFINGER AG, which has introduced professional sustainability management in the company, follows with 3.0 points (see Tab. 2). With reference to the classification matrix and the semantic analysis of the selected companies, the following research questions could be answered.

Table 2 Evaluation of Austrian industrial companies [18], [21], [22], [23], [24], [25], [26], [27], [28]

Company	Business Unit	Sust-aina-bility Rating	Score	Financing Forms	Sustainable Use of Funds
AGRANA Beteiligungs-AG	Production of agricultural products	ba	1,8	Shares, credits, loans, promissory note loans Green Revolving Credit Facility	Installation of photovoltaic systems, phasing out of coal, electricity from renewable energies
AMAG Austria Metall AG	Production of metal components	ba	1,6	Shares, credits, loans, Leasing liabilities, no indication of sustainable forms of financing	Reduction of emissions in the area of recycling, environmentally friendly production
AT&S Technologie & Systemtechnik AG	Production circuit boards	ba	1,5	Shares, bonds, loans, promissory note loans, OeKB equity financing, no indication of sustainable forms of financing	Reduction of CO_2 demand in production, reorganization of water treatment, optimization of resources
KAPSCH Trafficcom AG	Production of agricultural products	B	1,6	Shares, credits, promissory note loans no indication of sustainable forms of financing	Maintenance and expansion of transport networks, reduction of environmental pollution
LENZING AG	Production of pulp and fibers	B+	3,9	Shares, bonds, credits, Leasing liabilities, OeKB equity financing, ESG promissory note loans	Investment in trees, modernization of wastewater treatment facilities, state-of-the-art production plant
PALFINGER AG	Supplier crane and lifting solutions	B+	3,0	Shares, loans, promissory note loans, Leasing liabilities, no indication of sustainable forms of financing	Investments in a new R&D center to strengthen innovation capacities
ROSENBAUER International AG	Production firefighting equipment	B	1,6	Shares, credits, Financing by the public sector no indication of sustainable forms of financing	Use of green electricity, substitutes for energy-intensive work equipment, reduction of heating, fuel and water consumption
WIENERBERGER AG	Production of bricks and pipe systems	Ba	1,7	Shares, Bonds, Loans, Leasing Liabilities, ESG credit	Investment in circular economy, biodiversity, reduction of CO_2 emissions, recycling, new product design
ZUMTOBEL AG	Supplier lighting technology	ba	2,0	Shares, credits, no indication of sustainable forms of financing	Investments in tools for new products, Expansion and maintenance investments, R&D

4.1 Sustainable Forms of Financing used by Austrian Industrial Companies

There is still potential for sustainable forms of financing among the companies analysed. A large proportion of the companies use conventional forms of capital procurement; the analysis of the company reports showed that there is often no indication of sustainable forms of financing.

In terms of green forms of financing, the sustainability loan, also known as the "green revolving credit facility" or "ESG-linked loan," and the ESG promissory note loan were mentioned. Referring to the ESG credit, the interest rate of the credit is linked to the ESG rating of the respective company.

4.2 Sustainable Investments made by Austrian Industrial Companies

The capital raised is used by most of the companies for sustainable investments. This was clearly evident in all the companies listed. Examples include investments in renewable energy, reduction of CO_2 emissions, use of photovoltaic systems, reorganization of water treatment, improvement of waste management and research and development of more sustainable products. Tab. 2 shows that industrial companies have anchored the topic of sustainability in their corporate philosophy by developing sustainability strategies and publishing them in comprehensive reports, and by making sustainable investments. The environmental, social and governance factors in particular are taken into account. It turns out to be essential for the qualification of an investment as "sustainable" that the project meets the ESG criteria and that the funds are used for sustainable purposes. Finally, transparency is also essential in the context of a sustainable investment, which is ensured through regular reporting and reporting.

4.3 Recommendations to Sustainable Forms of Financing

Green Bonds currently do not have a general standardization of green bond standards. In order to create a uniform framework for issuers of green bonds, the Green Bond Principles (GBP) were introduced by the industry. The most important criteria for issuing green bonds are transparency in project selection, use of funds, reporting and external verification. In order to maintain transparency vis-à-vis investors regarding the use of capital, verification by

third parties, such as a rating agency, is advantageous. Tab. 3 shows the main criteria of the GBP.

Table 3 Criteria of GBP [13], [14], [20], [29], [30], [31]

Criteria of the Green Bond Principles	Description
Use of issue proceeds	Use of issue proceeds in the bond prospectus
Process of project evaluation and -selection	Information for the investor: Ecological/sustainable objective, Procedure for determining the suitability of projects, Enumeration of suitability and exclusion criteria
Revenue management	Transparency of the use of capital Third-party verification of capital utilization
Reporting	Regular publication on the Green Bond: Project description, expected environmental impact, Indication of the amounts disbursed

In Austria, the Austrian Ecolabel, as a standard for green bonds, was established in 2020.

Concerning green promissory note loans there is no reporting obligation for them and no obligation to prepare a prospectus. However, there is a certification in the form of a green label.

With green bank loans, sustainability targets, such as predefined CO_2 emissions of the company, can be included in the loan agreement. To ensure that these targets are actually met, the companies are assessed by a sustainability rating from an independent agency.

Subsidies are also an instrument for raising capital. In Austria, green subsidies are available for those companies that are committed to positive environmental effects and actually carry out this transformation. These include a reduction in CO_2 emissions, use of renewable energy sources, construction of energy-efficient buildings, waste reduction, and purchase of e-cars.

On January 1st, 2023, the EU directive on corporate sustainability reporting, the Corporate Sustainability Reporting Directive, will come into force. Companies must then disclose, for example, their consumption of raw materials and resources, their suppliers and their CO_2 emissions [19]. This also indicates the respective focus areas and projects of the companies. It is expected that this reporting obligation will also be extended to SMEs in the near future.

Crowd investing is an interesting instrument for raising capital, especially for investments in young companies and start-ups that are specifically involved in sustainability. Participants receive interest on the capital invested, but have no say or voting rights. The company is required to provide investors with up-to-date information on its business performance. This makes sustainable crowd investing particularly transparent. There are no criteria in this type of financing that are directly in line with sustainability aspects.

Green Venture capital is used to establish and finance the growth of companies with above-average potential in the Greentech sector, where the focus is on the development of resource-saving technologies. Venture capital funds and corporate venture capital funds can be issued by industrial companies as possible forms of financing. This enables technology-oriented and production-related start-ups of companies. Ref. [17] see further potential in the use of venture capital and point to a revision of the framework conditions and tax regulations in order to mobilize more capital via Greentech investments in the future.

Notice

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Implications of the Digitalization on Human-Resource-Controlling

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Abstract: The advancing digital transformation is increasing the cost pressure on companies. People's work performance needs to be re-evaluated. Therefore, efficient Human-Resource-Controlling (HR-Controlling) with increased use of technologies promises companies a sustainable improvement in their financial situation. This paper shows the potential of the recent digital technologies on HR-Controlling, such as Big Data or Advanced Analytics. To demonstrate the impacts of the digital transformation on HR-Controlling, an empirical study with Austrian companies has been done. As a result, the most promising technologies for each stage in the HR-Controlling-loop are shown to increase the efficiency in HR-Controlling.

Keywords: Advanced Analytics; Big Data; Controlling; Digitalization; HR-Controlling-Loop; Human-Resources

1 INTRODUCTION

A trend, which was known for several years, has been intensifying recently: Human-Resource must demonstrate the value added and successes that investments in HR processes lead to [1]. Still, Human-Resource-Controlling is an underrepresented discipline in many companies. Companies underestimate the contribution of personnel controlling to their value creation. The fact that this can cause long-term damage to the company is often not perceived or only noticed when it is too late. On the other hand, companies are facing new challenges [2]. Especially in times of crisis, many HR departments are busy managing the company. Unfortunately, there is a lack of key figures and statistics at the push of a button, as well as scenario-oriented HR forecasting tools. However, to emerge successfully from a crisis, these tools are needed. Even without a crisis, they are immensely important: shortages of skilled workers, international workforce developments, etc. must be well managed [3].

Recent developments in digital technologies support also approaches in the field of controlling. The application of innovative technologies like HR-software systems, Artificial Intelligence, Big Data or In-Memory-Computing promise potentials in data consistency, time and resource savings, which have a direct impact on the planning, steering and monitoring [4]. HR-Controlling moves away from traditional reporting in the direction of forecasts and scenarios. The maximization of key figures is thus replaced by an understanding of interrelationships, which is reflected, among other things, in better and more comprehensible decision-making and in the identification of risks [1].

According to a survey of IDC, 74.1% of the most successful enterprises use a HR-Management-Software-System for their HR agendas [5]. Although the benefits of a software support are known, like data consistency and therefore, time and resource savings, companies are still insecure which specific impact with the use of an innovative digital technology occurs [6].

2 RESEARCH PURPOSE AND METHODOLOGY

This paper emphasis on the impact of digitalization in the field of HR-Controlling. Within the paper the following research questions will be answered:
- How can digital technologies help in HR-Controlling to demonstrate the added value?
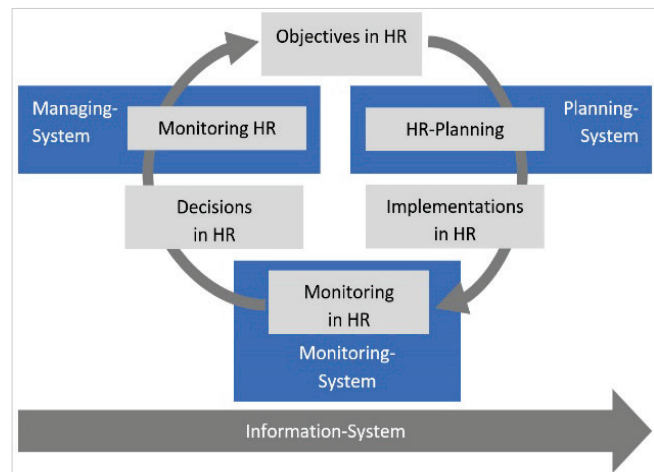- What innovative digital technologies are used in Austrian companies in each step of the HR-Controlling loop?

Figure 1 HR-Controlling loop [14, 16]

For this purpose, initially fundamentals of HR-Controlling are outlined, and the main tasks are described. The results of the subsequent impact analysis of digital technologies are then merged with the areas in Human-Resource-Controlling. To get a statement on the relevance of these tools for the company's success, an empirical study in Austria's small and medium sized companies is introduced. Therefore, the online tool "Lime Survey" was chosen as a survey software based on appropriate quantities on other research projects at the University of Applied Sciences Joanneum, Industrial Management. Therefore, 22 questions have been sent to 1,861 Austrian companies, excluding

companies, which have less than nine employees. Whereby 136 companies participated, mostly employees of the HR department. As a result, the most often used digital technologies for each stage in the HR-Controlling-loop are shown.

3 FINANCIAL SUSTAINABILITY THROUGH DIGITAL TECHNOLOGIES IN HR-CONTROLLING

3.1 Human-Resource-Controlling to Display the Value Creation of Labour

In the rapidly changing and increasingly complex realities of today's knowledge-based business world, the awareness of the HR function as a central role in the corporate value creation process is critical to the quality and sustainability of a company's success [7]. Controlling is the sum of all measures that serve to coordinate the management areas of planning, steering, monitoring, and informing in such a way that the company's goals are optimally achieved [8]. Therefore, controlling means the control, regulation and steering of a company. Subsequently controlling takes care of securing the company's existence by increasing the value creation and supporting the management [9, 10]. Interpreted in terms of HR, Human-Resource-Controlling is a sub-function of personnel management that monitors an optimal ratio of personnel-related expenditures to personnel-related earnings, considering current and future economic developments in the company and its environment [11]. This involves both planning, objective assessment, and the recommendation of targeted HR-measures to optimize the performance of personnel and human resources work.

Human-Resource-Controlling will be found in various forms in companies in 2022. It represents an area of personnel management as well as controlling in companies. The way in which it is implemented varies in practice from company to company [12]. In the past, HR controlling had a strongly administrative character and primarily provided information about what had already happened. For example, an attempt was made to achieve cost transparency and to show the employment structures and attendances of employees. Accordingly, personnel costs and remaining vacation days are still the most important key figures [1]. The focus of the historically grown HR-Controlling is basically the consideration of the quantity as well as the quality of the employees' work [13]. Optimizations regarding employees are managed and monitored by HR-Controlling. Controlling thus creates transparency in terms of performance, costs, and results [12].

HR-Controlling can therefore also make use of the controlling loop [14]:

- In HR-Controlling, personnel targets are derived from the corporate objectives and target values are defined for the corresponding goals (planning-system).
- In the next step, the personnel controller measures the current actual values. The comparison of actual values with the planned target values indicates any need for action. In the event of discrepancies between actual and target values, these are analysed by the HR controller (monitoring-system).

- Based on the results of the analysis, corrective actions are implemented by managers, and the HR controller can/should make recommendations regarding corrective actions (managing-system).

HR-Controlling should thus provide a planning reaction and control system, which is supported by all different systems through the personnel information system to increase the quality of information [15].

3.2 Potentials of Digital Technologies in HR-Controlling

Due to the rapid rate of digitization, new possibilities are constantly emerging to plan, monitor and manage Human-Resource-Activities. Digital technologies will fundamentally change the quality of information. According to Peter Drucker, *"If you can't measure it, you can't manage it"*, the importance of gaining and collecting information is evident [17]. To guarantee high-quality analysis, tools must be synchronized, and the data must be accessible at a central location and regularly collected and validated. Software tools like an Enterprise-Resource-system (ERP) combined with a Data Warehouse (DWH) or Big Data, HR-Analytics, and Robotic-Process-Automation (RPA) are widely considered of being high relevance for HR-Controlling, significantly contributing to plan, monitor and manage HR activities.

- Companies usually use *ERP and DWH systems* to support, integrate and automate their business processes. An ERP system consists of modules that communicate with each other and share a database. Every application, often referred to as a software module, typically focuses on one business area, for example, finance, controlling, human resources, sales, and logistics [18]. By using an in-memory database inside an ERP, transactional and analytical data can be managed in a system in real time [19]. Although ERP systems are powerful instruments mapping business processes and resources in one consistent system, they are not the preferred approach for an integrated solution in terms of planning, monitoring, and managing HR activities. With the extension of special tools like business intelligence systems (BI), HR-Controlling can achieve a new level of relevance. BI systems focus on corporate planning and reporting and are integrated with ERP systems. BI systems support controlling by using modern information technologies, for example a DWH or Big Data technologies. Data Warehouse Systems provide and integrate aggregated information from multiple sources [20]. DWH enable to perform complex queries and analyses and handle large amounts of data [21]. Concerning HR-Controlling the benefit of these software applications is evident. In addition to historical data, present data and many other data can be used to create analyses, reports, and queries for the HR area [22].
- The concept of *Big Data* rests on in-memory platforms aiming at integrating and analysing huge amounts of various data coming from different internal and external sources. In-Memory computing is a new storage technology, where data is no longer stored on hard disks,

but constantly provided in the random-access memory of the information system. Therefore, Big Data allows a constant monitoring of relevant data sources in real-time, leading to an event-triggered analysis and can be utilized to predict and forecast future developments [23]. While the concept of Big Data is still open for discussion [24], Big Data will revolutionize the established ways of making decisions and making sense of the prevailing realities [25]. Regarding the retention of employees for example, Big Data is used to perform probability calculations for the respective employee to perform a match between career opportunities in the company and the development desires of the person [26]. By linking data from different sources, Big Data opens completely new dimensions in strategic HR corporate planning. Internal personnel, financial and production data can be combined with external, macroeconomic data (e.g. changes in labour markets, demographic developments, competitive situation) and analysed more precisely than ever before from a holistic perspective [27].

- *HR Analytics* or People Analytics refers to projects that use, actively collect, and evaluate data from employees and workers. HR Analytics is part of the concept of business intelligence and consists of several sub-processes, which are built on one another: Based on *descriptive analytics*, which considers data from the past, like number of employees or fluctuation rate. In this first process step querying and searching analyses are mostly applied. Online-Analytical-Processing (OLAP) software systems, like a DWH, act as a basis and enable the user to quickly access a wide range of information [28]. In the second step *diagnostics* measures the relationship between two variables to understand the driver or explanation for what happened, e.g. job satisfaction vs retention or engagement vs profitability [22]. Building upon this, *predictive* analysis relates data of the past (reporting) with data of the present (monitoring) and recognizes samples, interrelationships, and meanings. With data mining in the background, predictions for the future are possible, for example training programmes predicts sales outcomes or changes in LinkedIn profile predicts absenteeism [28, 22]. HR-Analytics, however, are not solely measures, but rather represent statistical techniques and experimental approaches that can be used to measure the impact of HR activities [29, 30]. Thus, HR Analytics provides HR management with objective decision-making aids.

- The automation of standardized processes with so-called *Robotic Process Automation* (RPA) promises to relieve the burden on employees, an acceleration of the processes and therefore creates capacities for value-adding activities. Software robots, analyse extensive data sets, recognize algorithms and with these patterns repetitive standardized processes can be automated. An example for the application of RPA in the HR-controlling area is the providing of all the necessary documents and contracts after the recruitment notice [30, 32]. Going one step further, the combination of RPA with Artificial Intelligence like machine learning, leads

to Intelligent Process Automation (IPA). In this case the software learns from human users by identifying and evaluating their behavioural patterns and interprets human activities using historical and current data. In addition, a robot with such abilities can also question decisions and thus gain experience. After an extensive learning phase, robots can also work independently [33].

4 IMPACTS OF DIGITALIZATION ON THE HR-CONTROLLING IN AUSTRIAN COMPANIES

To demonstrate the impacts of the previous presented digital technologies on HR-Controlling, an empirical study with Austrian companies has been done. An online survey was chosen as research methodology. Therefore, 22 questions have been sent to a total of 1,861 Austrian companies, excluding companies which have less than nine employees. Whereby 136 companies participated, mostly employees of the HR department. For this paper, relevant excerpts of the survey, with a special emphasize on the impacts on the three main stages of the controlling loop, are shown.

82,7% of the respondents stated that they had already dealt with HR-Controlling. The awareness for the contribution of HR-Controlling for the financial sustainability is certain, however, it must be considered that 37,5% of the participants have worked in the HR department.

67,9% of the total number see the greatest benefit on the application of digital technologies in the operative HR-Controlling. Considering this result, digitalization has a substantial impact on the efficient conduction of daily business, e.g. key figure systems or HR cost analysis. 13,5% detect benefits in the strategic area of HR-Controlling by using digital technologies. The remaining votes don't see a gaining for the HR-Controlling.

The deployment of digital technologies in the HR-management context results in the following: 70,4% of the participants use an ERP-system with the module in Human Resource for HR-management agendas. 34,6% use HR-Analytics and 25,9% optimise tasks with the application of Big Data. Only 2,5% work with RPA in the HR-area. Whereas ERP-systems have a long history in supporting companies within their resource-planning-process, the new technologies like HR-Analytics, Big Data or RPA are less used in Austrian companies.

4.1 Efficiency in HR-Controlling

Nevertheless, 89,6% of the participants think that with the application of digital technologies an increase in efficiency for the HR-Controlling can be fulfilled. Also, 66,2% believe that the implementation of an effective HR-Controlling is well supported through digital possibilities. More than one third of the participants identified time savings with the use of digitalization in HR-Controlling between 20-30%. Almost 20% think that more than 40% of the time for executing controlling tasks can be saved. Considering the cost savings with the application of digital technologies in HR-Controlling, 58,4% of the participants

indicated that 2-5% are realistic. 26% stated that cost savings more than 6% are possible. 15,6% of the participants only see savings less than 1% or even no cost savings.
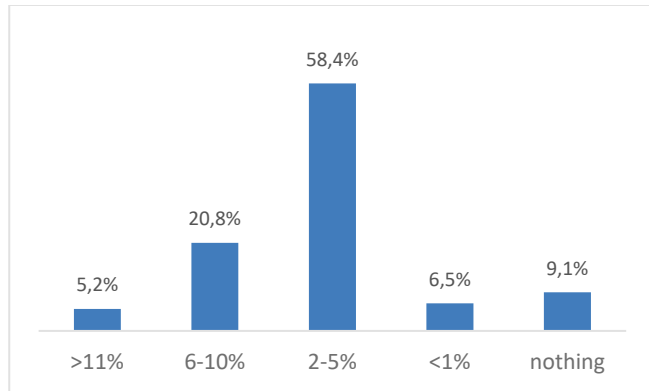

Figure 2 Estimated cost savings in HR-Controlling with digital technologies

4.2 Digitalization in the Planning-System

Based on the HR-Controlling-loop (Fig. 1) companies submitted that the highest relevance of new digital technologies for the planning-system in HR-Controlling plays HR-Analytics. 86,1% of the participants think that this approach is relevant or rather relevant. Therefore, descriptive analytics, diagnostics, or even predictive analysis to foresee future developments are highly important for personnel budgeting or annual staff planning. 80,6% stated that Big Data has a relevance in the planning processes of HR-Controlling. The management of data with the "Four V – Volatility, Volume, Velocity and Visibility" in the planning context promises a high influence. The relevance of RPA or Artificial Intelligence in the planning-system of HR-Controlling is indifferent. 51,4% see that this concept is relevant or rather relevant – the other half hasn't recognized an impact.
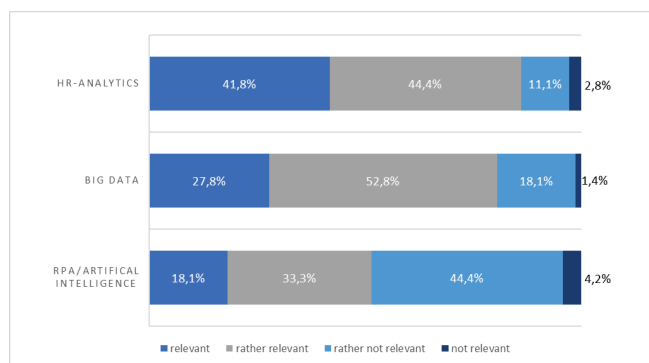

Figure 3 Relevance of new technologies in the planning-system

4.3 Digitalization in the Monitoring-System

The figure below visualises the evaluation of the empirical survey with the relevance of new technologies in the monitoring-system of HR-Controlling. In addition, in this process step HR-Analytics is the most important approach for the participants. 87,5% stated a relevance - deviation analyses or KPIs in HR-Controlling refer to HR-Analytics.

According to the diagram, Big Data has a high significance to the monitoring-system. 75% indicated a relevance in this HR-process-step. Artificial Intelligence in the context of RPA is for more than a half of the participants relevant this stage.
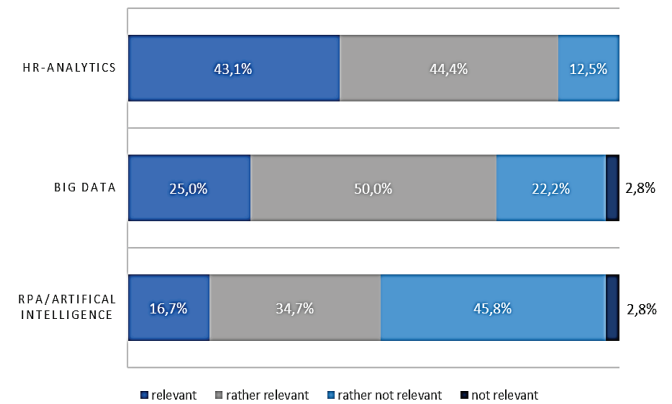

Figure 4 Relevance of new technologies in the monitoring-system

4.4 Digitalization in the Management-System

Fig. 5 shows the assessment of the relevance for new technologies in the management-system of the HR-controlling-loop. HR-Analytics is highly relevant for the participants in this process step (41,7%), followed by Big Data (26,4%). Artificial Intelligence is considered very relevant by 11,1%. According to the surveyed, reporting or staff forecasting, for example, can be optimised with the application of HR-Analytics. The needs of the employees are focused more strongly – the right course can be set, and costs saved.
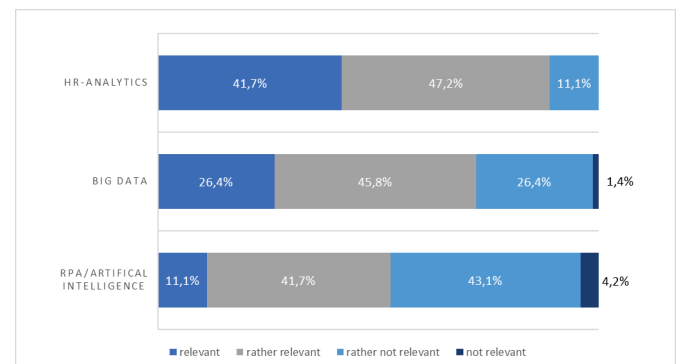

Figure 5 Relevance of new technologies in the management-system

5 CONCLUSION

Especially in times of crisis as well as in a world of constant changes, increasing competition and hence growing cost pressure, enterprises must optimise their processes for their financial sustainability. Working in today's digital age is characterized by the intense use of digital technologies and (as a result) increased flexibility. Thus, HR-Controlling is a comprehensive approach to plan, monitor and manage tasks in Human Resource. Thanks to ongoing process analysis, HR-Controlling identifies and implements improvement

opportunities for the HR department. This ensures consistent optimization and stability of HR processes. Moreover, the standardization of processes with the aim of increasing the automation in HR is focused. In this paper, we showed the benefits of using digital technologies in HR-Controlling. Afterwards we have examined the implications and relevance of modern digital technologies in the specific context of HR-Controlling. For this purpose, we asked companies for their assessment on the relevance of selected technologies on the HR-Controlling-loop.

According to the participants HR-Analytics is the most promising digital technology considering the relevance in the planning-, monitoring- and management system of the HR-Controlling-loop. Nevertheless, only a little more than a third used HR-Analytics to optimise personnel controlling. The most widely used tool is the ERP-system, which plays a central role in the digitalization strategy of companies. Big Data, a concept that integrates and analyses huge amounts of different data, is perceived as relevant in all the three stages by most of the participants, although only about a quarter is using it. RPA, which is a tool, that automatises standardized processes, is considered as particularly relevant in managing HR activities, although only 2,5% of Austrian companies work with this possibility in HR. Furthermore, the connection of RPA and artificial intelligence is very promising, and companies must confront themselves with this new technology. Almost 90% stated that with the application of digital technologies efficiency gains in HR-Controlling could be achieved. However, Austrian companies have recognized the benefits of new technologies for HR-Controlling, but the holistic use of these concepts is still a long way to go for enterprises.

Notice

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Abstract: Article abstract contains maximum of 150 words and is written in the language of the article. The abstract should reflect the content of the article as precisely as possible. TECHNICAL JOURNAL is a trade journal that publishes scientific and professional papers from the domain(s) of mechanical engineering, electrical engineering, civil engineering, multimedia, logistics, etc., and their boundary areas. This document must be used as the template for writing articles so that all the articles have the same layout. (Style: Arial Narraw, 8pt)

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1 INTRODUCTION (Article Design)
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(Tab 6 mm) The article is written in Latin script and Greek symbols can be used for labelling. The length of the article is limited to eight pages of international paper size of Letter (in accordance with the template with all the tables and figures included). When formatting the text the syllabification option is not to be used.

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1.1 Subtitle 1 (Writing Instructions)
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The document format is Letter with margins in accordance with the template. A two column layout is used with the column spacing of 10 mm. The running text is written in Times New Roman with single line spacing, font size 10 pt, alignment justified.

Article title must clearly reflect the issues covered by the article (it should not contain more than 15 words).

Body of the text is divided into chapters and the chapters are divided into subchapters, if needed. Chapters are numbered with Arabic numerals (followed by a period). Subchapters, as a part of a chapter, are marked with two Arabic numerals i.e. 1.1, 1.2, 1.3, etc. Subchapters can be divided into even smaller units that are marked with three Arabic numerals i.e. 1.1.1, 1.1.2, etc. Further divisions are not to be made.

Titles of chapters are written in capital letters (uppercase) and are aligned in the centre. The titles of subchapters (and smaller units) are written in small letters (lowercase) and are aligned left. If the text in the title of the subchapter is longer than one line, no hanging indents.

10pt

Typographical symbols (bullets), which are being used for marking an item in a list or for enumeration, are placed at a beginning of a line. There is a spacing of 10pt following the last item:

- Item 1
- Item 2
- Item 3

10pt

The same rule is valid when items are numbered in a list:

1) Item 1
2) Item 2
3) Item 3

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1.2 Formatting of Pictures, Tables and Equations
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Figures (drawings, diagrams, photographs) that are part of the content are embedded into the article and aligned in the centre. In order for the figure to always be in the same position in relation to the text, the following settings should be defined when importing it: text wrapping / in line with text.

Pictures must be formatted for graphic reproduction with minimal resolution of 300 dpi. Pictures downloaded from the internet in ratio 1:1 are not suitable for print reproduction because of unsatisfying quality.
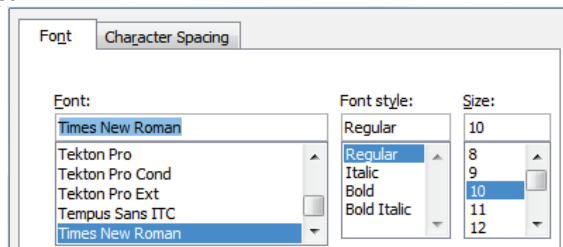
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Figure 1 Text under the figure [1]
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The journal is printed in black ink and the figures have to be prepared accordingly so that bright tones are printed in a satisfactory manner and are readable. Figures are to be in colour for the purpose of digital format publishing. Figures in the article are numbered with Arabic numerals (followed by a period).

Text and other data in tables are formatted - Times New Roman, 8pt, Normal, Align Center.

When describing figures and tables, physical units and their factors are written in italics with Latin or Greek letters,

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Table 1 Table title aligned centre
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	1	2	3	4	5	6
ABC	ab	ab	ab	ab	ab	ab
DEF	cd	cd	cd	cd	cd	cd
GHI	ef	ef	ef	ef	ef	ef

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Equations in the text are numbered with Arabic numerals inside the round brackets on the right side of the text. Inside the text they are referred to with equation number inside the round brackets i.e. ".... from Eq. (5) follows ...." (Create equations with MathType Equation Editor - some examples are given below).

10pt

$$F_{\mathrm{avg}}(t, t_0) = \frac{1}{t} \int_{t_0}^{t_0+t} F\left[q(\tau), p(\tau)\right] \mathrm{d}\tau, \tag{1}$$

$$\cos \alpha + \cos \beta = 2\cos \frac{\alpha + \beta}{2} \cdot \cos \frac{\alpha - \beta}{2}, \tag{2}$$

$$(\boldsymbol{AB})^{\mathrm{T}} = \boldsymbol{B}^{\mathrm{T}} \boldsymbol{A}^{\mathrm{T}}. \tag{3}$$

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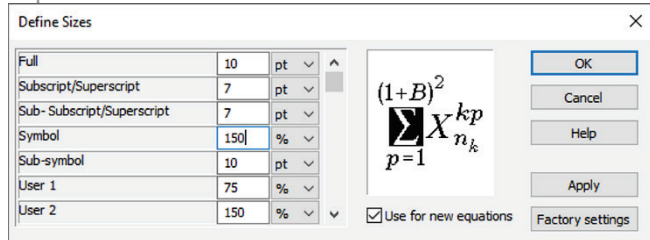
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Figure 2 The texts under figures
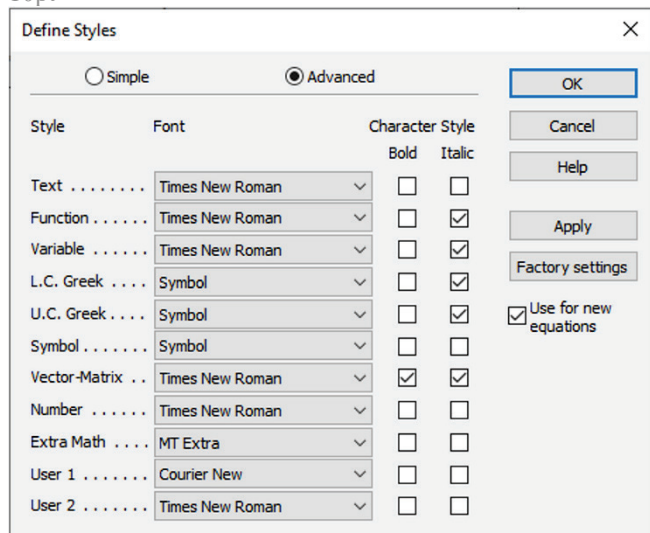(Style: Arial Narraw, 8pt, Align Centre)

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Figure 3 The texts under figures
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2 PRELIMINARY ANNOTATION

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Article that is offered for publication cannot be published beforehand, be it in the same or similar form, and it cannot be offered at the same time to a different journal. Author or authors are solely responsible for the content of the article and the authenticity of information and statements written in the article.

Articles that are accepted for publishing are classified into four categories: original scientific papers, preliminary communications, subject reviews and professional papers.

Original scientific papers are articles that according to the reviewer and the editorial board contain original theoretical or practical results of research. These articles need to be written in such a way that based on the information given, the experiment can be repeated and the results described can be achieved together with the author's observations, theoretical statements or measurements.

Preliminary communication contains one or more pieces of new scientific information, but without details that allow recollection as in original scientific papers. Preliminary communication can give results of an experimental research, results of a shorter research or research in progress that is deemed useful for publishing.

Subject review contains a complete depiction of conditions and tendencies of a specific domain of theory, technology or application. Articles in this category have an overview character with a critical review and evaluation. Cited literature must be complete enough to allow a good insight and comprehension of the depicted domain.

Professional paper can contain a description of an original solution to a device, assembly or instrument, depiction of important practical solutions, and similar. The article need not be related to the original research, but it should contains a contribution to an application of known scientific results and their adaptation to practical needs, so it presents a contribution to spreading knowledge, etc.

Outside the mentioned categorization, the Editorial board of the journal will publish articles of interesting content in a special column. These articles provide descriptions of practical implementation and solutions from the area of production, experiences from device application, and similar.

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Article is written in the English language and the terminology and the measurement system should be adjusted to legal regulations, standards and the International System of Units (SI) (Quantities and Units: ISO 80 000 - from Part 1 to Part 14). The article should be written in third person.

Introduction contains the depiction of the problem and an account of important results that come from the articles that are listed in the cited literature.

Main section of the article can be divided into several parts or chapters. Mathematical statements that obstruct the reading of the article should be avoided. Mathematical statements that cannot be avoided can be written as one or more addendums, when needed. It is recommended to use an example when an experiment procedure, the use of the work in a concrete situation or an algorithm of the suggested method must be illustrated. In general, an analysis should be experimentally confirmed.

Conclusion is a part of the article where the results are being given and efficiency of the procedure used is emphasized. Possible procedure and domain constraints where the obtained results can be applied should be emphasized.

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4 RECAPITULATION ANNOTATION

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The literature is cited in the order it is used in the article. No more than 35 references are recommended. Individual references from the listed literature inside the text are addressed with the corresponding number inside square brackets i.e. "… in [7] is shown …". If the literature references are web links, the hyperlink is to be removed as shown with the reference number 8. Also, the hyperlinks from the e-mail addresses of the authors are to be removed. In the literature list, each unit is marked with a number and listed according to the following examples (omit the subtitles over the references – they are here only to show possible types of references):

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[4] Amidzic, O., Riehle, H. J., & Elbert, T. (2006). Toward a psychophysiology of expertise: Focal magnetic gamma bursts as a signature of memory chunks and the aptitude of chess players. *Journal of Psychophysiology, 20*(4), 253-258.
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