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Preface

International Conference On Informatics and Computer Science (ICI-CS2024), held in March 2024 with participants from Turkey and abroad and hosted by Gazi University Institute of Informatics, was a great success in terms of providing an interdisciplinary platform for innovative approaches to complex global agendas. The success of the first year has led us to organize the second year of this comprehensive conference. 3rd International Informatics and Computer Science Conference (ICI-CS2024) aimed to continue the interdisciplinary discussions and pave the way for innovative solutions to global agendas.

ICI-CS2024 was held in March 2024, once again hosted by the Gazi University Institute of Informatics. We have invited researchers, academics, students, and industry practitioners from informatics, computer science, and other interdisciplinary fields to contribute to the conference. This year, we aimed to focus on current and raising technologies in the field. In addition to the presentations of original research articles, we have a series of invited talks from distinguished scholars and practitioners and created an environment for discussions and collaborations. This way, ICI-CS2024 also enabled participants to establish lasting connections with colleagues in their respective fields.

We would like to sincerely thank the conference program chairs, committee members, and all the reviewers for their great professionalism and efforts in reviewing the submitted papers. Additionally, we thank all the participants and sponsors for their valuable contributions and support to ICI-CS2024. We also look forward to announcing the fourth year of the conference, ICI-CS2025, and hope to see you all there.

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Blockchain Integration in Healthcare Information System: A Secure and Efficient Approach

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Abstract. In the realm of healthcare blockchain technology offers an approach, to storing records facilitating medical transactions and fostering trust within a decentralized healthcare network. While the healthcare sector has shown interest in technology concerns persist regarding the security and privacy implications associated with sharing medical information. This piece delves into the issues surrounding security and privacy, in utilizing blockchain within healthcare focusing on studies conducted from 2018 to 2023.This study aims to tackle challenges and explore real world uses by assessing existing literature. The goal is to offer an evaluation that sheds light on directions, for future research and advancements.

Keywords: Blockchain, Healthcare, Medical Data, Security and Privacy.

1 Introduction

Blockchain technology has been increasingly prominent, in sectors with healthcare being no exception. It's not surprising since blockchain acts as a transparent and decentralized distributed database establishing trust in the value chain. As the healthcare industry embraces transformation the development of medical information systems becomes essential. Healthcare holds importance in people's lives and data plays a role in diagnosing illnesses and guiding treatment decisions. Traditionally data was recorded on changeable or insecure mediums. However, with advancements, like technology, secure and efficient data transmission is now achievable [1-7]. Furthermore, these technologies are expected to enhance user anonymity, privacy, and access control. Without adequate security, privacy, and trust, individuals may be hesitant to share sensitive information or delay seeking necessary medical treatments[8]. Hence, data security becomes paramount, leading to the emergence of blockchain technology, a cutting-edge solution that promises to safeguard data from breaches and vulnerabilities[9]. The inherent decentralized nature of blockchain technology enables it to resist setbacks and attacks in a distributed and steadfast manner. These technologies will also be expected to advance user anonymity, privacy and control.

Thus, inadequate security, trust and privacy can make individuals reluctant to share personal information or delay seeking important medical attention[10]. Therefore, data

safety is critical; hence the advent of blockchain technology. This technology is particularly known for its decentralized character which makes it resistant to failures and attacks at large. Besides this, it documents data ownership and validates that it's genuine[11]. In the last years blockchain has been recognized as an adjustable technology with numerous applications in industry specific solutions such as identity management, supply chain management, healthcare, insurance and contract administration [12] Notable characteristics of blockchain are decentralization, openness, traceability and reliability.

Thus, Blockchain comes in handy when one needs to tackle issues of security confidentiality and interoperability. It allows for transactions within networks among untrusted parties while acting as means of collecting distributed networked device data[13].

It has been largely recognized that blockchain technology has the potential to revolutionize how patient data is exchanged and stored in the healthcare sector, thereby improving metrics like process security and efficiency. Nonetheless, in terms of medical field there are challenges with regard to security and privacy particularly in safeguarding confidential patient data. A review of literature on this topic is aimed at providing a preview for various scholars who are involved in making contributions into research on this issue. The study by Hasselgren et al. involved a scoping review about blockchain utilization in healthcare where they noted the existence of unresolved issues such as regulatory environment and interoperability requirements [13]. However, they concluded that blockchain can improve the security and privacy levels within healthcare. Azaria et al make an important point regarding the security or privacy of patient data during modern times – it matters a lot [14]. They suggest that tracking medical data using blockchain technology will help meet objectives related to authenticity, accountability, and certainty. In general, from available evidence one can deduce that blockchain technology could potentially enhance the safety features around transfer of patients' health information storage as well as its privacy.

However, there are still some issues that need to be sorted out such as proper access controls, regulatory concerns and interoperability. More studies should be done in order to fully explore what blockchain might do in the health care system in relation to the protection of patient privacy and confidentiality. This paper presents a review that was critically carried out based on these factors. Although other useful investigations can be found in literature [16-18], this work looks at the issue from a different angle and purpose.

2 Background

2.1 Blockchain Technology

The blockchain technology, which became popular through Bitcoin's success, provides a safe and dependable way of doing business without relying on a central third party over decentralized networks. Here then are the key elements in blockchain [19]-[21].

2.2 Blockchain Systems' Types

There are four types of blockchain systems depending on whether the network nodes have been given permissions or not:

Private Blockchain: In this case, the network is restricted to those who are invited or authorized. Network control through access restriction.

Public Blockchain: Anybody that wants to be a node or miner can join a public blockchain and it is widely accessible and participatory.

Hybrid Blockchain: these combined elements of public and private blockchains they allow for control over who can see and access the information on the blockchain.

Consortium blockchain: This is also known as "semi-private" blockchain lies between public and private blockchains. It is accessible to a selected number of authorized organizations often helping companies in achieving their goals.

2.3 Blockchain in Healthcare

It is crucial to ensure that medical records are secure in the healthcare industry. Healthcare organizations employ multiple security measures to protect patient data, and blockchain technology has the potential of transforming the healthcare sector by securely storing and transmitting sensitive patient data. In healthcare, data security becomes important because it keeps confidential information like test results, prescriptions details, and medical histories [14-17,22-24].

The safekeeping of medical records is crucial in healthcare. Medical organizations use various security measures to protect patient data; secure storage and transmission of sensitive patient data using blockchain technology may revolutionize healthcare sector. In healthcare, as it helps to guard confidential information like diagnostic test results, prescriptions, and family histories.[14-17, 22-24]

Confidentiality of medical records is a big issue in healthcare industry also. Blockchain technology could be used to improve healthcare privacy because it has many advantages. It minimizes the chances for a single point of failure or target by making the ledger decentralized and distributed. This allows smart contracts that are compliant with privacy laws and which automate sharing of data to be established on a blockchain protocol system. However, pseudonymization and encryption methods provide ways through which private data stored on blockchains can be protected while still allowing authorized parties access to that particular information. Nevertheless, several challenges remain in using blockchain for privacy in health care particularly, how different blockchain platforms can interoperate among themselves and dealing with the challenges related to implementation process itself (Fernandez et al., 2018).14 25 27

2.4 Interoperability Challenges

Incorporating blockchain technology into healthcare is a major challenge, with interoperability being one of the biggest technical hurdles. The diverse nature of such systems as they employ different electronic health record (EHR) system and medical devices with dissimilar data formats and standards make complicated healthcare data exchange challenging. These interoperability difficulties can be overcome through careful planning and transformation of information particularly when dealing with legacy systems that are not compatible with blockchain technology.

To realize the full potential of blockchain in healthcare, there are several ways to address these challenges. They include creating standardization for medical data within the network, employing middleware to facilitate communication between the networks of blockchains and existing systems, and reaching consensus on data standards by collaborating amongst healthcare organizations, regulators and technology providers.

3 Methodology

In this review a systematic search was conducted in different bibliographic databases such as MEDLINE, Embase, Cochrane Library, Scopus, Google Scholar, Compendex, Inspec ACM IEEE etc. The search strategy combined the terms “blockchain” AND “health” using Boolean operator AND. The selection process involved filtering titles, abstracts, and full papers based on inclusion and exclusion criteria, with a reviewer and supervisor reviewing and discussing publications to ensure consistency.

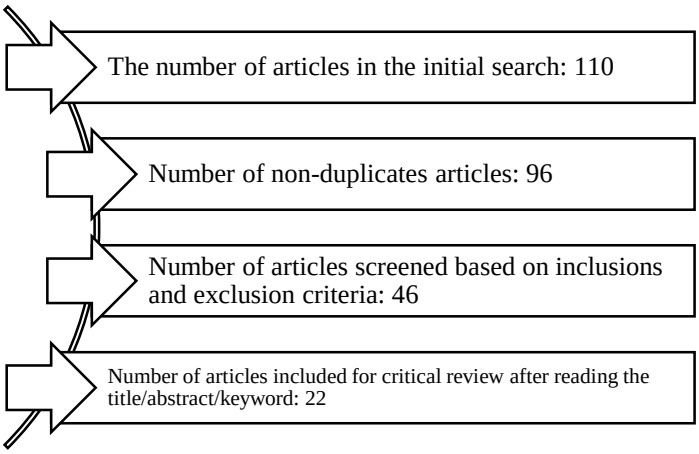

Fig. 3.1. Selection process.

3.1 Inclusion and Exclusion Criteria

Inclusion Criteria

1. Research was published from 2018 to 2023.
2. The research's exclusive domain is the journal.
3. The two primary areas of research should be "blockchain" and "healthcare."
4. Articles that put forth a framework, paradigm, or system.

Exclusion criteria

1. Press pieces being pulled.
2. Articles in languages other than English.
3. Books, dissertations, monographs, conferences, reviews, and works derived from interviews are not included.

3.2 Data Extraction

The collected research data was utilized to construct a preliminary development matrix. Once the reviewer had extracted the majority of the data, the supervisor reviewed it again. The data was extracted, organized, and condensed into a matrix format, which was subsequently converted into tables and graphs. The data matrix was initially created in Google Sheets and later converted to Microsoft Excel 2023 for the convenience of the study group.

3.3 Data Analysis

After extracting relevant quantitative data, the data analysis was carried out using Microsoft Excel 2023. When applicable, the standard deviation (SD) and mean, indicated by ±, were calculated. All numerical values were rounded to the nearest whole number. Categorical statistics were presented as percentages unless otherwise specified.

4 Results and discussion

This study shows that blockchain can provide information security, confidentiality as well as integration in the healthcare industry. The main aim of this research is to tackle the persistent security and privacy issues within the domain. The findings show that these technologies can protect patient and doctor's privacy by efficiently distributing and limiting access to medical information. The suggested processes satisfy the expected safety norms and have competitive computation and communication overheads. For example, (Kumar et al., 2022).'s work outlines a new model for sharing decentralized medical image data using blockchain technology through federated learning[31]. Also, it mentions an off-chain health data storage architecture based on Interplanetary File System (IPFS) which demonstrates its extraordinary security, scalability, and resilience. It also demonstrates that sending data to blockchain only affects processing time and effort because of the anonymous nature and encryption provided by design [32-44].

Many research papers proposed methods where patients are able to decide whether or not their data should be accessed [45-50] Technology advances can be used to help healthcare organizations and healthcare providers conform better with the privacy regulations. Additionally, these solutions are able to provide secure payment options thus allowing patients and hospitals to pay for storage and diagnostic services without any risks. According to a comprehensive security study and rigorous testing, these solutions have shown great resilience against various attacks such as impersonation, collusion or middle man attack. Finally, in terms of secure transmission and storage of health privacy data within or outside the health system, the findings demonstrate high-security encryption performance, balanced storage space allocation as well as robust anti-attack capabilities by the suggested approaches. In order to ensure safe searching in IoT medical applications like IoMT (Internet of Medical Things) framework 5; we propose using custom-made smart contracts that rely on modified attribute-based cryptographic primitives.

The development of Internet of Things (IoT) technology has led to increased interest in Wireless Sensor Network (WSN) systems.[52] Further studies have improved their techniques for small sensors nodes found in IoT devices.[53] The sophistication level

involved in different sensors depends on factors such as cost efficiency, power consumption, sensing range among others. There are some important technologies that are employed by WSNs' energy management system under this field.

This paper presents several developments which have been carried out with an intention of conserving energy through utilization of wireless sensor networks. In many cases a miniaturization technique is used when trying to produce ultra-small sensors which do not need any battery or even wire.

Furthermore, researcher may wish to experiment with different types photovoltaic materials such as organic cells instead of silicon-based cells

Additionally, researchers might want to explore other sorts photovoltaic elements like organic ones rather than silicon based cells.

Another research (Yugha et al., 2022, p. 52) concludes that the suggested method is a secure and efficient way for transmitting medical data in IoT while maintaining privacy of patients. Another study by (Yugha et al., 2022) shows that the proposed approach provides a secure and efficient means to facilitate the transfer of IoT medical data while preserving patient privacy. The above studies collectively demonstrate how blockchain technology can be used to enhance efficient, safe and secured healthcare data sharing and access control. A major reason why these methods are suitable for IoMT applications is because they meet the expected security standards, as well as provide competitive communication and processing costs. These findings show how these technologies can effectively solve longstanding security and privacy problems faced by health industry.

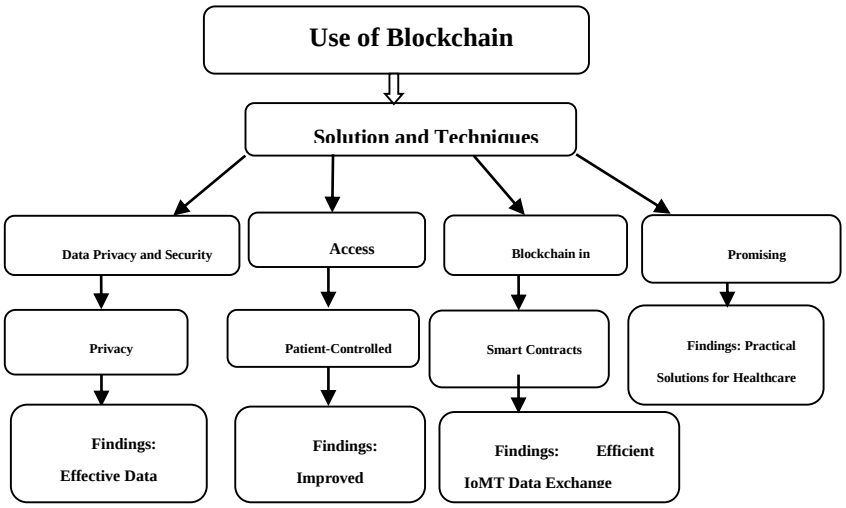

Fig. 4.1. Blockchain and cryptography for privacy and security in healthcare

TABLE 1. HEALTH RECORDS APPLICATIONS

Use Case
1. Electronic health records (EHRs)[43]
2 Personal health records (PHRs) management and sharing [22]
3 Management of EHRs [23]
4 Blockchain technology for EHR management [44]
5 Enhancing EHR privacy using blockchain [45]
6 Automation of EHR and related services [46]
7 Integration of bitcoin payments and smart contracts in EHR systems [47]
8 PHR [48]
9. EHR sharing [49]
10. Patient record management [50]

Robust security and privacy measures are essential for the sharing and administration of Personal Health Records (PHRs). PHRs store sensitive health information such as test results, diagnoses, and medical histories. By employing blockchain technology for data sharing, patient privacy can be protected, and access to the data can be restricted to authorized personnel (Table 2). Enhancements in healthcare data security and privacy can be achieved through privacy-preserving Knearest Neighbors (K-NN) training for Internet of Things (IoT) data, and the exchange of electronic health records (EHRs) can contribute to privacy protection.[50,51]

Patients' medical information can be exchanged and stored securely on blockchain platforms that use the technology offering confidentiality and data integrity (“Table 4.3”). Thus, additional security options such as authorization or authentication mechanisms improve healthcare data protection through blockchain (“Table 4”). While Table 4.5 contains publications that address improvement of security methods, table 4.6 separately lists all applications per each use cases.

TABLE 2. DATA MANAGEMENT

Use Case and Reference
1. Sharing of IoT data in health. [42]
2. Safe communication of data. [44]
3. Sharing.[52]
4. Sharing of medical data.[53]
5. Data sharing using blockchain assistance. [56]
6. Sharing of medical data. [57]
7. Healthcare data transfer with privacy preservation provided by IoT. [41]
8. Information exchange. [58]
9. Sharing of health information. [56]
10 Safe exchange of health information between various organizations. [58]
11. method for protecting privacy and sharing medical data.[59]
12 Data management in healthcare.[60]
13 Group decision-making in medicine. [61]
14 Big data management in healthcare.[62]
15 Sharing of protected health information (PHI).[63]
16 Transfer of data.[64]
17 Information management in healthcare.[30]
18 Storage of data.[26]
19 COVID-19 medical record protection facilitated by blockchain technology.[65]
20. Medical data transmission enabled by AI and blockchain.[66]

TABLE 3. PRIVACY ENHANCEMENT

Use Case
1. Preserving privacy [67]
2. Improvement of privacy [68]
3. An e-health system that protects privacy [69]
4. Sharing of data while protecting privacy [70]
5. Protection of privacy [71]
6. Better location sharing in healthcare that protects privacy [72]
7. Protection of medical data privacy [73]
8. Protection of medical privacy [74]
9. Sharing medical data while protecting Privacy [75]
10. Sharing of electronic health data while protecting privacy [76]
11. IoT data privacy-preserving K-NN training [79]
12. Privacy of health data [77]
13. Medical data privacy protection program [78]
14. Blockchain privacy in healthcare [85]

4.0 Authentication and Security Enhancement

These include identity authentication, machine learning authentication, blockchain-based healthcare data authorization and authentication, authentication, PPBA authentication, and anonymity on the Internet of Things.[78-82] A key component of this use case in the healthcare industry is security enhancement, with particular attention paid to areas like biomedical security, medical data security, collaborative analysis, and enhanced security and privacy in the patient healthcare framework.[83-87] This use case takes into account a number of additional applications in addition to the main focus. Verifiable data classification, contact tracing, IoT healthcare security and privacy, and federated learning are some of these applications. [87, 45, 35,22]

4.1 Research question 1: What healthcare-related blockchain applications for security and privacy are there?

In healthcare industry, patient confidentiality and security have become crucial concerns.Electronic health records (EHRs), which contain sensitive and private data, must be secure and private in order to protect patients' rights and stop data breaches. One of the biggest problems facing the healthcare industry is patient information privacy. Blockchain-based EHR systems could offer a secure, ‘unhackable’ system that patient information transfers and storage. While intelligent contracts and cryptocurrency payments will ensure only permitted individuals gain access to the information, the decentralized structure of blockchain has proven capabilities not to allow data compromise and provide assurance to data authenticity. Another way that patients can choose who gained full or limited control to their information and revoke or grant access as needed is through patient-controlled access. Blockchain-based access control may also improve data privacy by letting patients grant or revoke access to their data whenever they choose and ensuring that only authorized parties may access it. They don't both show off how to use smart contracts

4.2 Research question 2: What security and privacy issues does blockchain present for the healthcare sector?

The issue of security and privacy is a delicate matter in medical data due to the possibility of harm and damage through unauthorized access or data breaches. In response to these challenges, blockchain technology presents itself as providing an alternative decentralized, secure platform for sharing and storage of data. Cryptographic primitives are useful for secure search and customized access control; whereas smart contracts offer information confidentiality as well as access control. The validity, efficiency, and safety have been proven by numerous suggested solutions during simulation and experimental investigations. Additionally, several empirical studies have demonstrated that blockchain-based systems can meet expected security requirements without escalating computation and communication expenses. By way of example, Modified attribute based cryptographic primitives together with certificateless public-key encryption may be suitable for protecting privacy in hospital settings where users need customizable access control. To this effect organizations must carefully assess such proposals to ensure they are feasible within real-life healthcare settings while at the same time meeting necessary privacy concerns.

4.3 Research question 3: How can blockchain technology protect patient privacy and security in the healthcare sector?

In the years ahead, healthcare is set to concentrate more on improving privacy and security. The potential of blockchain technology to secure medical data is growingly admitted nowadays. A smart medical cloud platform ensures that a user's privacy can be protected while allowing for data consumption without borrowing. Such new technologies like edge computing, federated learning, and blockchain are among others that could help improve data security and privacy. Access control is made secure while data manipulation is stopped by use of blockchain technology while supporting private information federation through cooperative analysis of data in federated learning. Moreover, edge computing can reduce the possibility of data breach by processing it closer to its source unlike centralizing it. Alternatively, regulations could be made stronger as part of ensuring safety of personal health information. This becomes more critical today because the amount of health-related information becoming available has multiplied exponentially over time leading to increased chances of cyber terrorism or hacking into such databases or networks if they are not adequately protected from unauthorized intrusion as well as other types or forms of breaches which people might not even imagine at first glance which would cause tremendous damages once done. Two acts that help protect personal health information are Health Insurance Portability and Accountability Act (HIPAA) and General Data Protection Regulation (GDPR). More laws will probably be established in the future with a view to ensure the security of health issues hence there may exist several regulations therefore requiring diverse measures in different countries during this period when quite a number of countries have already developed their own legal frameworks in respect to privacy matters only waiting for discussions among stakeholders so as their enactment process can eventually begin too under certain circumstances given that e-PHI includes any medium used by organizations to record patients' conditions such as paper records or electronic systems storing patients' test results plus doctors' diagnostic findings among others thereby making one wonder what specific measures ought to be taken here apart from just securing such details?

5 Conclusion

Efforts should focus on developing state-of-the-art technologies that enable efficient management of the substantial volume of healthcare data within blockchain networks while ensuring seamless connectivity across multiple networks. Scalability and interoperability should be prioritized in healthcare blockchain networks to facilitate efficient data processing and seamless network connectivity. The dynamic interaction between blockchain technology and the healthcare sector presents numerous research opportunities and practical applications. Resolving interoperability and scalability challenges is the most pressing issue. Blockchain's security features can facilitate secure global transmission of healthcare data, particularly when treating patients from different countries. Blockchain has the potential to revolutionize the management of the medical supply chain by ensuring patient safety and validating the authenticity of medications. Additionally, combining blockchain technology with artificial intelligence can unlock powerful data analytics capabilities while protecting data privacy. Patients may have more control over their medical records and even earn income from them through the use of blockchain technology. However, careful consideration is needed for patient consent and identity management. Blockchain technology can assist healthcare organizations in complying with regulations, particularly those related to data security. It can also enhance the security of IoT medical devices by protecting the integrity of patient data collected by these sensors. Improving user interfaces and seamless integration of telemedicine and blockchain-based electronic health records with existing healthcare infrastructure is another potential avenue. This review highlights key research topics and demonstrates how blockchain technology can transform the healthcare field. It emphasizes the potential of blockchain technology in addressing longstanding issues in the sector. Blockchain technology offers a novel approach to medical data storage, transaction processing, and integration and sharing within a decentralized healthcare network. However, the security and privacy challenges associated with sharing information using blockchain need to be carefully addressed. The paper presents research conducted between 2018 and 2023 on the privacy and security of blockchain in healthcare.

The aim of this research review is to assess the current state of affairs, focusing on practical applications and challenges. The analysis concludes that blockchain technology holds promise for addressing practical privacy and security issues in the medical domain. By providing a decentralized and tamper-proof platform for exchanging and storing sensitive patient data, blockchain technology enhances the privacy and security of PHRs and EHRs. It also enables patients to have more control over their data through patient-controlled authentication. Healthcare organizations and practitioners need to carefully evaluate the suitability of blockchain solutions for their specific contexts to ensure practicality and compliance with privacy requirements. While blockchain technology has significant potential, it is not a one-size-fits-all solution and may require customization to meet specific needs. Overall, the study identifies areas that require further research and development to unlock the full potential of blockchain technology in healthcare.

Carefully addressed privacy and security concerns on blockchain-based sharing of information, though. This implies that sharing any health information on a blockchain should be treated with care because there are inherent risks associated with it. The article presents work done between 2018 and 2023 about the privacy and security of blockchain technology regarding healthcare. Blockchain technology can also help in

complying with regulations, especially those concerned with data security for healthcare providers. In addition, this can secure IoT medical devices by ensuring patient data which was gathered from such sensors is kept intact. Furthermore, the improvement of user interfaces as well as seamless integration into existing health infrastructure could also be considered as a possibility presented herein. By doing so, the current issue points out some important directions for research and outlines how blockchain might change the medical field through several case studies suggesting an array of potential impacts to various stakeholders within that sector. It highlights how blockchain might address long-standing problems within healthcare systems. This enables medical data to be stored, processed, transacted or shared in a decentralized manner across the Internet as its key attributes without any third party intervention – thereby making Blockchain Technology revolutionary in EHRs storage as compared to other traditional record keeping approaches like EMR/EHR systems built over centralized databases (Nakamoto, 2008).

The primary objective of this research review is to assess the current situation focusing on applications and challenges. The study concludes that blockchain technology has the potential to address practical privacy and security issues in healthcare. Therefore, blockchain technology improves PHR's and EHR's privacy and security by providing a decentralized and tamper-proof platform for sharing sensitive health information. It also allows patients to maintain more control over their data through patient-controlled authentication. In a bid to be practical and meet with various privacy requirements, healthcare organizations should evaluate how appropriate it would be to apply block chain solutions in their organizations as well as adhere with legal considerations relating to patient information rights among other things. Nevertheless, while blockchain technology has great potential, it is not a universal solution that can be used without customization. This paper however pinpoints specific areas which require further investigation regarding blockchain technology's full potential in medical field.

6 Recommendations

1. Interoperability and Scalability: Urgently address interoperability and scalability challenges in healthcare blockchain networks. Focus on developing innovative solutions that enable efficient data processing and seamless network connectivity across multiple networks. Explore approaches that can effectively manage the substantial volume of healthcare data while ensuring secure and reliable connectivity.

2 International Data Transmission: Investigate the benefits of using blockchain's security features for transmitting medical data across borders, particularly when treating patients from different countries. Explore how blockchain can enhance the security, privacy, and integrity of data in international medical transactions.

3 Revamping the Medical Supply Chain: Analyze the possible consequences for healthcare supply chain management that may arise from using blockchain technology. Elucidate on how blockchain is capable of enhancing patient's safety and validating the genuineness of drugs. Propose viable approaches that will safely embed blockchain in extant supply chain practices, which will continue to be responsible, liable and open.

Disclosure of Interests. Both Author A (Taiye Muktar) and Author B (Timur Inan) have no known competing interest anywhere.

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Object Detection of the Selçuk University Campus Images Using YOLO

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Abstract. In the field of Artificial Intelligence, real-time object detection is a popular topic of study and there are various recent works in the literature on this topic. In the field of real-time object classification, the algorithm named YOLO (You Only Look Once) is frequently used. In this study, we tested the v3 version of the YOLO algorithm. The algorithm was implemented in Google Colab environment and tested using various images of Selçuk University Campus in order to classify the objects. The research findings explained in detail of this study.

Keywords: You Only Look Once (YOLO), OpenCV, Deep Learning, CNN.

1 Introduction

With the recent developments in technology, we frequently encounter visual and auditory data in almost every aspect of our lives. With the increasing number of visual and auditory data, analyzing these data and obtaining meaningful results has become very important. As can be seen in the literature, there are a wide variety of image processing algorithms, deep learning models, artificial intelligence applications and tools used together with visual and auditory data. Much more operations that are advanced and results can be obtained by using deep learning models [1]. By definition, deep learning is a subfield of machine learning that extracts high-level features from pure input data using multiple sequential layers. There is non-linear processing and learning. Each layer takes the data of the previous layer, processes it and sends it to the next layer. Deep learning is basically about understanding the representation of data [2]. In deep learning, there are different architectures and structures such as Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Long-Short Term Memory (LSTM), etc. [3].

The analysis operations performed on visual data are carried out for various purposes and directions. Applications such as image classification, object recognition, face recognition, etc. can be used for various purposes. In order to make a successful analysis of a visual data, it is not enough just to classify this image. In addition, analyzing the concepts and regions of the objects in the image is another factor that will be beneficial in terms of classification and representation. The examples of object recognition includes license plate recognition, human-animal recognition, bone type recognition, etc. Applications with object recognition can be found in many places in daily life.

Examples include autonomous cars, bridge and highway toll systems and alarm systems. For object classification on visual data, first the area where the object is located in the image should be selected. As a second step, feature maps in the selected area should be extracted and classification should be performed accordingly [4]. There are various methods for object detection and classification such as R-CNN (Region Based Convolutional Neural Networks), YOLO (You Only Look Once), SSD (Single Shot Multibox Detector), Mask R-CNN, Fast R-CNN, Faster R-CNN [1].

In the field of object classification, there is a wide variety of studies with different methods in the literature. In his thesis, Ali (2022) developed a GPU (Graphics Processing Unit) based application for multiple object detection [5]. In his master's thesis, Anı (2022) trained a deep learning network named DARKNET-53 and used it for object classification [6]. Carion et al. (2020) introduced a new method for object recognition using a transformer in their study [7]. Tian et al. (2019) presented an alternative method called FCOS (Fully Convolutional One-Stage Object Detection), which gives more successful results than other alternative methods in the literature [8]. Yin et al. (2021) presented a point-based object classification algorithm for the detection of three-dimensional objects [9]. Zoph et al. (2019) compared data augmentation techniques that can be used in object recognition algorithms [10]. In his thesis, Albayrak (2021) presented an application that performs object detection using images obtained from unmanned aerial vehicles [11].

In this study, we preferred the YOLO object detection algorithm, which is frequently used in the literature and whose success has been accepted by the studies. We performed an object detection classification with YOLO algoritm on the images obtained within the boundaries of Selçuk University Alaeddin Keykubat Campus. The outputs obtained are analyzed in detail in the following sections of the study.

2 Materials and Methods

Object recognition applications, which have increased in popularity in recent years, can be found in almost every aspect of life, from unmanned aerial vehicles to autonomous vehicles. Using an artificial neural network, objects in an image are found and the location and type of objects are indicated on the image.

Today, the methods used for object detection are divided into two groups: one-stage and two-stage methods. In two-stage methods, areas where objects can be found are selected and classification operations are performed in these areas. In one-stage methods, the areas where objects are found and classification operations are performed simultaneously. YOLO provides object detection using an end-to-end Artificial Neural Network and is much faster than methods such as R-CNN, Fast R-CNN, etc., but with slightly lower success rates. YOLO divides the input image into equal square areas and the necessary classification processes are carried out on the divided square areas. Classification and merging operations are performed on the square areas until the boundaries of the relevant object are determined. Figure 1 shows the working method of the YOLO algorithm [12].

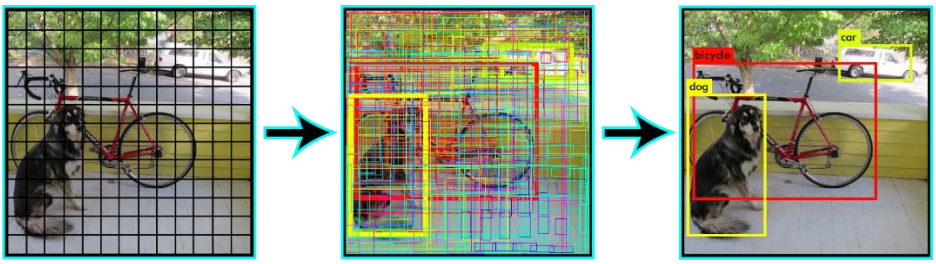


Fig. 1. The method of YOLO

The YOLO algorithm has its successes as well as its negative sides. For this reason, it gives unsuccessful results in detecting objects in a group (for example, a swarm of ants) in an image. The YOLO algorithm is an Artificial Neural Network inspired by the GoogleNet deep learning model and consists of 24 convolution layers and 2 fully connected network layers. There are different versions of the YOLO model such as v2, v3, v4, v5, etc. In this study, we preferred YOLOv3 version using DarkNet-53 deep learning network structure. This version is more advanced than v2 and does not contain the problems found in v1. The network structure has a total of 106 layers and includes shortcut connections as in the ResNet model. Figure 2 shows the network structure of the YOLO model [12].

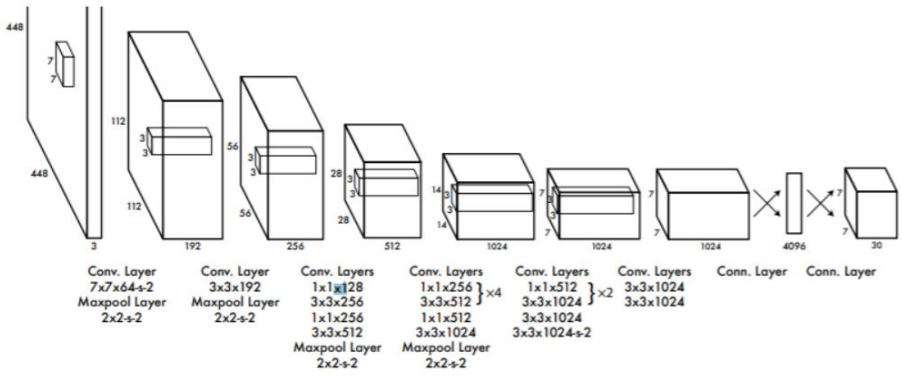


Fig. 2. YOLO network (DarkNet-53 based)

In this study, we tested to classify the objects on the images of Selçuk University Alaeddin Keykubat Campus with using YOLO. We executed the YOLO on Google Colaboraty (Colab) environment. Google Colab is a free Jupyter Notebook execution service. It was created for artificial intelligence and data science experts to share their work and experiences. Using Google Colab, Jupyter Notebooks can be executed on Google-owned hardware. Optionally, CPU (Central Processing Unit), GPU or TPU (Tensor Processing Unit) can be selected. Various hardware services and high usage times are possible with paid versions [13].

In this academic study, we used YOLOv3, a deep learning model consisting of 106 layers. YOLOv3 is basically a structure built on the DarkNet-53 deep learning model. There is also a library developed using C and CUDA under the name Darknet. With the help of this library, training and testing operations can be performed on both CPU and GPU [14].

3 Research Findings

In this study, YOLO model is used to detect objects in the visual data recorded in the boundaries of Selçuk University Alaeddin Keykubat Campus. There are different approaches, methods and algorithms in the field of object detection.

In this study, Google Colab was chosen as the execution environment and development was performed on a Jupyter Notebook. The 106-layer YOLOv3 model was prepared using the pre-training weights from [14]. The main reason for this process is to improve the success rate and prediction quality. The YOLOv3 deep learning model was run on Google Colab using a library called Darknet. As a first step, a test image was evaluated. The results of the outputs from the test image given in Figure 3 are correct. The dog, person, and horse outputs were 99%, 100%, and 100% respectively, taking 1867.89 milliseconds for prediction.

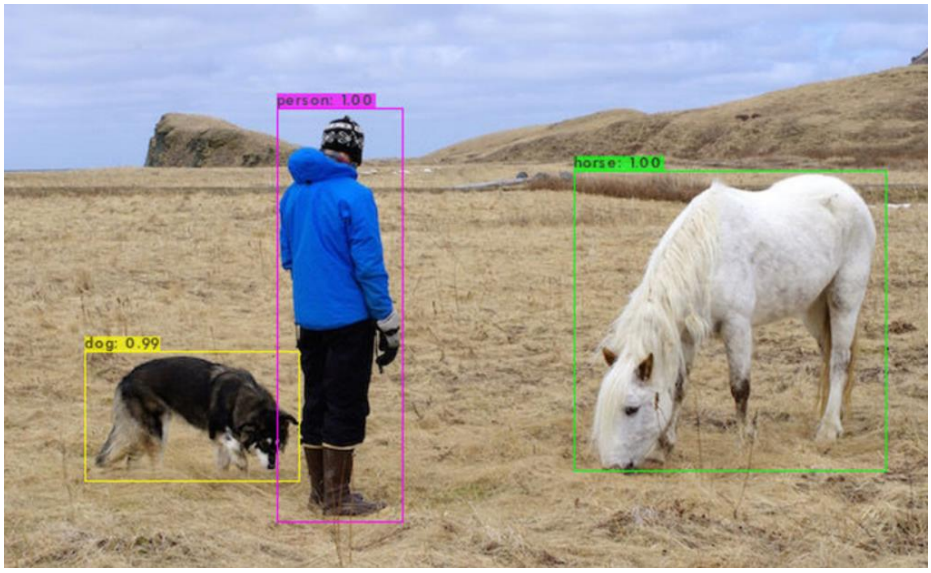
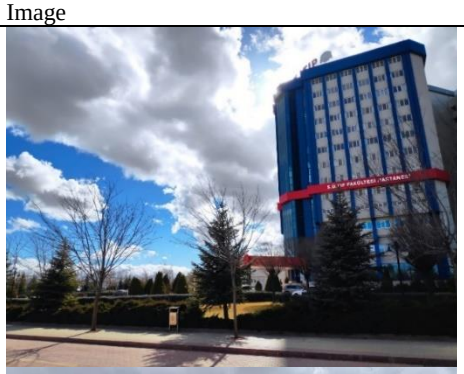
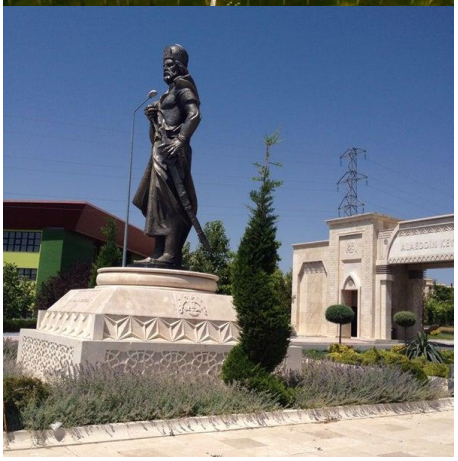


Fig. 3. First phase testing of the YOLOv3 model on Google Colab

We tested more than fifty images obtained from the boundaries of Selçuk University Alaeddin Keykubat Campus with the YOLOv3 model. In this study, we shared several representative images. Table 1 shows the representative images taken from the boundaries of Selçuk University Alaeddin Keykubat Campus.

Table 1. Representative sample photos taken from the images tested in Selçuk University campus

Image No	Image	Explanation
1		A view of the Faculty of Medicine Hospital in Selçuk University campus.
2		General view of the Faculty of Technology building on campus. Recorded from the view of the Faculty of Agriculture.
3		General view of Selçuk University Rectorate Building.
4		The sculpture located at the entrance of Selçuk University Main Campus.

5		A bird's eye view of Selçuk University Campus from the air.
6		General view inside Gökküşağı Shopping Center located within the campus boundaries.
7		Representative drawing of the entrance gate on the ring road passing in front of Selçuk University.
8		General view of a reading room in Erol Güngör Library.

9		A hall in Selçuk University Süleyman Demirel Cultural Center.
10		A horse riding training at Selçuk University Equestrian Facilities.

We obtained successful results from some images and unsuccessful results from others. Especially bird's eye view and general view images had low success rates. On the other hand, close-up images and images with many objects were found to have high success rates. The images processed by YOLOv3 are given in Figure 4.

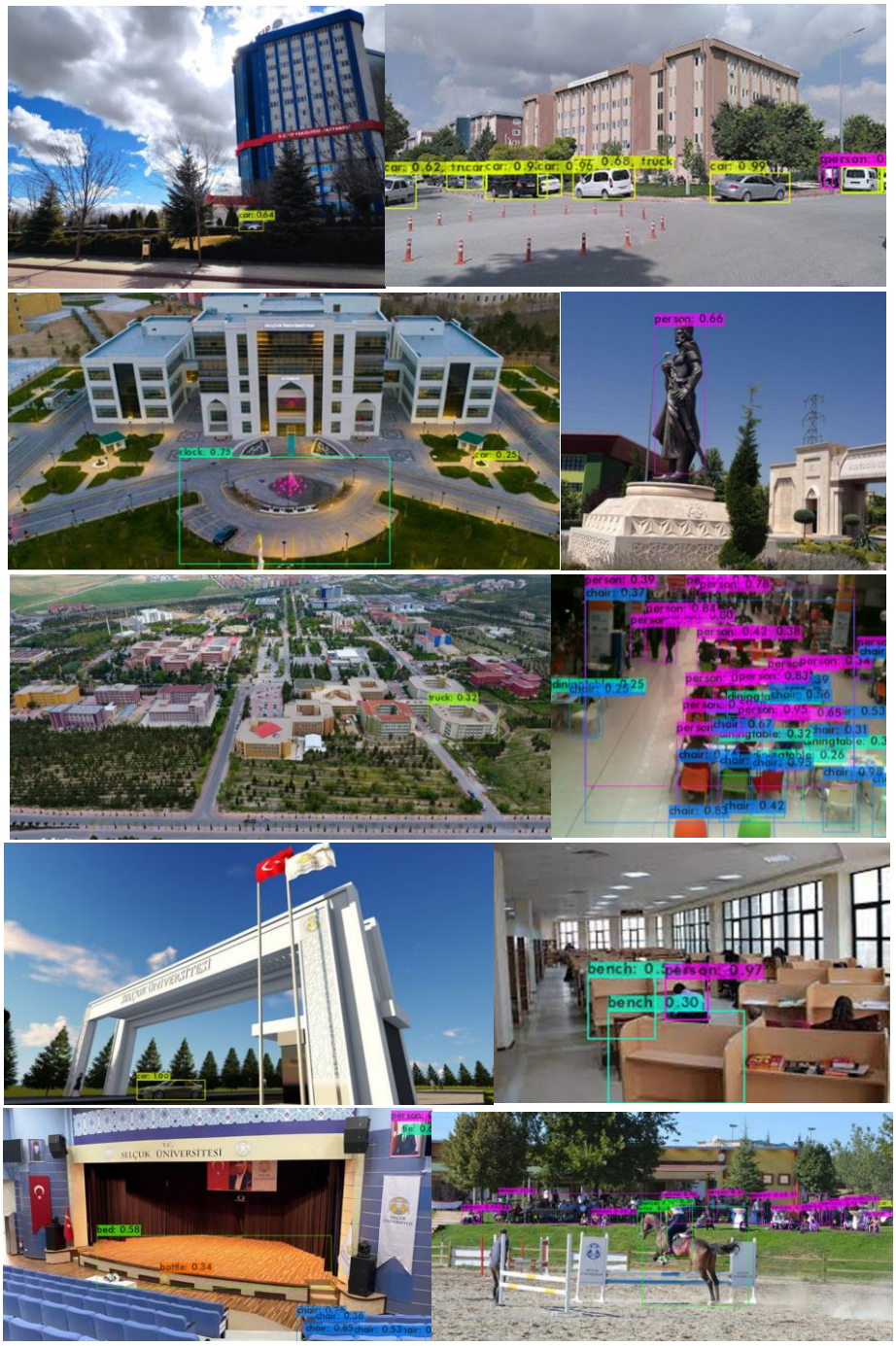


Fig. 4. Detected objects' results from the campus images of Selcuk University

As can be seen in the outputs, in the image number 1, a car can be correctly classified even though only the tip of the car is visible. In the image number 2, parked cars were correctly identified, but a semi- commercial vehicle was classified as a truck. In the image number 3 of the rectorate building, all object identifications are incorrect. In the image number 4, campus entrance image, 66% of the sculpture is classified as human and is correct. In the number 5 bird's eye view campus image, there is a classification error. In the image 6, Gökkuşağı Shopping Mall image, the people, chairs and tables are correctly classified. Image No. 7, the car in the campus entrance gate sample architectural image is also correctly identified. In the image number 8 library image, some tables and individuals were detected, but not all of them were detected. In the image number 9, there are misclassification errors in the hall image of the cultural center. In the image number 10, horses and people are correctly classified.

4 Results

Object detection is a method that is frequently used in almost every field as technology increases its place in our lives. From driving assistants in autonomous cars to active cruise control, from face recognition systems to parking lot entrance and exit zones, there are examples in every field.

In this study, the YOLOv3 model was implemented in the Google Colab work environment using the Darknet library. Various images of Selçuk University Alaeddin Keykubat Campus were tested. Images of the library, cultural center, shopping center, entrance and exit units and other areas within the campus were used. As seen in the classification processes performed with YOLOv3, the detection success was low in bird's eye view images and images where objects were taken from far away. In addition to low detection success, it was observed that various objects were misclassified. In this study, 10 different representative campus images were used and the prediction processes were obtained as 598.29, 577.24, 593.90, 578.57, 589.59, 1044.27, 580.58, 597.48, 575.94 and 597.95 milliseconds respectively. The YOLOv3 network used in this study produces fast detection results. However, it is not clearly possible to predict its output and success rates according to the states of the images. Success rates can be increased by using different YOLO versions or YOLO alternative methods.

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Advancing Emotion Recognition: A Systematic Review of Emotion Induction Techniques and Machine Learning Approaches

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Abstract. Emotion plays a pivotal role in human-computer interaction, making accurate recognition and effective induction of emotions crucial for developing systems that can understand and respond to human emotions. This paper surveys 31 existing papers in the literature, focusing on emotion induction techniques, data collection types, emotion models, and machine learning methods employed in emotion recognition. According to evaluations, researchers commonly rely on visual stimuli and dimensional emotion models. EEG signals enjoy considerable popularity among various modalities, and the prevalent trend in machine learning approaches involves the use of Support Vector Machines (SVM). This paper aims to contribute to the field by analyzing the recent trends in emotion recognition and induction and be a guide for future research.

Keywords: Emotion recognition, emotion induction, emotion models, machine learning.

1 Introduction

Although the concept of emotion is widely recognized and often discussed, there is no universal agreement on its definition, leading to varied interpretations and understandings of what an emotion is [1]. There is widespread acceptance of the componential structure of emotion including mental and bodily components [2]. A componential definition of emotion, which is named as the Component Process Model (CPM), defines emotion as a sequence of interconnected, synchronized changes in the states of all or most of the five organismic subsystems in reaction to the assessing an internal or external stimulus event as significant to the organism's primary interests [1, 3]. According to this definition, an emotion comprises a collection of various interrelated

changes within the following five different components: (i) cognitive, (ii) motivational, (iii) physiological, (iv) behavioral, and (v) experiential (feeling) [1].

The universal relevance of emotions in daily life has led to the development of Affective Computing (AC). This interdisciplinary field strives to create systems and devices capable of recognizing, interpreting, processing, and reacting to human emotional states. [4]. The central motivation of AC stands on the idea that emotions play a crucial role in forecasting the mental state and future behaviors of humans. Thus, AC can significantly enhance the performance of computer-based systems in recognizing and responding to human emotions [5, 6].

Emotion recognition and emotion induction have key roles for improving AC [7]. Emotion recognition involves accurately figuring out emotions from different sources like facial expressions, gestures, speech, and more, while emotion induction intentionally triggers specific emotional reactions using various methods [8]. These play important roles in diverse fields such as psychology [9], physiology [10], healthcare [11], safe driving [12], education [13], and marketing [14].

This study systematically reviews emotion recognition and induction research, emphasizing emotion models and machine learning methods from 2019 to 2023. Given the growing popularity of this interdisciplinary field and the increasing number of studies, it is crucial to identify, evaluate, and synthesize research results for future advancements. Focusing on the past five years, the goal is to implement the latest state-of-the-art works and methods.

2 Background

2.1 Emotion Induction Techniques

Emotion induction techniques play a pivotal role in experimental settings aimed at eliciting and studying emotional responses. Commonly utilized methods include viewing pictures, watching videos, listening to music, reading emotional text, recalling past experiences, or imagining an emotional event [15]. These techniques are considered as passive induction as they require passive involvement of individuals in a controlled setting offering benefits, such as controlling the stimuli presented, standardizing measurement conditions, and minimal risk of external factors interfering with the results [16].

Emotion induction aims to gather data that provide indications for identifying the elicited emotions. Facial expressions, physiological changes, biosensors data such as Electroencephalogram (EEG), Electrocardiogram (ECG), Electromyography (EMG), Electrodermal Activity (EDA), Skin Temperature (SKT), and Galvanic Skin Response (GSR) are mostly used to measure emotions.

2.2 Emotion Models

Several models of emotion have been developed to understand and categorize human emotions. These models can be classified into two categories: discrete and dimensional. Discrete models propose the existence of distinct, basic emotions. According to the discrete model, each emotion differs based on its unique characteristics [4]. Dimensional models consist of continuous dimensions that propose emotional states are composed of several changes in psychological and physiological dimensions, such as valence, arousal, and control (or dominance/power) [17]. Arousal refers to the strength or intensity of an emotional state, ranging from high to low. Valence means the positivity or negativity of an affective state. The control/dominance dimension describes the degree of influence or control over the situation [17].

Ekman's Basic Emotion Theory is an example of discrete models, and it proposes that certain emotions appear universally recognized apart from the cultural background and identifies six basic emotions: anger, disgust, fear, happiness, sadness, and surprise [18]. Plutchik's Wheel of Emotion is another example which categorizes eight basic emotions: trust, surprise, joy, fear, disgust, sadness, anticipation, and anger [19].

In case of dimensional models, the Circumplex Model of Affect (CMA) categorizes emotions into a two-dimensional circular space [20]. The vertical axes represent arousal, and the horizontal axes represent the valence dimension. These two axes divide the space into four quadrants. Another two-dimensional model is the Geneva Emotion Wheel (GEW). It categorizes 20 distinct emotions [21]. The GEW measures emotional reactions to objects, events, and situations. It places emotion families in a circle, with intensity bubbles ranging from 0 to 5 [17]. Finally, all three dimensions unite in a three-dimensional model, Valence-Arousal-Dominance (VAD) [22].

2.3 Related Work

In recent years, researchers have conducted studies on emotion recognition and induction with the aspect of emotion models and machine learning methods. Duville et al. [23] presented a systematic literature review (SLR) that focuses on emotion recognition and regulation using electrophysiological signals. They selected a total of 42 articles from 2014-2020. In the articles examined, attention was paid to the presence of at least one of the emotional models and the usage of electrophysiological signals. Prabowo et al. [24] introduced an SLR of 107 primary studies between 2017 and 2023 to explore data trends, classifiers, and contributions to emotion recognition using EEG signals. Ortmann et al. [25] identified 21 works out of 256, including facial expression recognition in virtual reality scenarios. Tomar et al. [26] provided a SLR on existing modalities for emotion recognition, emotion models, and trends in relevant studies by selecting articles published from January 2010 to June 2021. The final 129 articles were reviewed according to research questions. Leszczelowska et al. [27] performed an SLR including over 40 articles to identify the commonly used datasets, electrodes, algorithms, and EEG features, as well as their extraction and selection methods. Sutedja et al. [28] studied the efficient methods of implementing facial ex-

pression recognition using a SLR, reviewing 20 papers. In addition to these works, other SLR examples focus on emotion recognition from EEG signals and facial expressions. From this, machine learning methods were explored only focusing on specific data modalities. We aim to search articles including any data modalities without focusing on a specific one.

In this study, we aim to review the recent studies on emotion recognition and induction to get insight into trending machine learning methods used for emotion recognition and popular emotion induction techniques.

3 Review Methodology

This section presents an overview of our research methodology followed by an overview of the systematic approach according to PRISMA guidelines [29]. It is an evidence-based reporting system designed to analyze all published reports related a specific subject to find answers to predetermined research questions. Various inclusion and exclusion criteria are determined to identify the reports to be included in the SLR. Then, the findings are synthesized.

3.1 Research Questions

This work focuses on emotion recognition and emotion induction with a focus on emotion models and machine learning methods, aiming to highlight the most frequently used induction techniques, modalities, and machine learning techniques.

Our research questions are as follows:

RQ1: What are the most frequently used emotion induction techniques in emotion recognition?

RQ2: Which emotion models are mostly used in classifying emotions?

RQ3: What are the types of data collected to analyze?

RQ4: What machine learning methods researchers prefer for emotion recognition? What are the recent trends?

3.2 Inclusion and Exclusion Criteria

In this study, we surveyed the articles from the journals, and conferences published in the English language from 2019 to 2023. It is important to highlight that to be included in this review study, an article must satisfy all inclusion criteria and not meet any of the exclusion criteria. For this study, the following inclusion and exclusion criteria were applied to all the retrieved papers:

Inclusion criteria.

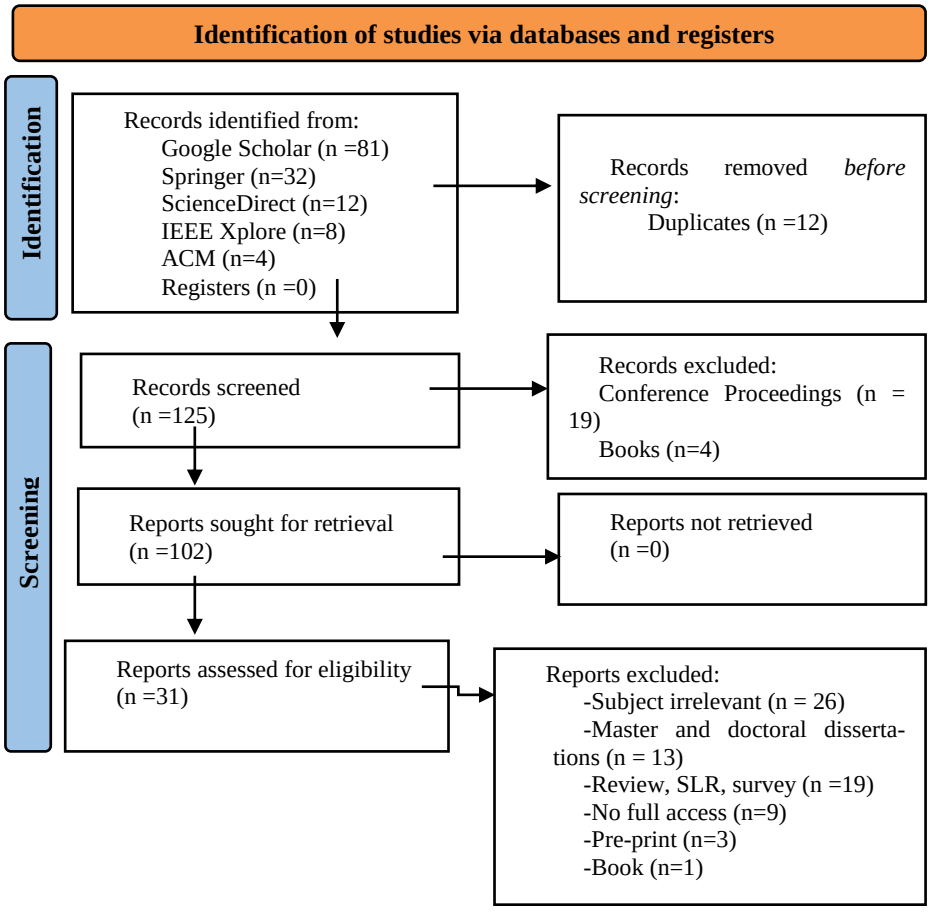
- Studies that are relevant to subject and published between 2019 and 2023.
- Full-text papers.
- Papers written in English language.

Exclusion criteria.

- Studies that are irrelevant to subject.
- Papers published before or after the given period.
- Uncompleted studies.
- Book chapters.
- Unavailable full-text research papers.
- Papers not written in English Language.
- Master or doctoral dissertations.
- Pre-print articles.
- Workshop descriptions.
- Reviews. Surveys.
- Conference proceedings.

3.3 Study Selection Process

The process began with electronic searches of studies published in English from 2019 to 2023 in Google Scholar, IEEE, ScienceDirect, ACM, and Springer databases. The following keywords were employed to search in the databases: emotion recognition, emotion induction, emotion models, emotion frameworks, and machine learning. As query sentence (“emotion recognition” AND “emotion induction” AND (“emotion models” OR “emotion frameworks”) AND “machine learning”) was used.



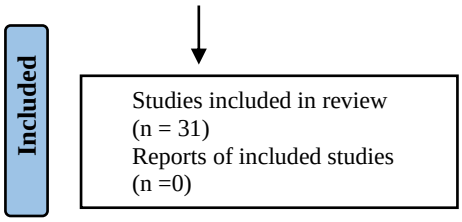


Fig. 1. Records identified from each database and exclusion according to criteria [61].

The search retrieved 137 results. 81 from Google Scholar, 8 from IEEE Xplore, 12 from ScienceDirect, 32 from Springer, and 4 from ACM. From these studies, only those which satisfied our inclusion and exclusion criteria have been included in this SLR. Duplicate studies and studies which use only statistical methods instead of machine learning were excluded. After employment of these inclusion and exclusion criteria, 31 articles were included in this work (see Fig. 1.).

4 Results and Discussion

In this section, the results of the SLR study are briefly presented. Here, we stated the answers to our four research questions in the selected 31 articles.

When the chart was investigated, a general upward trend becomes apparent (see Fig. 2.). It has been observed that in years that do not conform the general trend, a periodic reduction is observed in the quantity of publications derived from the query and deemed within the scope.

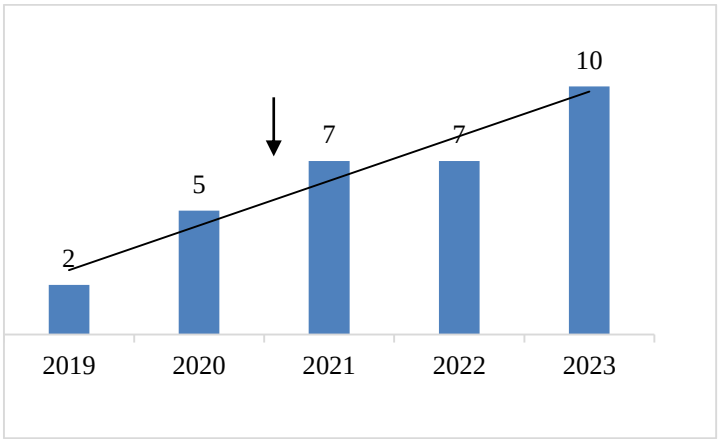


Fig. 2. The distribution chart by years.

4.1 RQ1: What are the most frequently used emotion induction techniques in emotion recognition?

In the context of RQ1, that aims to identify the most frequently used emotion induction techniques by researchers, the reviewed studies were evaluated. A notable trend emerged from the evaluation, indicating a predominant utilization of video clips as the primary induction paradigm across the reviewed studies. This consistent pattern highlights the importance of visual stimuli in evoking emotional responses.

Researchers have a significant preference for the dynamic and multi-modal nature of video-based stimuli. Videos offer a wealth of information beyond just the visual content. They also capture facial expressions, body language, and context, all of which are crucial for recognizing emotions. This multifaceted nature of video allows for a more comprehensive understanding of emotional states compared to static images or textual descriptions.

One of the reasons that make video clips preferable for researchers can be that videos allow researchers to control and manipulate the stimuli that participants are exposed to. This makes it possible to create controlled experiments and isolate the effects of specific factors. Also, videos are available and easily can be accessed online. This makes it easy for researchers to collect large datasets of video stimuli and study emotion recognition in a variety of context. Compared to self-reported measures, videos minimize subjectivity. And the most significant thing is that videos offer a more ecologically valid way to study emotion recognition compared to other static stimuli types. All these features seem to make video clips favorite choice of stimuli for researchers.

In addition, pictures also are employed, following video clips. From this, it can be said that visual stimuli, namely, videos and pictures are the most preferable induction techniques. They are both can be edited and manipulated to increase the emotional impact. However, compared to video clips, pictures have a static nature and they capture a single moment unlike video clips which are more engaging with the combination of visual and audio elements. With all these advantageous features, researches prefer video-based stimuli.

Table 1. Emotion Induction Techniques

Stimulus	Article References
Video Clips	[32], [33], [34], [35], [36], [42], [43], [44], [45], [56], [57]
Pictures	[30], [41], [42], [49], [51], [60]
Gameplay	[31], [39], [48]
Music, Audio	[37], [50], [52], [54], [59]
Driving Simulator	[47], [58]
VR Games	[40]
VR Applications	[46]
Breathing exercises (unguided/guided)	[53]
Autobiographical Recall	[55]

In addition to the visual stimuli, it was observed from Table 1. that autobiographical recall, VR applications and games are less frequently used induction techniques. It can be inferred that the potential of VR is being explored in various contexts, including as an induction technique. However, the observation that these VR techniques are less frequently used, in comparison to visual stimuli, may indicate that there is still ongoing exploration and experimentation with the application of VR in the given context.

4.2 RQ2: Which emotion models are mostly used in classifying emotions?

When emotion models were evaluated to be able to answer RQ2, it was observed that dimensional models have superiority over discrete models (see Table 2) in emotion classification.

In studies that no specific emotion model is defined, researchers employed a binary classification method. For example, in [46, 53], emotions were classified as either stress or no-stress, while [30, 37, 41, 42, 57] utilized a categorization into negative and positive emotions. In the study described in [47], participants, using a driving simulator, were categorized as either frustrated or not.

Due to the continuous nature of emotions, dimensional models capture this dynamic structure of emotions, allowing for a more detailed representation of emotional experiences. While discrete emotion models simplify emotions by placing them into a restricted set of categories, dimensional models enable researches to label emotions in a more detailed manner. With these advantageous features of dimensional models over discrete ones, researchers more likely to prefer dimensional models in their studies. While dimensional models offer advantages, it is necessary to note that the choice of model type depends on the specific application and goals of emotion recognition.

Table 2. Emotion Models

Model Type	Article References
Dimensional	[30], [31], [32], [36], [40], [45], [46], [47], [48], [51], [56], [58], [59]
Discrete	[27], [28], [35], [39], [44], [50], [60]
Both Discrete and Dimensional	[29], [34], [41]
Binary Classification	[26], [33], [37], [38], [42], [43], [49], [57]

Among all dimensional models, CMA is the most frequently used model. It is a two-dimensional model based on valence and arousal. VAD combines three dimensions, namely, valence, arousal, and dominance(control). The distribution of dimensional studies is shown in Fig. 3.

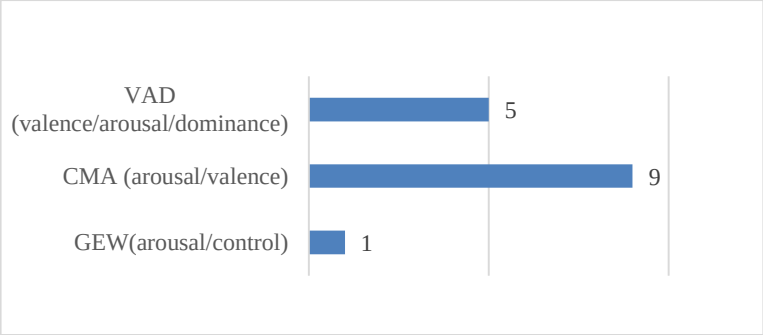


Fig. 3. Distribution of Dimensional Models.

4.3 RQ3: What are the types of data collected to analyze?

In almost all reviewed studies, participants were asked to rate the intensities of stimuli using scales such as Self-Assessment Manikin (SAM) or Differential Emotion Scale (DES). From this knowledge, participants' self-assessments are always significant data sources for researchers.

In the overall evaluation, aside from self-assessment answers, EEG signals were researchers' favorite data sources. Following that, GSR signals and facial expressions were also popular data sources for emotion recognition studies. As an answer for RQ3, a detailed distribution of studies by data types can be seen in Table 3.

Biosensor data such as EEG, ECG, and GSR provides objective measurements, reducing reliance on self-reporting data. As physiological responses are less sensitive to bias that arise from self-reporting, this objectivity enhances the emotion recognition. Unlike facial expressions, which can be intentionally faked by individuals, EEG and ECG represent physiological signals that cannot be consciously controlled by the person. The characteristic properties of EEG data give clues why it is favored in research studies, providing insights into an individual’s emotional states naturally, without the possibility of intentionally deception.

Table 3. Data Types

Measurements	Article References
Facial Expressions	[30], [33], [34], [40], [47], [48]
Keystroke	[30], [52]
Speech	[30], [38]
EEG	[31], [32], [34], [35], [36], [37], [40], [41], [42], [44], [45], [50], [51], [53], [56], [57], [58], [59], [60]
GSR or EDA	[30], [34], [40], [43], [46], [48], [55]
ECG	[40], [43], [45], [46], [49]
Wrist Pulse Signal (WPS)	[39]
Skin Temperature (SKT)	[30], [40], [43], [55]
Heart Rate (HR)	[40], [43], [47]
EMG	[46]
Blood Volume Pulse (BVP)	[30], [48], [55]
Acceleration	[40], [55]
Eye Tracking	[60]

4.4 RQ4: What machine learning methods researchers prefer for emotion recognition? What are the recent trends?

To be able to answer RQ4, the reviewed studies were evaluated in the context of machine learning methods. In most of the studies, not only one method was used but more. The results showed that Support Vector Machine (SVM) classifier was the most favorite machine learning method by researchers [34, 35, 36, 39, 40, 44, 45, 46, 47, 49, 51, 54, 57, 58]. In addition to SVM, K-Nearest Neighbors (KNN) [32, 34-36, 42, 44, 46, 49, 51], Random Forest (RF) [34, 36, 46, 49, 51, 52, 56, 58], Naïve Bayes (NB) [32, 35, 36, 46, 49, 54], Decision Tree (DT) [36, 46, 49], and Logistic Regression (LR) [51, 59] were other machine learning methods.

Besides, it can be seen from the evaluation (see Fig. 4.) that neural networks such as CNN [41, 50], LSTM [30, 34, 53], CNN-LSTM [37], ANN [36, 42, 48, 51, 54, 58], CNN-based EDL [43], 3D-CNN [34], Multilayer Perceptron (MP) [46] were employed. Deep learning is a subset of machine learning that focuses on using neural networks with multiple layers, to learn and make predictions from data. The reviewed studies indicates that deep learning methods give promising results on emotion recognition. The distribution of methods that were used in the studies can be seen in Fig. 4.

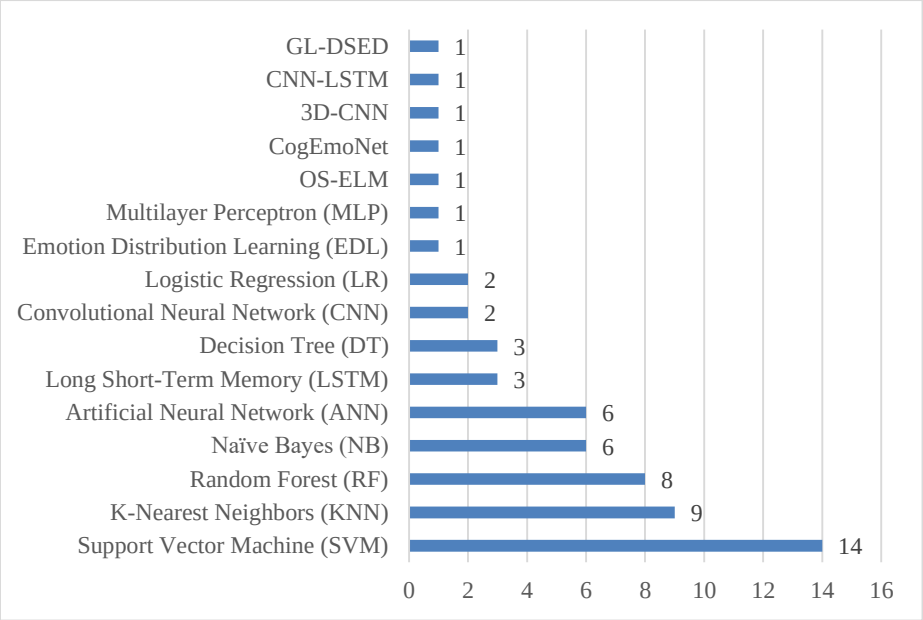


Fig. 4. The distribution of methods that were used in the studies.

The success of the selected machine learning methods changes according to the selected emotion measurements. In the studies which SVM was used, high accuracy rates were observed. However, it is hard to generalize accuracies. The rates change across datasets and measurements. In [39], SVM classifies discrete emotions (anxiety, pain, boredom, reference) with a maximum accuracy rate of 100%, using wrist pulse signals (WPS) collected with game induction. But, in [46], SVM classifies stress and no-stress states with a maximum accuracy of 63.98%, using ECG, EMG, and GSR data provided from a VR application. Examples propose that accuracy rates of SVM change across dataset features, selected emotion model, and induction techniques.

There is an increasing trend in employment of neural network architecture in emotion recognition studies. Neural networks also show high accuracy rates. In [42], ANN was used to classify positive and negative valence from EEG data from visual stimuli with 96.1% accuracy, while 80.2% for KNN. In [36], ANN classifies EEG signals according to arousal-valence model with a maximum accuracy rate of 60.4%, while 98.2 % for RF with a better performance.

From these results, it is not possible to definitively conclude whether classical machine learning methods or neural networks are superior in performance. They both perform differently according to the selected dataset, measurements, and emotion model. Researchers should therefore choose the method that best aligns with their specific objectives and research framework.

5 Conclusions

The study set out to gain a better understanding of emotion induction techniques, emotion models, and machine learning models. The findings revealed video clips as the most prevalent emotion induction technique, with VR and games being less favored. Dimensional models, particularly the CMA, emerged as superior for identifying emotions with multi-components. EEG signals were widely adopted due to their ability to capture uncontrollable brain activity, offering improved recognition accuracy compared to other static data types. Among machine learning methods, SVM stood out for its high accuracy, while neural networks showed promise. Comparing classical machine learning methods with neural networks presents challenges due to their varied performance, which is highly dependent on the choice of dataset, measurement criteria, and emotion model. Researchers are advised to choose the approach that most closely aligns with their specific research objectives and the nature of their work.

The current study is limited by the fact that it surveyed the related literature without focusing on a specific measurement and stimuli. This creates a restriction on finding the best machine learning method for emotion recognition. Our results are not broadly generalizable within the scope of machine learning. Notwithstanding these limitations, this work offers valuable insights into trending learning methods, induction techniques, and emotion models.

A further study could assess the comparative effectiveness of VR-based emotion induction to traditional methods. This will enhance our understanding of emotional responses in diverse contexts, contributing to the advancement of the field.

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Machine Learning for Cartoon Character Recognition

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Abstract. This study focuses on Convolutional Neural Networks (CNNs), a significant technology that enables artificial intelligence systems to operate independently or with minimal human involvement. CNNs are powerful tools used for handwriting, digit, character, and object recognition. These networks can learn and adapt to solve various problems with minimal input data. The study aims to address the challenges of using automated methods to identify and recognize cartoon characters. Advances in machine learning have enabled the development of accurate and efficient methods for the detection of cartoon characters, especially using Convolutional Neural Networks (CNNs). In this study, a special CNN-based network is trained, an end-to-end architecture is designed using machine learning techniques, and a new algorithm is developed for the multi-class classification problem. A new dataset of cartoon characters has been created. Studies have shown that the caricature character recognition algorithm has a high success rate.

Keywords: Cartoon Character Detection, Deep Learning, End-to-End Architecture, Machine Learning, Multi-Classification.

1 Introduction

This paper discusses the difficulty of recognizing characters in comics, which are graphic stories told through abstract drawings. Identifying important comic book characters is crucial for analysis [1]. The detection of cartoon characters differs greatly from human detection because their shape and appearance can be exaggerated by the artist. It is not possible to directly apply identification methods based on humans to comics. This challenge is one of the reasons why work on cartoon character face detection or character detection is limited. Sun and Kise [2, 3] demonstrated that the Viola-Jones detection framework [4] can accurately detect faces in manga. According to Takayama et al [5], the techniques used for real human faces cannot be applied to colorful comic

book characters for detection and recognition purposes. This is because cartoon character faces and bodies differ significantly from real human faces and bodies in terms of the positioning of organs, size, and color tones. The research aims to contribute to computer vision studies and focuses on an unexplored topic in Turkey. A study was conducted to classify cartoon characters, and a new dataset was prepared for this purpose. With the cartoon characters created by artist Varol Yaşaroğlu [6], the first data set on cartoon characters at the national level was created. Based on the experimental results, it can be concluded that the developed model works efficiently.

2 Background

2.1 End-to-end learning

End-to-end learning adopts the fundamental idea of solving complex network problems without breaking the entire image processing process into several modules or sub-steps, unlike divide-and-conquer logic. From a different perspective, deep learning can directly map between the original input and the desired output, and this process can be trained in its entirety from end-to-end eğitilebilmektedir [7].

2.2 Multiclass Image Classification

Multiclass classification is a classification problem with more than two classes. In these types of problems, the learning algorithm analyzes the input data and generates confidence or probability scores for each class. Then, the system uses the scores it receives to determine which class the input belongs to [8]. CNN (Convolutional Neural Network) is a type of ANN designed for image recognition and processing. It is specifically created to process pixel data.

2.3 Related Work

The literature review highlights extensive research on cartoon character detection employing diverse methodologies. Several studies have contributed to this field using machine learning models. Approaches range from skin color regions [5, 9] and edges [10, 11] for face detection or character detection to novel methods such as effective edge labeling, screen tone removal, and edge orientation histogram. Various deep learning techniques, including R-CNN [12, 13], YOLO [14, 15], and CNN [16, 17, 18], have been proposed, demonstrating their effectiveness in tasks like face detection and comic book analysis. The literature underscores the diversity of methods, each tailored to address specific challenges in cartoon character detection, considering the unique characteristics and appearances of these characters. The present research specifically focuses on character recognition in videos, acknowledging the rich diversity of characters in this context.

3 Review Methodology

In this section, we discuss the model and definitions to be used in the study. A laptop with an Intel Core i7-3750HF processor, 16 GB of RAM, and Windows 10 operating system was utilized to create the model. Python version 3.x was used in this study, and the studies were created using Jupyter Notebook version 6.x. After creating the model, we continued to work on Google Colab Pro. We were able to easily perform experiments during the training phases thanks to the speed of Tesla K80 GPUs.

To create a deep learning application, there are some basic steps we need to follow. For this study, we developed a model by designing an end-to-end network. The method consists of five stages.

3.1 The Formation of Architecture

The first stage involves coding the architecture, followed by the preprocessing of the data in the second stage. In the third stage, we train the model created in the coded architecture. The fourth stage involves visualizing the results of the trained model, and in the last stage, we visualize the prediction values taken as a result of the model's prediction. The architecture developed for this project is called cartoonNet. The code includes the libraries necessary for the program, with the Keras library being used to create the architecture and the Tensorflow library being used to call the optimizer. The architecture is made up of a convolution layer, batch normalization layer, and max pooling layer, taking inspiration from CNN architecture. Additionally, some easy-to-use layers proposed by the Keras library, such as CNN and AlexNet, are also used in other architectures. By multiplying these layers, four layers are created. The data is then flattened using the Flatten method and inserted into the Dense layer, which has a fully connected structure.

In the context of deep learning applications, the learning process can be viewed as an optimization problem. Optimization methods are utilized to determine the optimal value when solving nonlinear problems. Optimization algorithms, such as stochastic gradient descent, adagrad, adadelta, adam, and adamax, are commonly used in deep learning applications. These algorithms differ in terms of their performance and speed.

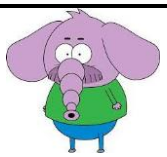
A total of 24 layers were utilized in the function. This figure represents the total count of each unique layer type. The layers comprise node drop-out layers, normalization layers, and activation functions. These layers are used to augment the network's complexity and enable better generalization. In the model prepared for the gray-scale study, the visuals were included in the model in gray with appropriate codes. In the model prepared for the RGB study, visuals were included in the model in color with appropriate codes.

Once the model was created, we proceeded with writing the code for compiling the model. In this step, we opted to use the Adam optimizer as our optimizer of choice, the loss function as our preferred loss metric, and the metrics for analyzing the results. The architecture of the model was defined as a method, and we then specified the dimensions of the input images using the input-shape parameter. Finally, by following these steps, we were able to successfully achieve the objectives of the project.

3.2 The Formation of Kralsakir Dataset

The study utilized a dataset that comprised images of three characters from the Kral Şakir [19] cartoon, namely Kral Şakir, Remzi, and Necati. Table 1 presents an overview of the classes that are included in the KralSakir dataset.

Table 1 KralSakir dataset classes

Classes	Class 1	Class 2	Class 3
	kral_sakir	remzi	fil_necati
Visuals			

The images were manually collected by searching on Google and YouTube, and then edited as necessary. The VLC Player program was used to capture images from the videos, which were then sorted into folders based on the relevant character. To standardize the dataset, images in various formats (jpeg, png, jfif) were converted and saved as JPG (Joint Photographic Experts Group) files. The final KralSakir dataset consists of 7559 RGB and 7559 gray-scale images that belong to three different classes, each having different sizes and quantities.

Fig. 1. Randomly Selected Images from the Gray-Scale Data Set

Fig. 2. Randomly Selected Images from the RGB Data Set

The KralSakir dataset comprises a gray-scale image with three classes. The data set is composed of gray-scale and RGB images that have pixels of different sizes. Each class has a different number of pixels. Gray scale and RGB images training was conducted on 1200 images from the Kral Şakir dataset. The trained model was tested on 7559 gray-scale and RGB images.

A dataset was created by collecting a series of images into a single file and renaming them starting from 1. These images were then labeled in an Excel file as follows: Images 1 to 200 were labeled as ['fil_necati'],1,0,0; images 201 to 400 were labeled as ['kral_sakir'],0,1,0; images 401 to 600 were labeled as ['remzi'],0,0,1; images 601 to 800 were labeled as ['fil_necati', 'kral_sakir'],1,1,0; and so on, up to image 1200. The images were collected and converted into a CSV file. Labels were assigned, and a script was written to save the entire dataset labeling process as a CSV file.

3.3 Model Training in Gray-Scale

The number of epochs needed for training a model is usually determined by the size and complexity of the dataset. If the dataset is large and complex, more epochs are typically needed, while smaller datasets may require fewer epochs. However, when deciding the number of epochs to use, it is important to consider other factors such as training time and computational resources.

The model was trained using L1 regularization for 100 epochs. This training process enables the model to learn and adapt to the dataset while preventing overfitting. By

stopping the training at a certain epoch, the model can generalize better and perform well on new data. The dataset used for training was split into 30% for testing and 70% for training purposes.

3.4 Model Training in RGB

The research was also studied in RGB. Many epochs were tried for 7959 images in the model. It took relatively longer to add than 1200 characters. The training of the study in Google Colab was first tried for 80, 100, 200 epochs. The training sessions lasted over 2 hours. At the end of the training, the models were recorded. According to the results, it was thought that 200 epochs was more accurate for the success of the model and the results were visualized at 200 epochs. The dataset used for training was split into 30% for testing and 70% for training purposes.

4 Results and Discussion

4.1 Gray-scale Model

After training a model traning in gray-scale with 1200 images from the KralSakir dataset for 100 epochs, accuracy and loss values were obtained. A separate test dataset of 7959 gray-scale images that the model had never seen before was used. Based on the experimental results, the accuracy value was found to be 60% and the loss value was 23%.

We included the Matplotlib library in our program for visualization of the results. To create a graph, we used the Seaborn-darkgrid theme. The Plt.plot method was used to obtain our graph. The x and y values in the graph were drawn from history. Training and validation performance graphs were obtained. The information pertaining to Figure 3 is presented below.

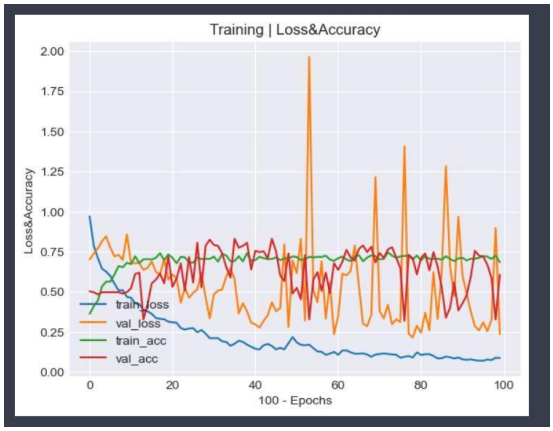


Fig. 3. Traning-Validation Loss and Accuracy Graph

Based on the graph, it can be concluded that the model is functioning effectively. After several rounds of training, the model was able to predict results for the given images with an accuracy rate of over 90%. This is demonstrated in Figures 4 and 5.

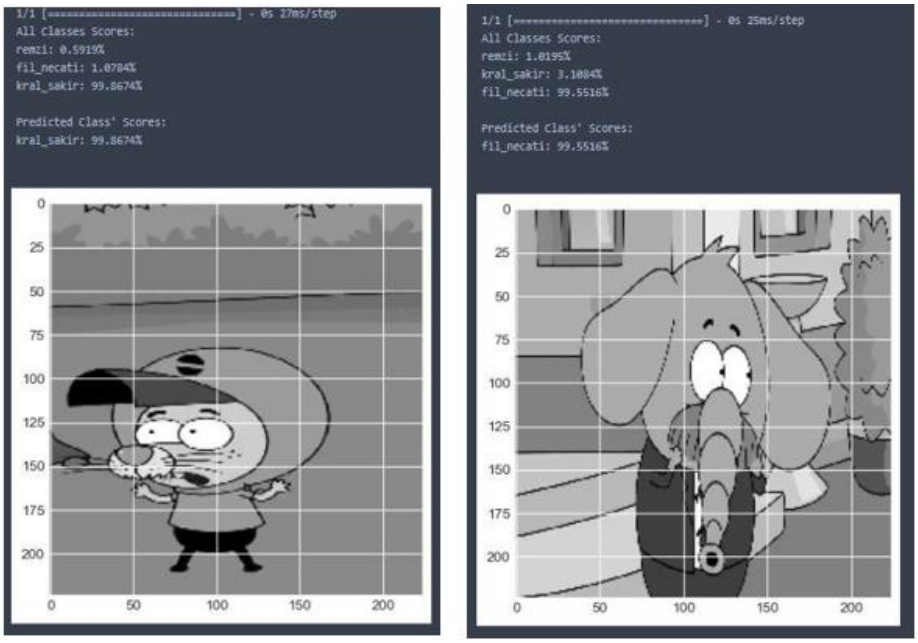


Fig. 4. Examples of Forecast Results

Figure 4 shows that the kral_sakir and necati classes were predicted correctly 99% of the time.

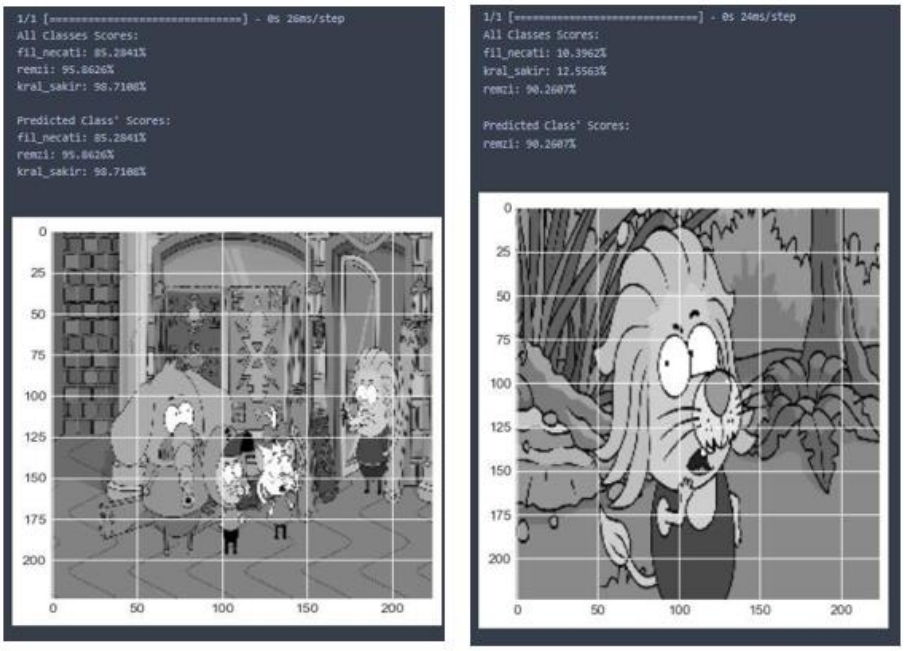


Fig. 5. Examples of Forecast Results

Figure 5 on the left side shows that king_sakir is predicted correctly 98% of the time, remzi 95% of the time and fil_necati 85% of the time, 99% of the time. Figure 4 on the right side shows that remzi is predicted correctly 90% of the time.

4.2 RGB Model

After training a model training in RGB with 1200 images from the KralSakir dataset for 100 epochs, accuracy and loss values were obtained. A separate test data set of 7959 RGB images that the model had never seen before was used. Based on the experimental results, the accuracy value was found to be 79% and the loss value was 0.09%. We included the Matplotlib library in our program for visualization of the results. To create a graph, we used the Seaborn-darkgrid theme. The Plt.plot method was used to obtain our graph. The x and y values in the graph were drawn from history. Training and validation performance graphs were obtained. The information pertain-ing to Figure 6 is presented below.

Fig. 6. Traning-Validation Loss and Accuracy Graph

Based on the graph, it can be concluded that the model is functioning effectively. After several rounds of training, the model was able to predict results for the given images with an accuracy rate of over 90%. This is demonstrated in Figures 7 and 8.

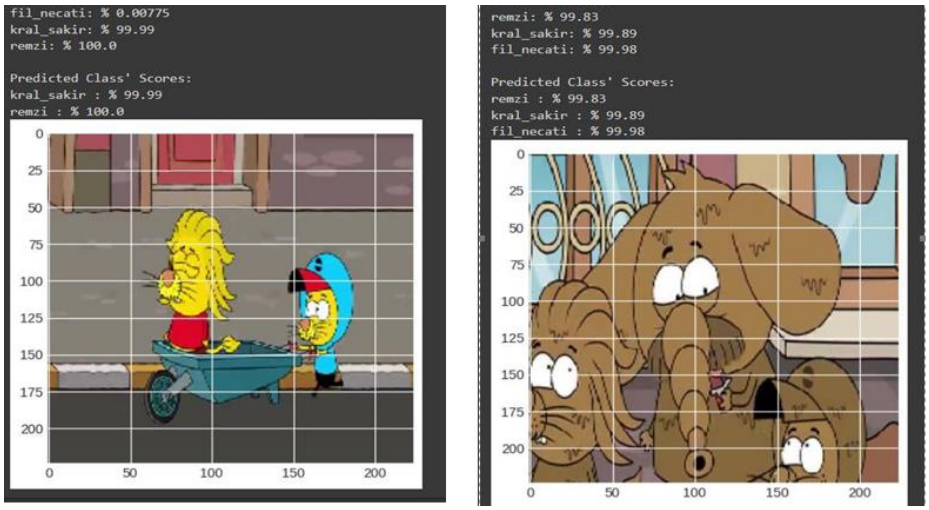


Fig. 7 Examples of Forecast Results

Figure 7 on the left side shows that kral_sakir is predicted correctly 99% of the time, remzi 100% of the time. Figure 7 on the right side shows that kral_sakir is predicted correctly 99% of the time, remzi 99% of the time and fil_necati is predicted correctly 99% of the time.

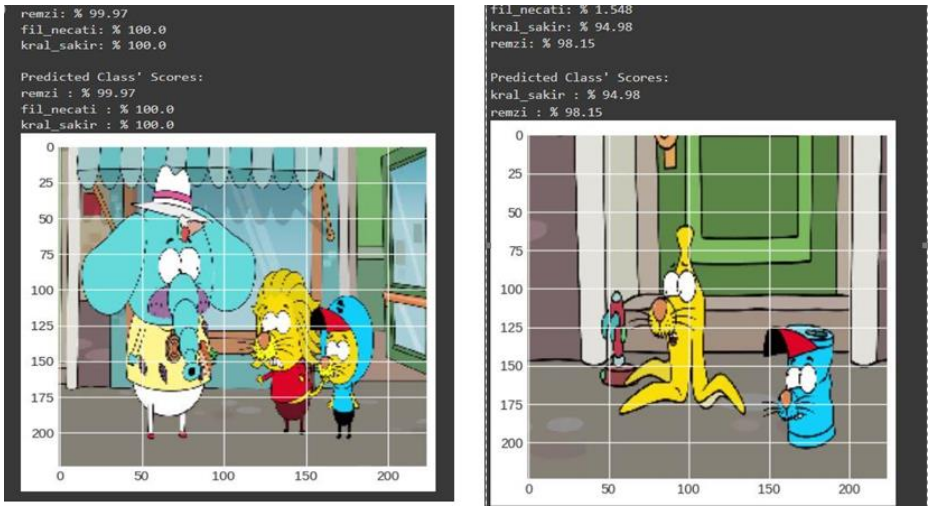


Fig. 8. Examples of Forecast Results

Figure 8 on the left side shows that kral_sakir is predicted correctly 100% of the time, remzi 99% of the time and fil_necati is predicted correctly 100% of the time. Figure 8 on the right side shows that kral_sakir is predicted correctly 94% of the time, remzi 98% of the time.

5 Conclusion

In recent years, there has been a significant focus on the automatic detection and recognition of cartoon characters. One particularly challenging problem in this field is cartoon character recognition. However, advances in machine learning have enabled the development of efficient and accurate methods for detecting cartoon characters, with CNNs being a prime example. Our study focuses on training a CNN and designing an end-to-end architecture using machine learning techniques. We developed a new algorithm and a model for the multiclass classification problem. Our dataset consists of cartoon characters created by the national artist Varol Yaşaroğlu. We conducted a comprehensive study on the dataset and observed that the proposed cartoon character recognition algorithm was successful. As a result of the studies on the dataset, it was observed that the cartoon character recognition algorithm worked successfully. This paves the way for different studies and experiments on the created dataset. In fact, it is thought that the data set and the number of cartoon characters will be increased and scientific research will be possible.

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Cell Nucleus Segmentation with a Lightened Segmentation Model

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Abstract. Nowadays, methods based on convolutional neural networks are the reason for preference for the segmentation of the region of interest due to their high success. However, during the training stage, the computational ability inherent in the traditional convolutional processing process requires powerful hardware units. Therefore, for systems with limited hardware power, it becomes necessary to develop lightweight methods based on convolutional neural networks to facilitate the segmentation process. In this research, the depthwise separable convolution process, which puts less load on the hardware than the traditional convolution process in terms of computational cost, is examined. The experiments were carried out on a previously proposed segmentation model (EnecaU-Net). Traditional convolution and depthwise separable convolution processes were evaluated on two separate EnecaU-Net models. The models were evaluated with a publicly available dataset containing white blood cell images. Within the scope of the applied research process, the EnecaU-Net model created with depthwise separable convolution has achieved high segmentation success in a shorter time by using fewer trainable parameters than the EnecaU-Net model created with traditional convolution. As a result of our experiments, the accuracy, sensitivity, specificity, Dice, Jaccard test values were found as 97.33, 82.01, 99.82, 89.10, 80.85 for traditional convolution and 98.80, 97.69, 99.09, 95.50, 91.59 for depthwise separable convolution, respectively.

Keywords: Depthwise Separable Convolution, Segmentation, EnecaU-Net.

1 Introduction

U-Net carries out segmentation at the pixel level. To perform the segmentation task, the U-Net architecture includes transaction execution elements such as the activation function and up/down sampling operations. Furthermore, this architecture also makes use of the convolution process, which is used to obtain feature maps and is a fundamental operation for the segmentation task.

In general, during the segmentation process, input images with a certain height and width are subjected to convolution operation through filters of a certain size, and

learning takes place at the end of this process. Although this traditional convolutional process leads to great success in the segmentation process based on artificial neural networks, the intensive computational process during the convolution operations creates a load on the hardware. In order to reduce this limitation, an alternative convolution process such as the depthwise separable convolution operation can also be applied. Both the number of parameters and the computational cost are decreased through this method. Thus, the computational load on the hardware is also lightened [1, 2]. As a result of reduced operational load, the realization of the network training process in a shorter time is of importance that cannot be ignored. Therefore, observing the benefits of the depthwise separable convolution operation constitutes our main motivation for this research. In order to make this observation, we investigate the traditional and depthwise separable convolution operations' effect on a previously proposed segmentation architecture (EnecaU-Net) [3, 4]. To this end, comparative evaluations of the architecture are performed on publicly available white blood cell images. The main contributions of this paper are:

- Evaluation of the EnecaU-Net architecture for white blood cell nucleus segmentation.
- Examining the effects of traditional and depthwise separable convolution operations on the segmentation success of the EnecaU-Net architecture.

2 Related Works

In the diagnosis of leukemia or other diseases associated with blood cell disorders, features such as cell quantity, cell shape, and cell nucleus structure give important clues about the diseases. One of the methods used to learn this information is also automatic image processing. The segmentation stage constitutes an important component of this image processing process as well. [5, 6, 7, 8, 9, 10] studies are some of the blood cell/nucleus segmentation-related recent studies. A study published in 2022 [5] used backbones such as EfficientNet or ResNet in the encoder section of the U-Net model and evaluated these segmentation architectures for the segmentation of white blood cells. In the study, 720 sample images were used for training (the number of used images was increased by the data augmentation method). The Dice and Jaccard coefficient values are over 90%, according to the authors' findings for the compared models. A similar study [6] using MobileNet, VGG, or ResNet backbones in the U-Net encoder section was published in 2021, and successful results of the method were observed. Situations such as the acquisition of images under different lighting conditions, different staining methods, or poor image contrast can make it difficult to segment the white blood cells. In order to overcome this difficulty, researchers can apply pre-processing to images in a neural network-based segmentation process. In 2020, Long [7] examined the U-Net+ model for cell nucleus segmentation. In the experiment, 546 grayscale images were subjected to pre-processing before training. At this stage, the "contrast limited adaptive histogram equalization" (CLAHE) process was applied to adjust the contrast of the images, and then the "total-variation denoising" method was applied to reduce the noise. In the study, the U-Net+ model was

introduced as a lighter version of the U-Net++ model, and it was proven that the model achieves comparable performance to U-Net++. In the study [8], blood cell images (RGB) were converted to HSV color space, and then the "adaptive histogram equalization-retinex correction" approach was applied to balance the color and brightness variability between leukocytes. The blood cells were segmented by the U-Net architecture, which includes an attention mechanism. Through the applied method, a 91.89% mean intersection over union (mIoU) value was reached. In a study published in 2023 [9], the “Joint Weighted Bilateral Filter” (JWBF) method was used to remove blur and noise before segmenting the white blood cells with U-Net. Researchers used the images by resizing them to a size of 254 × 254. In their proposed clustering-based segmentation approach, spatial Fuzzy C-Means was integrated into U-Net (to reduce feature sparsity). With the proposed model, a Dice similarity coefficient value of 0.951 was reached. In another study [10] that segmented the blood cells with the DeepLabv3+, U-Net, and FCN architectures, the DeepLabv3+ architecture showed the best segmentation result with a value of 0.9604.

3 Materials and Methods

The general workflow of the study is schematized in Figure 1. In the study, cells’ nuclei are segmented with a previously proposed segmentation model (EnecaU-Net) [3, 4]. Before the segmentation process, the images (RGB) are normalized (with min-max normalization) and resized to a size of 256 × 256. The study includes two experimental examination stages. In the first stage, the effect of the “up-sampling” operation used in the EnecaU-Net's encoder section on the EnecaU-Net architecture (it uses the traditional convolution process) is examined. In this scope, cell nucleus segmentation is performed by the EnecaU-Net model (using the "up-sampling" operation in the encoder section with or without it) and the segmentation results of the two experiments are evaluated. At this stage, experiments are performed with 5-fold cross validation and 30 iterations per fold.

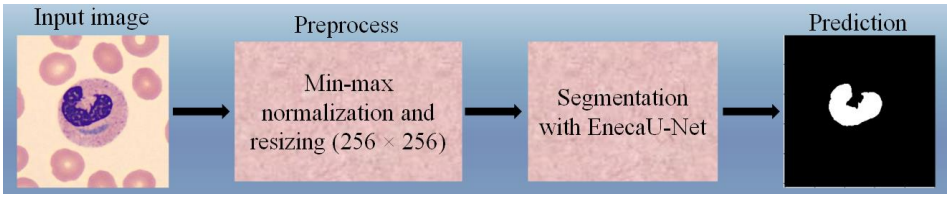

Fig. 1. The general workflow.

In the second stage, the effect of traditional convolution or depthwise separable convolution operations on the EnecaU-Net model is examined. In this scope, the results of the EnecaU-Net model constructed with the traditional convolution operation and the EnecaU-Net model constructed with the depthwise separable convolution operation are compared. At this stage, experiments are performed with 35 iterations. We used the Keras library [11] for the traditional convolution (Conv2D) and depth-

wise separable convolution (SeparableConv2D) operations. The evaluation was measured by metrics commonly used in research, such as accuracy, sensitivity, specificity, Dice, and Jaccard index [12, 13].

3.1 Depthwise Separable Convolution

In the traditional convolution method, filters of a certain size perform the creation of feature maps from the input in a single stage, and the channel amount of the output is generated according to the amount of filter. As different from traditional convolution operations, depthwise separable convolution provides an effective way to reduce the number of trainable parameters and the computational cost. Depthwise separable convolution involves a two-step process: 1) In the first stage, the convolution process (depthwise convolution) is applied to each channel of the input. In this step, the convolution operation is performed with a separate filter per channel, and at the end of the process, the number of input channels (depth) is preserved. 2) In the second stage, filters of 1×1 pixel size (pointwise convolution) are applied to the feature maps obtained by the previous convolution process. As a result of this process, an output form is created, such as the traditional convolution, and the number of channels is increased.

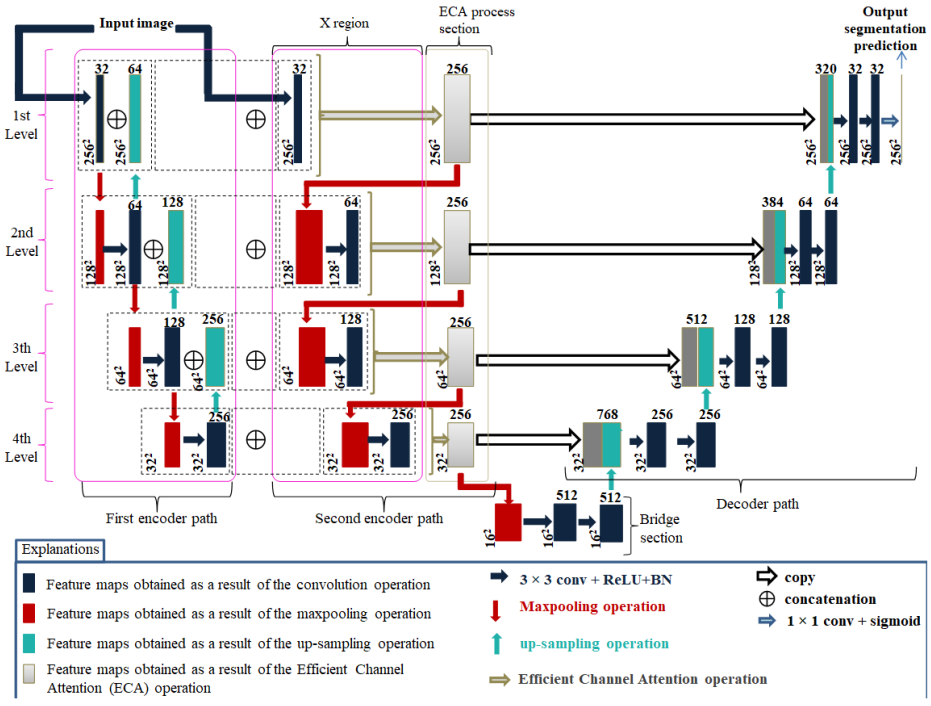

Fig. 2. The EnecaU-Net model [4].

3.2 Dataset

We used a publicly available dataset [14, 15] for the evaluation of the experiments in this paper. The images were collected under different imaging and staining conditions. The first group of images in the dataset was obtained from ”Jiangxi Tecom Science Corporation" (China). The data group, including 176 neutrophils, 22 eosinophils, 1 basophil, 48 monocytes and 53 lymphocytes, has three hundred 120 × 120 images. The second group, including 30 neutrophils, 12 eosinophils, 3 basophils, 18 monocytes and 37 lymphocytes, has one hundred 300 × 300 color images. The images are presented in “.bmp” format. The ground truth equivalent of each image is provided from the web address [15]. In this study, a total of 20 test samples were separated from both datasets and the remaining 380 images were used for training.

3.3 The EnecaU-Net Model

Figure 2 shows the representation of the applied model (EnecaU-Net). As shown in Figure 2, the EnecaU-Net model [3, 4] has two encoder paths and one decoder section. The same input images are fed to the two encoder paths simultaneously. The encoder and decoder paths consist of 4-level blocks from top to bottom. Within each block at each level of the first and second encoder sections, the convolution process occurs once. In the decoder section blocks at the same level, the convolution operation takes place twice. The up-sampling operation is used in the model's first encoder section to make a precise segmentation of the region of interest. The second encoder path consists of a section that performs the convolution process, which we define as the “X region,” and a second section that performs the ECA process [16]. The block outputs at each level of the first encoder section are concatenated by means of the "concatenation" operation with the block outputs in the "X region" sub-section of the corresponding second encoder section at the same level. In the continuation, the ECA process is applied to the feature maps obtained. The final outputs obtained as a result of the operations in the first and second encoder sections merge with the corresponding layers in the decoder section, as in the U-Net model. The bridge and decoder section architecture in the model retained the same architectural construction as in the U-Net model, but the number of channels in the feature maps was reduced. In the whole model, the batch normalisation process was applied after the convolution process (3 × 3), and ReLU was used as the activation function. The authors [16] proposed the ECA-Net module to obtain the most important and distinctive features and to more efficiently take information from the channels. The ECA-Net module is also used in the EnecaU-Net model. To obtain the mean pixel value per channel, the "global average pooling" approach is used in the ECA-Net module. After the features are obtained, 1D convolution takes place to learn the effective information in the channel. After applying the convolution operation in the first encoder section and the ECA method in the second encoder section, we used the maxpooling operation (2 × 2) to down sample the feature maps. In the decoder section, after the second convolution process, the up sampling task was performed by the bilinear interpolation method. One convolution operation is performed in the first encoder and the X region blocks

in the second encoder section at the same level, whereas two convolution operations are performed consecutively in the bridge and decoder section blocks. The proposed network produces feature maps with a size of 256 × 256 and 32 channels by convolution from the raw image at the first level for both encoder sections. With the convolution process applied after each down sampling process in the first encoder section, the channel amount of the feature maps is doubled and their size is halved, the number of channels and dimensions of the feature maps obtained after the convolution process in the second encoder section blocks are the same as the feature maps obtained as a result of the convolution operation in the corresponding (at the same level) first encoder section blocks. The Adam technique [17] and binary crossentropy loss were utilized as the proposed model's optimization algorithm (starting with a learning rate of 0.001) and loss function, respectively. We used a 1 × 1 convolution layer with the sigmoid activation function at the output. The Keras library [11], which utilises the TensorFlow library framework [18] on the backend, was used to execute this research.

4 Results

In this paper section, the results of the operations carried out on EnecaU-Net are presented. Table 1 shows the average training results obtained with 5-fold cross validation. Here, EnecaU-Net is evaluated according to whether it has an up-sampling operation in the encoder part or not. Table 2 presents the average results obtained by the models for 20 test samples according to the best weight values given by the models. The visual results of some of the test samples are presented in Figure 3.

Table 1. The metric values (mean value±standard deviation) obtained as a result of training the models (according to whether EnecaU-Net has an up-sampling operation in the encoder part or not) with 5k-cross validation (Acc= Accuracy, Sens= Sensitivity, Spe= Specificity).

Model	Evaluation Metrics (%)				
	Acc	Sens	Spe	Dice	Jaccard (IoU)
EnecaU-Net	97.66 ±1.04	90.81 ±5.38	98.85 ±0.53	91.58 ±3.74	84.76 ±6.27
EnecaU-Net (without upsampling)	80.41 ±25.76	72.03 ±20.57	83.16 ±31.95	65.99 ±23.45	53.93 ±25.02

As seen in Table 1 and Table 2, using the up-sampling process within the encoder section of the EnecaU-Net model reduces the standard deviation values in the metric results given by the model. In this way, results that are more consistent and close to average values are obtained. Furthermore, training and test success rates (accuracy, sensitivity, specificity, Dice, Jaccard) improve with this operation.

Table 2. Models' (according to whether EnecaU-Net has an up-sampling operation in the encoder part or not) metric values (mean value±standard deviation), which were obtained from 20 test samples (Acc= Accuracy, Sens= Sensitivity, Spe= Specificity).

Model	Evaluation Metrics (%)				
	Acc	Sens	Spe	Dice	Jaccard (IoU)
EnecaU-Net	99.11 ±0.69	96.51 ±3.73	99.63 ±0.38	96.78 ±1.73	93.82 ±3.19
EnecaU-Net (without up-sampling)	98.14 ±1.65	90.95 ±9.34	99.56 ±0.59	93.32 ±4.57	87.81 ±7.69

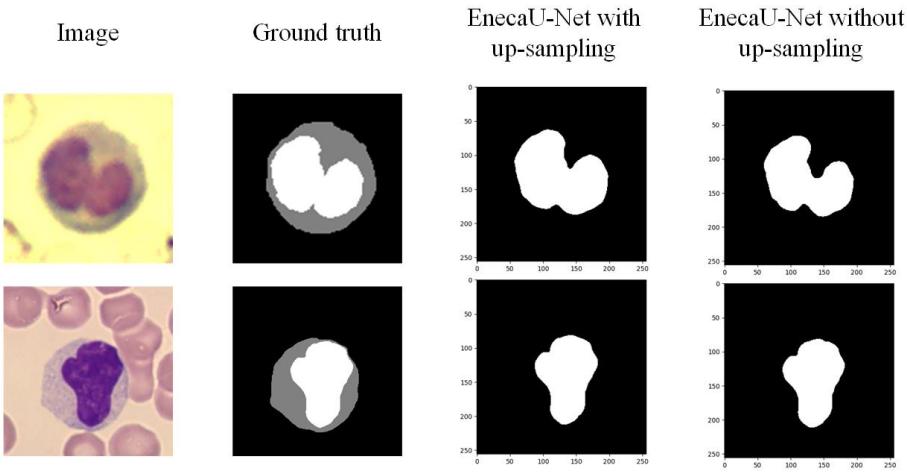

Fig. 3. The visual results of some of the test samples.

Table 3 shows, according to the traditional convolution operation or depthwise separable convolution operation, the training results that were obtained by the EnecaU-Net model. The average metric values obtained for 20 test samples are presented in Table 4. According to Tables 3 and 4, the depthwise separable convolution operation has an improving effect on the EnecaU-Net model's success. The visual results of some test samples are presented in Figure 4.

Table 3. The training results of different convolution operations used in EnecaU-Net (Acc= Accuracy, Sens= Sensitivity, Spe= Specificity).

Model	Evaluation Metrics (%)				
	Acc	Sens	Spe	Dice	Jaccard (IoU)
EnecaU-Net (traditional convolution)	96.25	74.63	99.83	84.98	73.91
EnecaU-Net (depthwise separable convolution)	98.51	97.77	98.62	94.32	89.27

Table 4. The test results of different convolution operations used in EnecaU-Net (Acc= Accuracy, Sens= Sensitivity, Spe= Specificity).

Model	Evaluation Metrics (%)				
	Acc	Sens	Spe	Dice	Jaccard (IoU)
EnecaU-Net (traditional convolution)	97.33 ±1.56	82.01 ±9.98	99.82 ±0.29	89.10 ±5.88	80.85 ±5.89
EnecaU-Net (depthwise separable convolution)	98.80 ±0.91	97.69 ±3.38	99.09 ±1.01	95.50 ±3.41	91.59 ±5.95

The mean and standard deviation values are computed according to the percentage equivalents of metric values (seen in Table 1, Table 2, and Table 4). Table 5 shows the number of trainable parameters and training time of the EnecaU-Net model according to different convolution operations. It seems that the depthwise separable convolution operation is more efficient in terms of time and trainable parameters.

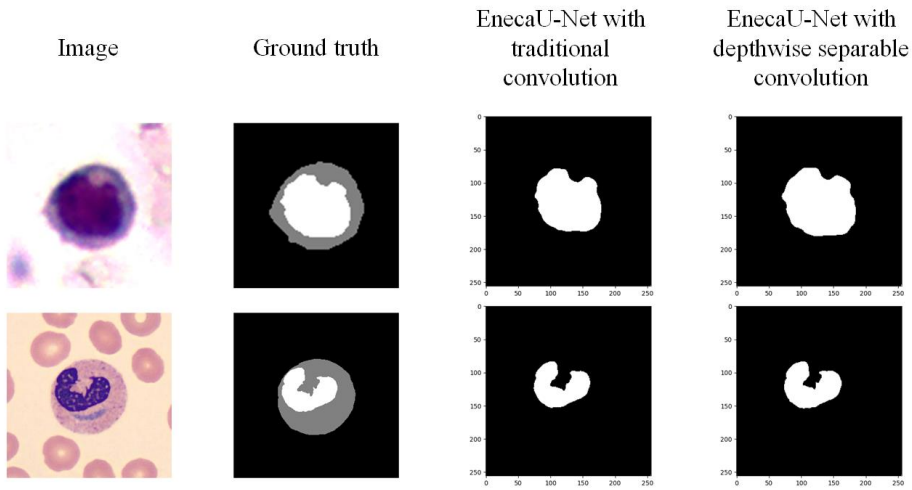

Fig. 4. The visual results of some test samples.

Table 5. Trainable parameter and training time of EnecaU-Net according to different convolution operations.

Model	Trainable parameter	Training time (h)
EnecaU-Net (traditional convolution)	11,669,947	2.28
EnecaU-Net (depthwise separable convolution)	4,227,185	1.48

5 Conclusions

In this study, the use of traditional convolution or depthwise separable convolution operations in the EnecaU-Net architecture for cell nucleus segmentation was compared. Within the scope of operations in our study such as the applied procedures, the used dataset and the amount of dataset, higher values in terms of accuracy, sensitivity, specificity, Dice, Jaccard coefficients were obtained by the depthwise separable convolution operation, which creates a lighter network (It shortens time). Furthermore, the effect of the up-sampling operation used in the encoder section of the EnecaU-Net model (which uses the traditional convolution process) on the model was investigated in our study. Through the applied up-sampling operation, it was observed that the success in terms of the accuracy, sensitivity, specificity, Dice and Jaccard coefficients increased. Through the used up-sampling operation in the encoder section, standard deviation values reduce, so more consistent and closer to average values are obtained. As a result, using the up-sampling operation in the first encoder section of the EnecaU-Net model, which has an attention mechanism, and using the depthwise separable

convolution within the EnecaU-Net model produces improved segmentation results in a shorter time. In the future, it can be foreseen to examine the lightened EnecaU-Net model for the different datasets.

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Classification of Lung Diseases from X-Ray Images Using Different Deep Learning Approaches

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Abstract. The coronavirus has expanded globally and turned into a pandemic, since late 2019. Even though the rate of infection got reduced, Covid-19 took its place among the lung diseases, and it should not be underestimated especially when we consider its impact around the world. One of the best strategies to fight the disease and stop an outbreak is to identify affected people as soon as possible. In many research, a deep Convolutional Neural Network (CNN) architecture based on the classification of chest X-ray images has been suggested to understand the lung diseases. In this study, we intended to evaluate various custom deep learning models (including CNN, Convolutional Attention Mechanism, and some of the pre-trained CNN models) in order to compare the efficiencies and obtain the most suited methods (not specific models) to this work since, our motivation is to acquire the most efficient methods to classify the lung illnesses in order to prevent any increment of infection rates, using deep learning. The work includes 3 pre-trained models which are ResNet50, VGG19 and InceptionV3 and 2 custom CNN models. The models had around %90 test scores. VGG19 was the winner performance-wise with %96 test score but InceptionV3 and Attention-CNN models were also successful with %92 test scores considering less time-consumption than VGG19.

Keywords: Covid-19, Deep Learning, Convolutional Neural Networks, Attention Mechanism.

1 Introduction

Covid-19 is probably the most well-known and one of the deadliest viruses in the world history. Unfortunately, due to the lack of information and prevention techniques, the virus has been spread all over the world. Since this situation is one of the most restraining things in life, we should have something to prevent this virus while searching for the exact solutions. Although, there are now numerous clinical trials examining potential treatments, COVID-19 infection does not have any particular medicine or vaccinations. Despite the lack of a vaccine or effective treatment, people can avoid getting sick by washing their hands frequently, remaining at home, covering

their mouth and nose when they cough or sneeze, and giving up on smoking. Although these measures are not intended to treat the condition, they can help keep people healthy and stop the spread of COVID-19.

Various studies have been done analyzing X-Ray images in order to identify and differentiate Covid-19. In order to identify the infection by examining X-Ray images of lungs, it is important to understand what pneumonia is since, they resemble each other in terms of deformation on lungs. Pneumonia is an illness that causes inflammation of the air sacs in one or both lungs. The air sacs could become clogged with fluid or pus (purulent material), which would result in a cough with pus or phlegm, a fever, chills, and breathing difficulties. There are some differences between normal pneumonia and Covid-19 infected pneumonia being more contagious. Also, normal pneumonia only infects one part of the lung but in the case of Covid-19, the whole lung can be infected which lets us to observe and differentiate on x-ray images.

This work is about evaluating a Deep Learning method to make a classification between x-ray images of lungs in order to differentiate if there is an infection of Covid-19 or not. Of course, the classification is not limited with this motivation. The other cases like being healthy or having pneumonia are considered as well. “Attention mechanism” method was used alongside with CNN in order to increase the number of options of observation. The uniqueness of this work comes up thanks to the application of different “Deep Learning” methods. One of the aims of this work is creating and applying Attention Mechanism to have stronger CNN models. Also, we used the pre-trained CNN models in order to have some well-known classifiers. It is intended to observe the results and compare the models. Python software language has been used because of its wide range of open libraries and understandability. The level of built-in functions inside Python to work on deep learning is high and well-known around the world.

Various studies have been done analyzing X-Ray images in order to identify and differentiate Covid-19.

In the study of Joy Iong-Zong Chen (2021) [1], infection of Covid 19 was detected and identified using feature extraction method on histogram-oriented gradients of x-ray images. In this study, the performance of proposed CNN classification method for medical imaging has been assessed based on different edge-based neural networks.

In a similar study, Karhan and Akal (2020) [2] aimed to detect Covid-19 infection using deep learning. To accomplish this, they also used ResNet50 as a CNN model. The aim was to create a sufficient detection system when PCR test could be less sufficient in order to identify.

Khan, Azhar, Ibrar, Alqahtani, Alsubai, Binbusayyis, Kim and Chang (2022) [3] have selected deep transfer learning method to train the pretrained model for feature extraction. After that, the deep models are fused using improved canonical correlation analysis that is further optimized using a hybrid algorithm named Whale-Elephant Herding. Finally, they have used extreme learning machine technique to choose the most identical features and utilized the for Grad-CAM visualization. Consequently, they achieved accuracies around 99.1-96.7% which is almost perfect and desirable percentage when we consider other works in literature.

In another work, done by Hussain, Hasan, Rahman, Lee, Tamanna and Parvez, (2021) [4] it was aimed to create a 22-later CNN architecture for 2, 3 and 4 class classification separately with scores of 99.1%, 94.2% and 91.2% respectively. They also compared their model with ten other CNN models. The main purpose of this project was to get over of inadequate number of test kits and detection systems.

2 Processing Pipeline

2.1 About Data

Chest X-ray images are contained in the dataset, which is divided into 3 folders (covid, pneumonia, and normal). There are 1800 X-Ray images of pneumonia cases, 1626 for Covid19 and 1800 X-ray images of normal cases, for a total of 5228 samples.

In this work, we have divided dataset into 3 sets as 3135 images for training, 1047 images for testing and 1046 images for validation datasets (%60, %20, %20 respectively). [5,6,7]

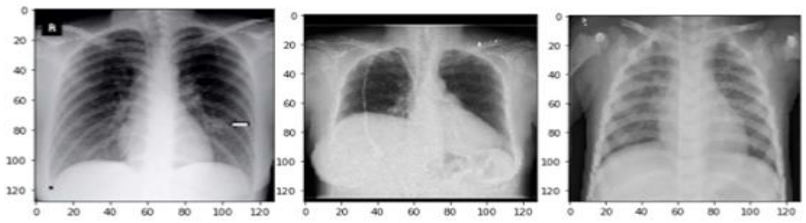

Fig. 1. Demonstration of Samples for Representing Each Class

2.2 Preprocessing and Augmentation on Data

In this work, we have used several image processing techniques in order to work on data by using "Python-OpenCV" [8] which is an open-source computer vision and machine learning software library. Each image had to be resized because the model has an input shape, and every input should be in the same size in order to be trained or predicted. Each image has been resized into 128x128 matrices by a manually created data generator using another open library called "Keras" [9].

We also normalized it in order to rescale the information inside the inputs like RGB values (1/255) since the best practices for training a Neural Network is to normalize your data to obtain a mean close to 0. Normalizing the data generally speeds up learning process and leads to a faster convergence.

Before training the CNN models, we have created data-generators that has been mentioned before to use augmentation while training the algorithm. Each data generator for training, testing and validation has the same properties for scaling the images for 1/255 as in RGB value normalization. Those properties are applied to all input images from the directory flow. Properties for training generator also includes width shift (range between +/- %5), height shift (range between +/- %5) and zooming (range between +/- %10). For exceeding windows while convolving inside the image,

the residual pixel was filled with the same value of the closest pixels. Each generator has been set with batch size of 32 which means it will be 32 inputs will be processed each time.

Finally, to increase the accuracy of the model, every image has been shuffled (inside their own classes) before training the models to avoid a possible creation of pattern and thanks to this situation, the models got healthier.

3 Learning Framework

In this section, the structures of CNN models and their implementation will be discussed. The same approach will be done for all pre-trained and custom CNN models.

Convolutional Neural Networks are kind of network architectures for deep learning algorithms and are specifically used for image recognition and tasks that involve the processing of pixel data [10]. The CNN models were called from open library of Keras for this work.

In this study, we have established two different CNN models. The first is a custom CNN model that contains standard layers, and the second one is a very similar model involving "Attention Mechanism". In order to create the mechanism, Channel Attention and Spatial Attention types are used as they are more applicable than the other for image classification.

We also worked on three pre-trained CNN models, well known in the literature which are ResNet50, InceptionV3 and VGG19. They all have been pre-trained with an open dataset called "ImageNet" which is a well-known and a sizable visual database intended for use in research on software for visual object recognition [11]. The project has manually annotated over 14 million images to identify the objects shown, and in at least one million of the images, bounding boxes are included. Thanks to this, we could compare our custom models with the pre-trained ones.

All the models have the same density of fully connected output layers to be fair between one another. Each of the fully connected network for all 5 models involves a density layer with 256 neurons, followed by a drop-out layer with another density layer with 3 neurons which represents each 3 classes of the dataset.

Also, it is important to acknowledge that the ordinary CNN model and the Attention CNN model have the same amounts of densities in terms of filters, window sizes and the number of layers. The only difference between these two is to have Channel Attention and Spatial Attention layers. Due to this circumstance, it would be fairer to compare these two models to see the effect of the attention mechanism.

As a result of our work with several CNN models, we have observed various structures with various hidden layer densities. Naturally, the input shape is 128x128 in size, and the library automatically installs the layers, but the density of the output layer depends on the number of work classes. For instance, there are 3 classes in this dataset, so the final layer will have a density of four (Input and Output Layers).

3.1 Custom CNN and Attention-CNN Structures

As for the custom and pre-trained CNN architectures we had the following layers,

Defining the Layers of Custom CNN Structure

Input Layer

Inputs are 2D X-Ray images rescaled in matrices with size of 128x128.

Convolutional Layers

Each filter in a convolutional layer has a set of parameters that need to be learned. The height and weight of the filter are less than the height and weight of the input volume. Each filter is convolved with the input volume to compute the neural activation map. Since different models are used in this work, different numbers of parameters need to be learned. Therefore, the size of the moving window will change for each layer and each model.

Max Pooling Layer

After the convolutional layers, a new layer is introduced called the pooling layer. Specifically, after applying a nonlinearity (such as ReLU) to the feature map generated by the convolutional layer. We used one of the functions that down samples the input along its spatial dimension (height and width) by taking the largest (maximum) value over the input window for each channel of the input.

Global Max Pooling Layer

In order to model your input layer and construct your neural network model, as well as properly feed those inputs into each and every neuron of the model, this function flattens the multi-dimensional input tensors into a single dimension.

Drop-Out Pooling Layer

By acting as a mask, the Dropout layer preserves the functionality of all other neurons while removing some neurons' contributions to the previous layer. Overfitting wouldn't be as likely to happen as a result.

Dense Layer

Each neuron in the simple layer of neurons known as the dense layer receives information from every cell in the layer below it. Based on the results of the convolutional layers, a dense layer is utilized to categorize the images. In this work, we had different density layers since we have worked on different datasets with different number of classes.

A convolutional block includes a convolution layer, batch normalization layer, max pooling layer and a drop-out layer respectively. There are 5 different convolutional blocks for each model and the only difference between the blocks are the densities of

the convolutional filters which are 32, 64, 128, 256 and 512 respectively. It can be observed that the densities of the filters are exponential of “2” since the architecture and the operating system work in bit-wise system. This situation helps to a more efficient and healthier relationship between these two.

Another difference between the convolutional blocks is having different densities for drop-out layers which are 0.3, 0.3, 0.5, 0.5 and 0.5 respectively which have been chosen arbitrarily (more dense filters may need higher level of drop-out).

Defining the Layers of Custom Attention-CNN Structure

Channel Attention Layer

In convolutional neural networks, a Channel Attention Module is a module for channel-based attention. By utilizing the inter-channel relationship of characteristics, we generate a channel attention map. Given an input image, "what" is meaningful is the emphasis of each channel in a feature map, which functions as a feature detector. We squeeze the spatial dimension of the input feature map in order to compute the channel attention efficiently.

Using both average-pooling and max-pooling processes, we first aggregate the spatial information of a feature map to create two distinct spatial context descriptors, which represent average-pooled features and max-pooled features, respectively.

After that, both descriptors are sent to a common network, which generates our channel attention map. A single hidden layer is present in the multi-layer perceptron (MLP) that makes up the shared network. A multilayer perceptron is a name for a modern feedforward artificial neural network, composed of fully connected neurons with a nonlinear sort of activation function, organized in at least three layers, renowned for being able to discriminate input that is not linearly separable.

We used element-wise summing to combine the output feature vectors after applying the shared network to each descriptor. In figure 2, an illustration of Channel Attention has been shown as defined in this section,

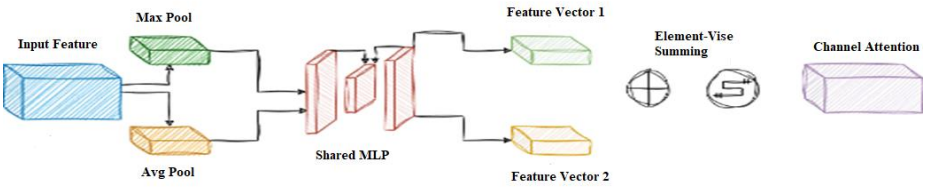

Fig. 2. Illustration of Channel Attention Module

Spatial Attention Layer

It allows us to prioritize a region of the visual field using spatial attention to interpret visual information selectively. The visual field selects a portion of space for attention, after which the data in that area is processed further. This is the source for the convolution layer, which produces a 1-channel feature map with the dimensions (1 x h x w). As a result, this convolution layer preserves the spatial dimension and uses padding to do this. In figure 3, a simple demonstration of Spatial Attention module has been visualized according to the description that has been mentioned,

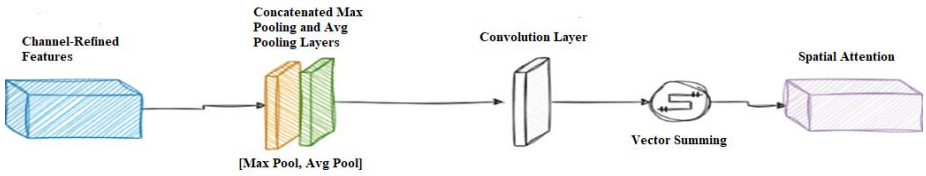

Fig. 3. Illustration of Spatial Attention Module

Using two pooling processes, we combine the channel information from a feature map to create two 2D maps. Average-pooled features and maximum-pooled features over the channel are indicated by each. The 2D spatial attention map is then created by concatenating and convolving those using a conventional convolution layer.

In this work, Channel Attention and Spatial Attention layers have been used together back-to-back after each Max Pooling layers. It is important to remind that the Attention CNN and ordinary CNN models have the same architecture except the Channel Attention and Spatial Attention layers to compare these two models as equal as possible.

For each 5 convolutional block, Channel and Spatial layers follow the Max Pooling layer with the filter densities of “4096” (for RGB values) and “7” (window size) respectively which have been chosen arbitrarily.

3.2 Metrics and Compilers

Functions

Softmax

Using the “softmax” function, the input vector is transformed into a probability distribution whose exponential function is proportional to the input value. This shows that the input vector elements can be positive, negative, or zero. However, the output values are consistently between (0,1). So, it's easy to interpret.

Categorical Cross Entropy

Calculate the cross-entropy loss between tags and predictions. When a multi-class classification model has two or more output labels, it is utilized as a loss function. One-hot category encoding value in the form of 0s and 1s is allocated to the output label. If the output label exists in integer form, keras is used to convert it into categorical encoding.

Adam Optimizer

Based on adaptive estimate of first- and second-order moments, Adam optimization is a stochastic gradient descent technique. It stores the change in impulse and the learning rate for each parameter and combine the RMSprop with the impulse.

Categorical Accuracy

For one-hot labels, categorical accuracy computes the proportion of expected values that agree with actual values. Making a feedback is crucial to the model's optimization.

Learning Hyperparameters

In the learning process, each model had 20 “epochs” which is the number of steps to learn.

The Batch size for each model has been selected as 32 by error-trial method and it was important that the batch size was an exponential of “2” since the operating systems of the computers work bitwise.

4 Experiments and Results

In this section, the model performances and their response to the dataset have been observed. By analyzing the evaluations, a strong perspective about the prediction and classification abilities of the models has been acquired.

4.1 Model Trainings

After creating and training the model, it has been saved into directory in a vector form thanks to “Pickle” library [12]. "Pickling” is the process whereby a Python object hierarchy is converted into a byte stream. Some sample predictions have been made and it has been seen that the model is accurate with the work. For each model, we have calculated and demonstrated the loss and accuracy for both categorical and validation parts.

Here are the model performances in below in order to observe the accuracy rate and loss of the models. Each graph represents a specific model. The accuracy rates are between 0-1 since the accuracy functions have been normalized.

It is important to see some graphs with loss greater than 1 but they tend to get lower than 1 as they converge to the end of the training process. Here are the graphs:

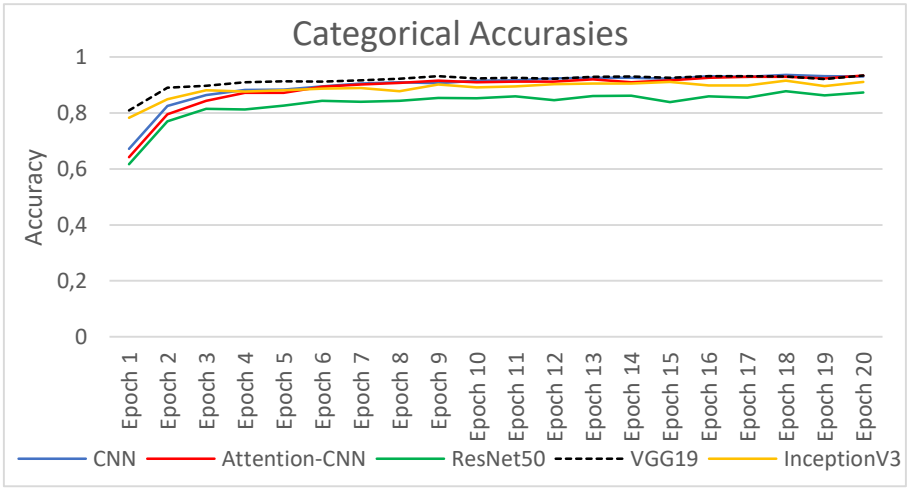

Fig. 4. Categorical Accuracies of the Models

Figure 4 shows the categorical accuracies of the models through epochs. All the models showed a similar behavior. At the end of the training, Custom CNN, Attention-CNN and VGG19 models have out-performed the others.

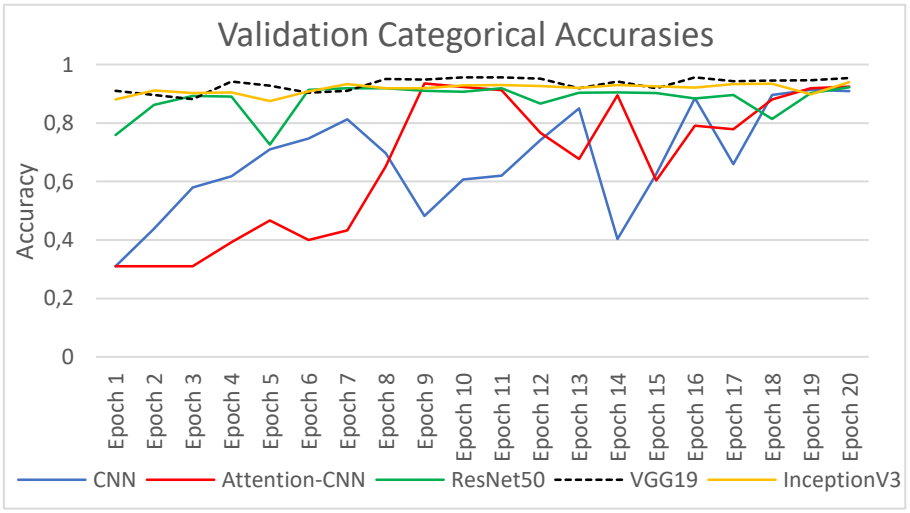

Fig. 5. Validation-Categorical Accuracies of the Models

Figure 5 shows the validation-categorical accuracies of the models through epochs. The difference between categorical accuracy and the validation-categorical accuracy is that the validation-categorical accuracy is tested on validation dataset while training the

model with the training dataset to get feedback for optimizing the model between epochs. This time models showed a bit more different and fluctuating performance especially the Custom CNN and Attention-CNN models since optimizing a model while training can be a complex process to work on.

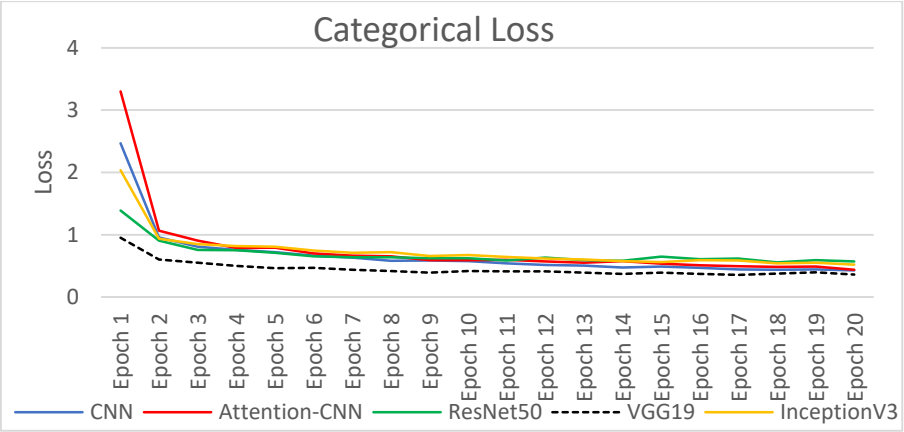

Fig. 6. Loss of the Models

A loss function quantifies the degree to which a single example's prediction by the model went off. The loss is bigger if the model's prediction is not accurate; otherwise, it is zero. Finding a collection of weights and biases with a low average loss over all cases is the aim of model training.

In this work, all the models showed a similar behavior again and they all converged under “1” as shown in figure 6, which is a desirable circumstance.

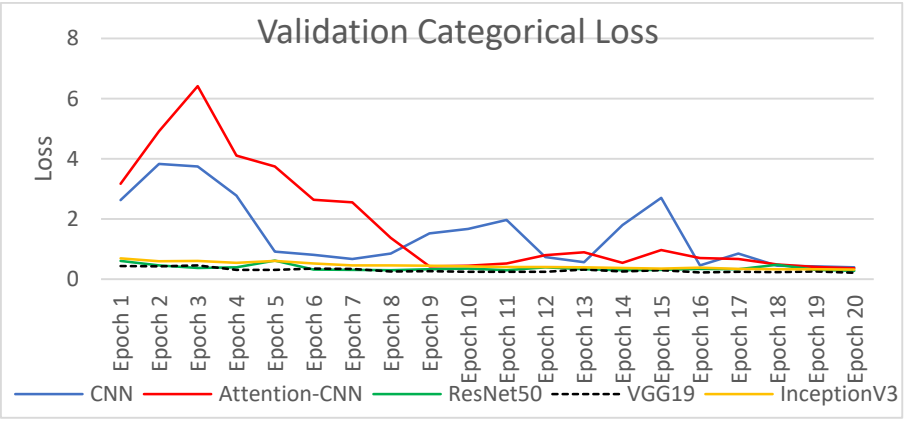

Fig. 7. Validation-Loss of the Models

Validation loss has been calculated on the validation dataset just like the validation-categorical accuracy with the same loss function as the previous one. Again, there are more fluctuations especially for the handmade CNN models while optimizing the models according to figure 7.

4.2 Model Evaluations

After the training process, all the models have been evaluated with the training, validation, and testing generators to finalize their performance analysis and time-consumption to compare them between each other. The experiments have been recorded in Table 1 as follows.

Table 1. Final Accuracies and the Time Consumption of the Models

	CNN	Attention-CNN	ResNet50	VGG19	InceptionV3
Training Score (%)	81	92	88	94	94
Validation Score (%)	91	92	92	95	94
Testing Score (%)	89	92	91	96	92
Time Consumption for an Epoch (seconds)	90	92	90	258	49

As can be seen, VGG19 out-performs the other models yet, it consumes time the most. InceptionV3 has proven that it is the most efficient one to work on this dataset in terms of time-consumption and performance. In any case, Attention based CNN model seems like it is a strong and time efficient option.

Table 2. Losses and of the Models

	CNN	Attention-CNN	ResNet50	VGG19	InceptionV3
Training Loss	55	40	37	26	33
Validation Loss	39	36	28	21	32
Testing Loss	42	40	34	23	37

Table 2 shows that it is reasonable to say that the losses are in the reverse relationship with the accuracy scores as in the previous table which is a proper situation. Again, VGG19 has proven itself in terms of loss function and followed by InceptionV3 and Attention-CNN respectively.

5 Concluding Remarks and Future Work

COVID-19 has gained popularity as a study topic recently due to the high number of deaths it has caused worldwide. There is still a ton of room for improvement in the precision and computational speed of the various computer-based techniques that researchers have created.

In this study, we developed various deep learning techniques such as CNN models and Attention Mechanism separately to observe their responses and compare them with one another. Although the main goal of this project is to develop an understandable AI-based system for COVID-19 diagnosis and classification based on chest X-ray images, we also had the opportunity to observe how the various methods we mentioned responded, which was a valuable learning experience for our literature knowledge.

We have observed that VGG19 is the strongest model among others but if we consider the time-consumption, it is important say that InceptionV3 and Attention-CNN could be more applicable depending on the motivation of the work, since they consume much less time around (200 and 160 seconds respectively for each epoch).

In the following stages, we can employ a similar approach in medical research facilities to conduct additional experiments to address this pandemic issue by boosting the quantity of data and classes. Each year, there is a larger increase in biomedical technological advancement, and as a result, the amount of biomedical data increases as well, providing us with more complete and in-depth information that we can use. We would benefit from having pretrained models and works like we did in this research because there may, unfortunately, be new diseases as well.

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Use of Simulation Systems in Law Enforcement Shooting Trainings and Shooting Error Detection: A Systematic Review

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Abstract. The aim of this research is to uncover simulation systems used in law enforcement shooting training, simulation-based training methods employed in the security domain and technological developments in this field. The study comprehensively examines various simulation-based training in shooting, comparing research related to marksmanship errors. The work delves into the application areas of simulation training on marksmanship education, with an in-depth analysis. It is assessed that the study will benefit law enforcement personnel and technology experts engaged in the use of simulation-based training in the security domain. A systematic literature review was conducted within the scope of the study, utilizing the Prisma 2020 method. In line with this, searches were conducted across six databases *(Web of Science, Proquest, Emerald, Scopus, Springer, Wiley Online Library)* using advanced search options with keywords and their derivatives related to law enforcement, training, simulation, shooting, error, and their variations (("law enforcement" OR "armed forces" OR "military" OR "police" OR "gendarmerie" OR "defence") AND ("use*" OR "train*" OR "educat*" OR "instruct*" OR "pract*" OR "exper*" OR "imple*" OR "application*") AND ("simulati*" OR "virtual reality" OR "augmented reality*") AND ("shoot*" OR "fire*") AND ("find*" OR "detect*") AND ("er?or" OR "mistake" OR "fail*" OR "fault" OR "inaccuracy")), and a total of 109 articles were identified. During the advanced search, a period of last ten years, article publication type, and English language were applied as criteria, and duplicate control was performed separately for each database, followed by a consolidated check. Upon reviewing the titles, topics, and abstracts of these 109 articles, 6 articles related to law enforcement were identified. It was observed that these studies focused on critical decision-making processes in the use of firearms by law enforcement personnel, particularly those resulting in fatal outcomes due to incorrect decisions termed as "errors." Consequently, the systematic literature review revealed no simulation-based research specifically addressing shooter or marksmanship errors. It is believed that studies in this area would contribute to the literature. Additionally, for future systematic literature reviews in this field, using fewer keywords might expand the scope and yield more results.

Keywords: Law Enforcement, Simulation Systems, Shooting Training, Shooting Error.

A Text Based Novel Dataset For Patentability Analysis

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Abstract. Assessing patent applications requires meticulous examination of their novelty and inventiveness to ensure that only truly original inventions receive patent protection. This process, known as patentability analysis can be complex due to the detailed and technical nature of patent documents and necessitates thorough expertise and a deep understanding of the subject matter for analysis. Text mining and semantic similarity techniques are becoming crucial tools in the patentability analysis process by automating the identification of similarities and differences among patents. However, these methods have not yet reached the level of a patent expert and require further development. This article talks about a new collection of data, carefully put together from published patent search reports, generated to help enhancements in this field. This collection focuses on patents related to electric cars and uses XML data analysis from a tool called EPOQNET, gathering a wide range of patent information. By combining the deep knowledge of experts with the efficiency of text mining, this new collection of data marks a big step forward in the field of not only patent analysis but also technology management.

Keywords: patentability, patent search report, text similarity

1 Introduction

The cornerstone of the patent application process is the rigorous assessment of an invention's eligibility for patent protection, which is predicated on satisfying patentability criteria. Firstly, an invention must demonstrate novelty, implying that it must not be part of the existing body of technological knowledge accessible to the public before the patent application date. This body of knowledge includes all forms of information, such as written documents, oral disclosures, and visual materials.[1] Secondly, the invention must exhibit an inventive step, also known as non-obviousness, which means it should not be an apparent solution to a professional in the respective field. The evaluation process involves a thorough comparison of the invention against prior patents and other disclosures, to ascertain its distinctiveness and inventive contribution over the known state of the art. [2]

This evaluation of patentability is not only a prerequisite for the granting of a patent but also a preventive measure against potential legal and economic repercussions associated with patent infringement or disputes over patent validity. [3] The use of advanced text mining techniques in this process is becoming increasingly vital, as they offer the potential to significantly enhance the precision and speed of the patent review process [4]. By automating the detection of similarities and differences between the invention and existing patents, these technologies facilitate a more efficient assessment of both novelty and inventive step criteria.[5] Such advancements support patent offices in managing application backlogs and empower inventors to make informed decisions regarding the patentability of their innovations, thus contributing to a more robust and streamlined patent system. [6]

Despite the potential of text mining technologies to revolutionize the patentability assessment process, their application is not without challenges, primarily due to the intricate nature of patent literature and the requirement of expertise in determining an inventive step[7]. Patent documents are characterized by highly technical language, domain-specific terminologies, and complex legal and scientific descriptions, which can pose significant hurdles for text mining algorithms designed to parse and analyze textual content. [8] Moreover, the determination of an inventive step goes beyond mere textual comparison, requiring a deep understanding of the technological domain and the ability to discern subtle technical advancements that are not obvious to practitioners in the field. [9] This level of analysis often necessitates human expertise and judgment, underscoring the complementary role of text mining technologies in assisting, rather than fully replacing, human evaluators in the intricate task of patentability assessment.[10]

In light of these challenges, this study introduces the development of a novel dataset, meticulously curated based on patent search reports prepared by patent experts. This dataset embodies a significant stride towards addressing the complexities inherent in patentability detection, encapsulating the nuanced judgments and rich insights that only come from expert analysis. By integrating the depth of human expertise with the scalability of text mining technologies, this dataset aims to bridge the gap between the intricate, expert-driven process of patent evaluation and the efficiency-driven demands of patent processing systems. Its contribution to the field of patentability detection is poised to be substantial, offering a valuable resource that enhances the training and performance of text mining algorithms, thereby facilitating a more accurate, and efficient assessment of patent applications in the quest for innovation protection.

2 Patent Search Reports

Patent search reports are comprehensive documents prepared during the patent examination process, which provide detailed analyses of the existing patents and literature related to a patent application. These reports are instrumental in determining the novelty and inventive step of the proposed invention by identifying and categorizing relevant prior art. The categorization of prior art into X, Y, and A segments within these reports

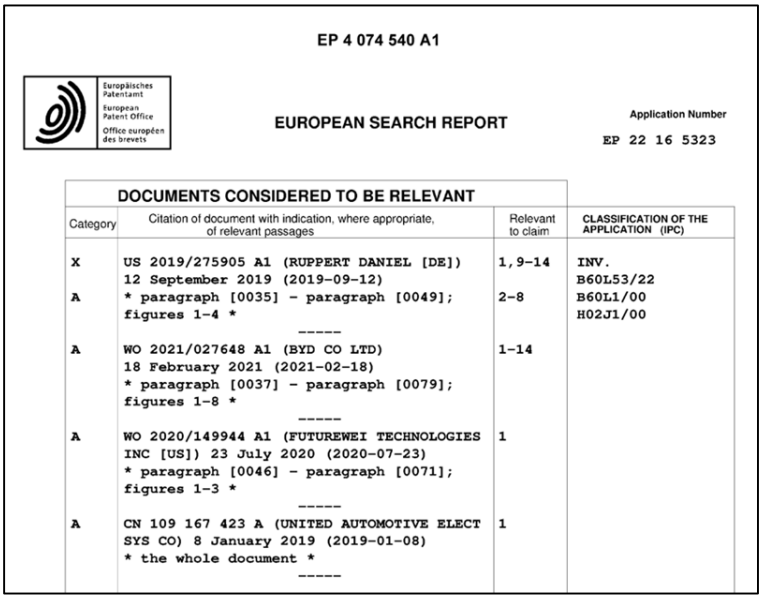
is critical for assessing the impact of existing knowledge on the patentability of an invention. The 'X' category typically denotes documents that are considered to significantly hinder the novelty or inventive step of a claimed invention, suggesting that the cited prior art is closely related and could potentially negate the patentability of the application. The 'Y' category refers to documents that, when combined with one or more other references, could challenge the inventive step or non-obviousness of the invention, implying a combined effect that might affect the patentability. The 'A' category, on the other hand, is used for references that are relevant to the general state of the art but do not individually or collectively threaten the novelty or inventive step of the invention, serving more as background information. [11] These expertise-based categorizations of patent documents are so valuable that they enable the extraction of significant insights. [12][13]

Incorporating these categorizations into the dataset enriches it with a nuanced understanding of prior art's impact on patent applications, as determined by patent experts. The X, Y, and A labels provide a granular view of the semantic similarities and differences between patents, reflecting the depth of expert analysis in evaluating the patentability of new inventions. This level of detail is invaluable for refining text mining algorithms and tools used in patentability detection, offering a more sophisticated approach to interpreting the complex landscape of patent literature. By leveraging this categorized knowledge, the dataset significantly enhances the capacity for accurate semantic analysis in patentability assessments, contributing to the development of more effective patent evaluation methodologies.

The dataset developed within the scope of this study represents a significant advancement in the field of semantic similarity analysis among patents. It encapsulates the similarity ratios between published patent documents, denoted by the X, Y, and A similarity categories found in patent search reports. These categories reflect the decisions made by patent experts after thorough readings and analyses of numerous patent documents, embodying a wealth of knowledge grounded in expert judgment. Despite the accessibility of patent search reports, which are publicly available and free from ethical concerns, their underutilization in previous studies primarily stems from the specialized knowledge required to interpret these documents. This barrier is compounded for data science professionals who might lack the requisite expertise in patent law and terminology, making the meaningful interpretation of these reports challenging. Furthermore, the categorization into X, Y, and A is typically presented in PDF formats within search reports and is not readily available as searchable metadata in databases, adding another layer of complexity to their utilization in research.

The search report for European Patent EP4074540 A1, as highlighted in the example, serves as a representative entry within the novel dataset developed in this study. This specific report sheds light on the meticulous process of patent evaluation, revealing that the US2019/275905 A1 patent document from 2019 is identified as the most semantically similar document to EP4074540, and is accordingly categorized with an 'X' similarity rating. This categorization indicates that the US patent document encompasses all essential elements found in EP4074540, casting doubts on the latter's compliance with patentability criteria due to potential overlaps in novelty and inventive content.

Additionally, the report delineates other documents with an 'A' similarity rating, suggesting a thematic but not critical technical resemblance to EP4074540, thereby not challenging its patentability. Documents like WO2021/027648, WO2020/149944, and CN109167423, while thematically related, are noted for lacking key technical features present in the EP4074540 application. This inclusion in the dataset exemplifies the depth of analysis encapsulated within each report, offering granular insights into the semantic relationships and distinctions among patents. Such detailed entries enrich the dataset, providing a robust foundation for enhancing text mining algorithms aimed at navigating the complex landscape of patent literature and improving the precision of patentability assessments.



EP 4 074 540 A1

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 16 5323

DOCUMENTS CONSIDERED TO BE RELEVANT

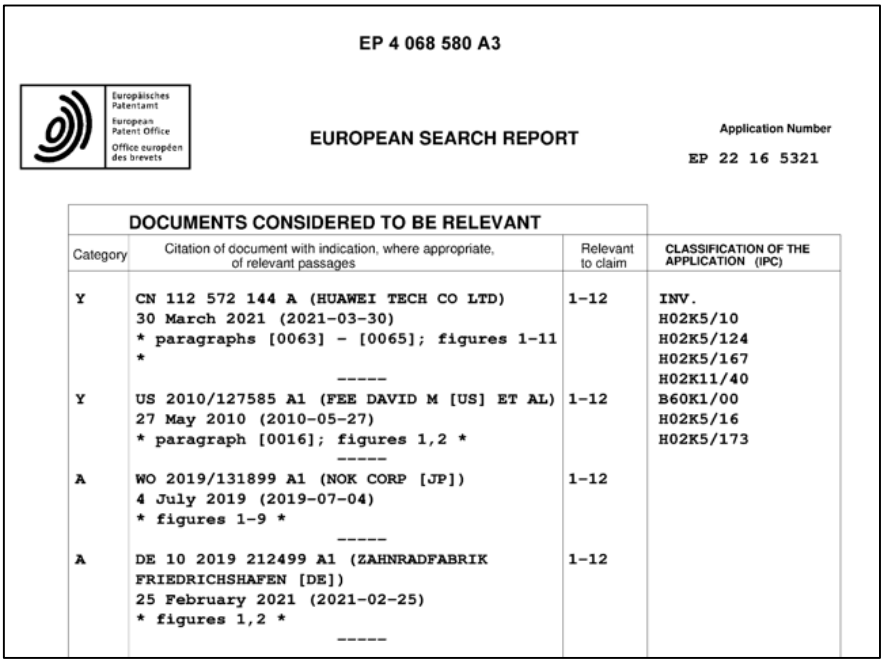
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2019/275905 A1 (RUPPERT DANIEL [DE]) 12 September 2019 (2019-09-12) * paragraph [0035] - paragraph [0049]; figures 1-4 *	1,9-14 2-8	INV. B60L53/22 B60L1/00 H02J1/00
A	WO 2021/027648 A1 (BYD CO LTD) 18 February 2021 (2021-02-18) * paragraph [0037] - paragraph [0079]; figures 1-8 *	1-14	
A	WO 2020/149944 A1 (FUTUREWEI TECHNOLOGIES INC [US]) 23 July 2020 (2020-07-23) * paragraph [0046] - paragraph [0071]; figures 1-3 *	1	
A	CN 109 167 423 A (UNITED AUTOMOTIVE ELECT SYS CO) 8 January 2019 (2019-01-08) * the whole document *	1	

Fig. 1. Search Report of Patent Number EP4074540

However, it's crucial to note that the X, Y, and A similarity categorizations within the search reports are determined specifically for the claims of the investigated patent documents. This means that the 'X' similarity identified in the report for EP4074540 does not pertain to the entirety of the patent's description but is instead assigned individually to the specific claims of the patent. The report elucidates that the US2019/0275905 document exhibits 'X' similarity for claims 1, and 9-14 of the EP4074540 document, indicating a significant overlap in these areas, while claims 2-8 are marked with 'A' similarity, suggesting that these claims contain certain key technical elements not found in the US document. Consequently, this analysis in the report suggests that while claims 2-8 of EP4074540 may meet the patentability criteria, the other claims might not be patentable. Moreover, the same report indicates that the WO2021/027648 document shares an 'A' similarity rating across all claims 1-14 of the EP4074540 patent, the WO2020/149944 document is rated 'A' for claim 1, and the

CN109167423 document also receives an 'A' rating for all its claims in relation to EP4074540.

It is noted that the search report for patent EP4074540 A1 does not contain any documents categorized under 'Y'. This absence is attributed to the fact that documents classified as 'X' already indicate a lack of patentability, and the expert preparing this report did not cite any additional documents under the 'Y' category. However, it is common to find documents categorized as 'Y' in many patent reports. The 'Y' similarity category denotes a level of similarity that lies between 'X' and 'A', where documents in the 'Y' category typically come in pairs. In such pairs, one document may contain some but not all critical elements of the investigated patent, while the second 'Y' document comprises elements absent in the first, collectively suggesting the investigated invention's lack of patentability when considered together. For instance, another patent report, EP4068580 A3, includes documents cited in the 'Y' category, illustrating how the combination of these documents can impact the assessment of an invention's patentability.



EP 4 068 580 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 5321

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	CN 112 572 144 A (HUAWEI TECH CO LTD) 30 March 2021 (2021-03-30) * paragraphs [0063] - [0065]; figures 1-11 *	1-12	INV. H02K5/10 H02K5/124 H02K5/167 H02K11/40
Y	US 2010/127585 A1 (FEE DAVID M [US] ET AL) 27 May 2010 (2010-05-27) * paragraph [0016]; figures 1,2 *	1-12	B60K1/00 H02K5/16 H02K5/173
A	WO 2019/131899 A1 (NOK CORP [JP]) 4 July 2019 (2019-07-04) * figures 1-9 *	1-12	
A	DE 10 2019 212499 A1 (ZAHNRADFABRIK FRIEDRICHSHAFEN [DE]) 25 February 2021 (2021-02-25) * figures 1,2 *	1-12	

Fig. 2. Search Report of Patent Number EP4068580

Building upon the insights gleaned from the shared search reports, the dataset that is to be produced should encompass the following critical information:

– The document number, title, abstract, description, and claims of the document for which the report is prepared should each be represented in separate columns within the dataset. This is because each claim of the document under review is compared with the cited documents individually. Therefore, it's essential for each claim to be

distinctly presented in the dataset to facilitate detailed comparisons. Moreover, in accordance with patent legislation which stipulates that claims are grounded in the description, the description must also be prominently featured in a separate column to provide a comprehensive basis for evaluating the claims.

- The publication number, title, abstract, description, and claims of the cited documents should also be included. This information is crucial for understanding the context and content of the prior art that is being compared to the claims of the document under review.
- Information on the similarity category is another vital component that must be included in the dataset. This categorization is paramount as it provides a direct insight into the level of similarity between the claims of the document under review and the cited documents. The similarity category information should be available for each claim in a separate table, underscoring the analysis of each claim's patentability in relation to the existing body of prior art.

This structured approach to compiling the dataset ensures that every element crucial to the patent evaluation process is captured, enabling a thorough and analysis of patentability. By systematically organizing this information, the dataset not only aids in the efficient comparison of claims against prior art but also enhances the depth and accuracy of patentability assessments, contributing significantly to the field of patent analysis and innovation protection.

3 Formation of the New Dataset

To construct a dataset containing the outlined information, a query related to electric vehicles was conducted using the EPOQNET application, focusing on applications published after the year 2000 to concentrate on more recent developments. However, not all published patents include information from search reports. To access patents with available search report information, a filter was applied to select European patents with the publication number prefix 'EP' and international patents with 'WO'. Given that not every publication in these categories contains search report information, publications coded as A1 and A3 were further filtered to ensure the inclusion of relevant data. Consequently, a comprehensive patent set comprising 7,941 patent documents and their associated search reports was compiled, as illustrated below. This set represents a significant resource for analyzing electric vehicle technologies, providing a rich basis for investigating patentability through the detailed examination of claims, descriptions, and the crucial categorizations of prior art as outlined in the search reports.

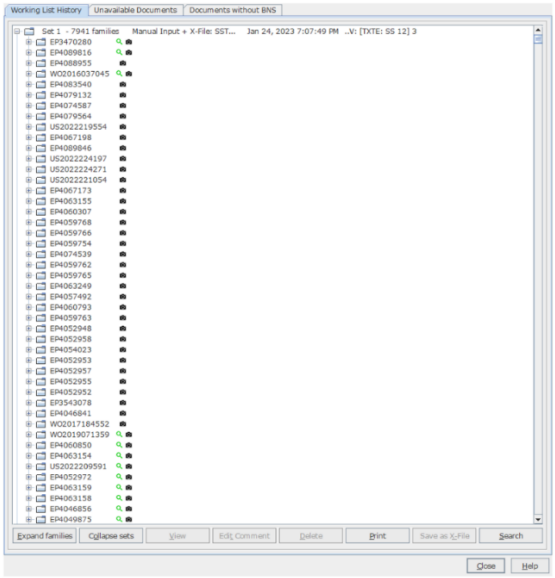


Fig. 3. Patents on Electric Vehicles to be Included in the Dataset

To incorporate this new detail into our discussion, it's important to understand that the EPOQUNET program provides raw data of the documents accessed through queries in an XML output format. XML, or Extensible Markup Language, is a versatile format widely used for representing structured data, making it suitable for detailed documentation like patent information. This format allows for a structured representation of the patent documents' various components, such as publication numbers, titles, abstracts, descriptions, and claims, in a way that is both machine-readable and human-readable.

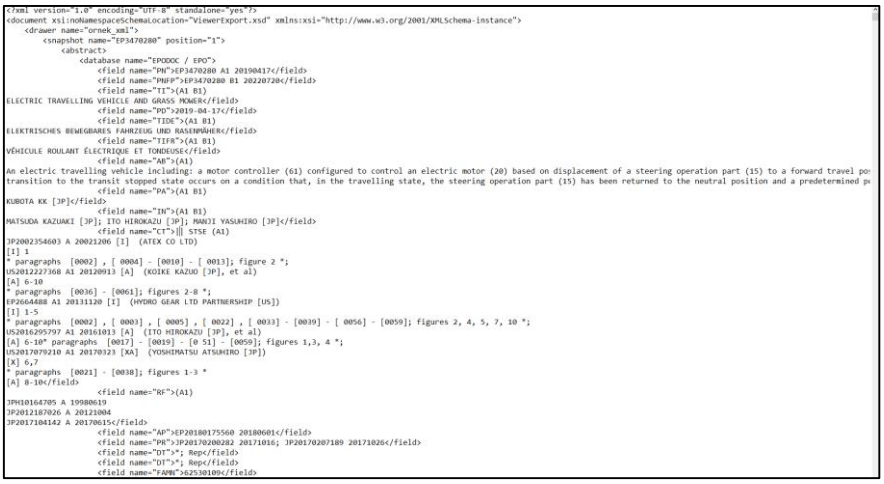
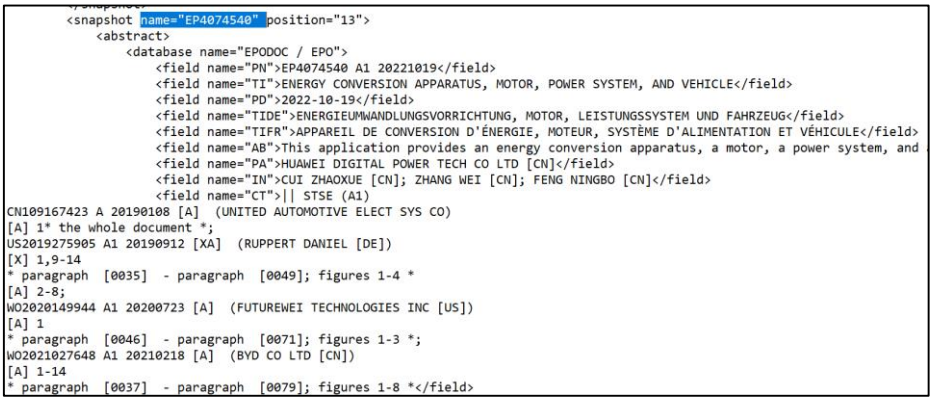


Fig. 4. XML File Containing Information on Patents to be Included in the Dataset

Within the XML output shown on Figure 4, comprehensive information pertaining to the investigated documents is available, providing a rich source of data crucial for this study. The required information, including the patent number, abstract, description, claims, and details from the search report, can be extracted from specific fields within the XML structure. Notably, the information about documents cited in the search report and their similarity ratings, which is pivotal for the dataset, is located within the "CT" (Cited Text) section of the XML.

The Figure 5 below demonstrates how the information from the search report of the previously discussed EP4074540 patent document is organized within the XML file. This structured representation in the XML format enables the precise extraction and analysis of key elements necessary for evaluating patentability, such as the detailed examination of claims against prior art and the assessment of semantic similarities based on expert categorizations. By leveraging the structured data provided in the XML outputs, the study can efficiently process and integrate this wealth of information into the dataset, significantly enhancing the depth and utility of the analysis for electric vehicle patent innovations.



```
        <snapshot name="EP4074540" position="13">
            <abstract>
                <database name="EPODOC / EPO">
                    <field name="PN">EP4074540 A1 20221019</field>
                    <field name="TI">ENERGY CONVERSION APPARATUS, MOTOR, POWER SYSTEM, AND VEHICLE</field>
                    <field name="PD">2022-10-19</field>
                    <field name="TIDE">ENERGIEUMWANDLUNGSVORRICHTUNG, MOTOR, LEISTUNGSSYSTEM UND FAHRZEUG</field>
                    <field name="TIFR">APPAREIL DE CONVERSION D'ÉNERGIE, MOTEUR, SYSTÈME D'ALIMENTATION ET VÉHICULE</field>
                    <field name="AB">This application provides an energy conversion apparatus, a motor, a power system, and
                    <field name="PA">HUAWEI DIGITAL POWER TECH CO LTD [CN]</field>
                    <field name="IN">CUI ZHAOXUE [CN]; ZHANG WEI [CN]; FENG NINGBO [CN]</field>
                    <field name="CT">|| STSE (A1)
CN109167423 A 20190108 [A]  (UNITED AUTOMOTIVE ELECT SYS CO)
[A] 1* the whole document *;
US2019275905 A1 20190912 [XA]  (RUPPERT DANIEL [DE])
[X] 1,9-14
* paragraph  [0035]  - paragraph  [0049]; figures 1-4 *
[A] 2-8;
WO2020149944 A1 20200723 [A]  (FUTUREWEI TECHNOLOGIES INC [US])
[A] 1
* paragraph  [0046]  - paragraph  [0071]; figures 1-3 *;
WO2021027648 A1 20210218 [A]  (BYD CO LTD [CN])
[A] 1-14
* paragraph  [0037]  - paragraph  [0079]; figures 1-8 *</field>
```


Fig. 5. Information on the Search Report in the XML File

In the process of creating the dataset, the mentioned XML files are meticulously analyzed to extract critical information about the investigated documents. This process involves parsing the publication number, title, abstract, description, and claims from the XML data. Subsequently, a detailed examination of the "CT" (Cited Text) section is conducted to identify the documents cited in the search reports, along with the specific claims they relate to and their respective similarity ratings. Additionally, the descriptions of the cited documents are retrieved separately from the EPOQUNET program to form the dataset properly.

As a result of this comprehensive analysis, a dataset is constructed that not only includes the foundational information about each patent document but also integrates

the details of the search reports, offering a multidimensional view of patentability assessments. The Figure 6 below displays a table of the data generated from the novel dataset showing the efficiency of the dataset in term of presenting the similarity categories between patent texts. This dataset stands as a testament to the intricate process of patent analysis, providing a valuable resource for understanding the complex interplay between patent claims and the prior art within the context of electric vehicle technologies. By systematically compiling this information, the dataset facilitates a deeper exploration of semantic similarities and the patentability landscape, contributing significantly to the field of patent analytics and innovation research.

It is possible to reach the dataset in json format through the following link:

https://kaggle.com/datasets/6cfe66ce0f1548de3e7c32c832a5701f49ae5498ed38eee027391a8a5fdd8b36

	Current Patent	Title	Abstract	Description	Claim Number	Claim Text	Similarity Category	Cited Patent	Cited Title	Cited Abstract	Cited Description	Cited Claims
52	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	1	d to the motor winding	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
53	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	2	ol connection and disc	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
54	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	3	ected to the motor win	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
55	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	4	of the three-phase bric	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
56	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	5	capacitors connected i	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
57	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	6	erter is specifically con	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
58	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	7	ge arm of the three-ph	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
59	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	8	is connected to the bi	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
60	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	9	e alternating current ch	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
61	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	10	rrent filter is disposed	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
62	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	11	ms 1 to 10, wherein the	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
63	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	12	version apparatus acc	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
64	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	13	he of claims 1 to 12, wh	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
65	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	14	ne of claims 1 to 11, th	A	WO2021027648	ELECTRIC VEHICLE, AND	Disclosed are an elect	Electric vehicle and its	["An integrated controller f
66	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	1	d to the motor winding	A	WO2020149944	INTEGRATED CHARGER	According to one aspe	INTEGRATED CHARGER	["The apparatus of claim 1
67	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	2	ol connection and disc	A	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
68	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	3	ected to the motor win	A	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
69	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	4	of the three-phase bric	A	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
70	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	5	capacitors connected i	A	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
71	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	6	erter is specifically con	A	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
72	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	7	ge arm of the three-ph	A	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
73	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	8	is connected to the bi	A	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
74	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	1	d to the motor winding	A	CN109167423	Electric integration de	The invention provide	Electrical integrated d	[]
75	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	1	d to the motor winding	X	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
233	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	9	e alternating current ch	X	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
234	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	10	rrent filter is disposed	X	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
235	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	11	ms 1 to 10, wherein the	X	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
236	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	12	version apparatus acc	X	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
237	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	13	he of claims 1 to 12, wh	X	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
238	EP4074540	ENERGY CONVERSION A	This application provi	TECHNICAL FIELD [0001	14	ne of claims 1 to 11, th	X	US2019275905	CHARGING DEVICE FOR A	charging device for a F	FIELD [0001]	The inve ["A charging device for a mo
239	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	1	tive post, and the cond	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
512	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	2	f the rim is fixedly conr	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
513	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	3	he fitting portion is anr	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
514	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	4	e end, facing away fror	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
515	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	5	er circumferential port	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
516	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	6	ere are at least two co	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
517	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	7	f the two planes are di	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
518	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	8	e middle portion in a t	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
519	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	9	acing the first sealing r	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
520	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	10	s, and the motor compr	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
521	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	11	any one of claims 1 to 1	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
522	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	12	rain according to claim	Y	US2010127585	(A1 B2)Grounding mec	(A1 B2)An electric moti	TECHNICAL FIELD [0001	["What is claimed is: ', 'An
523	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	1	tive post, and the cond	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
524	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	2	f the rim is fixedly conr	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
525	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	3	he fitting portion is anr	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
526	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	4	e end, facing away fror	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
527	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	5	er circumferential port	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
528	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	6	ere are at least two co	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
529	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	7	f the two planes are di	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
530	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	8	e middle portion in a t	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
531	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	9	acing the first sealing r	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
532	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	10	s, and the motor compr	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl
533	EP4068580	(A2 A3)MOTOR, POWER	(A2 A3)This applicatio	TECHNICAL FIELD [0001	11	any one of claims 1 to 1	Y	CN112572144	(A)Motor, power asser	(A)The invention relati	Motors, powertrains a	["The motor according to cl

Fig. 6. A Table of The Data Generated from the Novel Dataset

4 Conclusions

The exploration of patent application evaluations through this study underscores the intricate balance required between leveraging advanced text mining technologies and retaining the essential human expertise in the patent review process. The critical assessment of an invention's novelty and inventive step is not merely a procedural necessity but a safeguard to maintain the integrity and advancement of technological innovation.

The challenges identified in the analysis of patent literature, characterized by its complex and technical nature, highlight the limitations of text mining technologies when used in isolation. These technologies, while transformative in their capacity to process and analyze vast quantities of data, necessitate a nuanced understanding and interpretation that currently resides within the domain of human expertise.

The development and introduction of the novel dataset, derived from expert-prepared patent search reports and focused on electric vehicle technologies, represent a significant stride towards bridging the existing gap in the patent evaluation process. By amalgamating the depth of human expertise with the efficiency and scalability of text mining, the dataset emerges as a powerful tool that enhances the precision and speed of patentability assessments. This integration facilitates a more nuanced analysis of semantic similarities and distinctions among patents, enriching the field of patent analytics with a resource that is both comprehensive and adept at addressing the nuanced demands of patent evaluations.

Furthermore, the dataset's focus on electric vehicle technologies not only reflects the current trends and demands of technological innovation but also sets a precedent for future expansions into other dynamic sectors. The structured approach to compiling and analyzing patent information, as demonstrated through the meticulous examination of XML files from the EPOQNET application, provides a replicable model for enhancing patent analysis across various domains.

In conclusion, this article contributes to the evolving landscape of patent analytics by offering a refined methodology for patentability detection that harmonizes the strengths of text mining technologies with the irreplaceable insights of human expertise. The resulting dataset not only facilitates a deeper understanding of the semantic landscape within electric vehicle patents but also opens avenues for future research and development in patent analytics. As the field continues to evolve, the integration of such datasets with advanced analytical tools promises to further streamline the patent review process, making it more robust, efficient, and aligned with the rapid pace of technological innovation.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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Human Footprint Recognition Using Pre-Trained Convolutional Neural Network Models

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Abstract. Human footprint recognition (FR) has garnered significant interest in the evolving biometric identification domain due to its unique advantages and applications. This study explores the efficacy of pre-trained Convolutional Neural Network (CNN) models in accurately identifying individuals based on their footprints. We aimed to develop a practical CNN-based framework capable of processing and analyzing footprint images for identification purposes. Our method fine-tuns several state-of-the-art pre-trained CNN models, such as MobileNet, ResNet, and EfficientNet, on the Biometric 220X6 Human Footprint dataset. We evaluated these models based on criteria like accuracy, model size, training time, and the ability to identify individual footprints correctly. The results highlight that these fine-tuned CNN models are highly effective in accurately identifying individuals based on footprints, with an accuracy exceeding 98.90. This finding paves the way for potential applications in forensics, security systems, and anthropological studies.

Keywords: Human Footprint Recognition, Pre-trained Convolutional Neural Network, Biometric Identification.

1 Introduction

Biometric identification systems are essential in modern security frameworks, offering distinct and dependable techniques for recognizing individuals based on physical or behavioral characteristics. While biometric methods such as fingerprint [1], facial [2], and iris [3] identification have been extensively studied and applied, there is still a need to investigate human FR further. Nevertheless, this region possesses a significant capacity for enhancing identifying technology and expanding the scope of biometric applications [4].

FR, which requires careful examination of the shape, size, and pattern of footprints, provides several distinct benefits in a variety of situations in which typical biometric

data would not be accessible. Because newborn children's other biometric organs frequently need to be fully formed, FR is a beneficial and non-invasive identification tool. This technology proved to be particularly advantageous in the process of identifying infants [4, 5]. In forensic science, particularly in crime scene analysis, FR becomes extremely important in situations where it may be the only accurate biometric evidence, and it helps in the identification of suspects and aids in the comprehension of the dynamics of criminal behavior [6]. Furthermore, anthropologists and historians use footprint analysis to gain insights into ancient civilizations and extinct species in the field of historical study [7]. This analysis reveals essential information about the habits, health, and movements of the individuals who lived during those times. As a result of its versatility, FR is a valuable complement to other biometric approaches and considerably expands the field of personal identity.

The introduction of CNNs has brought about a significant transformation in the field of image identification, especially in challenging tasks such as human footprint analysis. These biologically inspired computational models have achieved superior performance compared to previous types of artificial intelligence in tasks related to machine learning [8]. CNNs can build high-level features from low-level ones, making them highly effective in analyzing medical images. They have demonstrated significant promise in tasks such as segmenting images and identifying and classifying different types of objects [9]. Furthermore, they have evolved into cutting-edge frameworks for image classification, requiring large training datasets and advanced techniques to maintain accuracy and precision [10].

In this paper, we explore the domain of human FR from an innovative perspective. We utilize the power of pre-trained CNN models, taking advantage of their exceptional capability to extract detailed features. Diverging from prior research that primarily concentrated on direct classification methods, our approach strongly emphasizes the extraction of intricate feature vectors. We then employ a cosine similarity [11] metric to compare these vectors. This metric facilitates a more nuanced and in-depth analysis of footprints, surpassing the capabilities of conventional similarity measures.

In this paper, we organize our content as follows: In Section 2, we review related works in the field, emphasizing the evolution of FR techniques. Section 3 describes our methodology, detailing the pre-trained CNNs we utilized and the process of extracting feature vectors. Section 4 presents the results and our discussion of these findings. Finally, Section 5 concludes our paper with a summary of our discoveries and provides suggestions for future research endeavors.

2 Related Works

CNNs have fundamentally transformed the field of image recognition [12] by providing unparalleled precision in a wide range of applications, including facial recognition [13] and medical imaging [14]. This improvement significantly influences specialized fields such as human FR, which previously depended on less precise and more time-consuming techniques [15].

Early methods for human FR predominantly relied on geometric analysis and pattern recognition. These methods, although fundamental, were constrained by their dependence on human skill and subjective interpretation. With the advancement of technology, automated techniques started to appear, utilizing the growing field of machine learning to improve precision and productivity [16]. So, in this section, we delve into an examination of the relevant literature.

The authors in [17] delineate the escalating significance of biometric methodologies in diverse sectors, notably in civil contexts, security paradigms, and anti-terrorism initiatives. Despite the need for comprehensive datasets in the field of footprint detection, this manuscript presents a novel and flexible hybrid approach. This approach synergizes image processing techniques with a sophisticated Artificial Intelligence algorithm, specifically the Ant Colony Optimization (ACO). This strategy intends to augment the dependability and precision of biometric systems, focusing on FR. Consequently, this leads to the inception of a novel Footprint Recognition Biometric System (FRBS) and the establishment of a comprehensive visual footprint database. Overall, the paper addresses a critical gap in biometric research and offers a promising solution to advance the field of FR.

The study in [18] introduces an innovative methodology for retrieving shoe footprint images, employing deep neural networks (DNNs) and transfer learning techniques. This research underscores the superiority of DNNs over conventional image retrieval methods, particularly their capacity to extract intricate features effectively. Furthermore, the authors emphasize the pivotal role of transfer learning in pre-training the neural network, enabling remarkable results even when utilizing limited datasets. The importance of these findings is notable, particularly in the realm of forensic science.

The paper [15] investigates the feasibility of utilizing human footprints for personal identification and verification by implementing DDNs. The paper explores the historical background of foot biometry and the conventional techniques employed for individual identification based on footprints. Furthermore, it emphasizes the emergence of machine learning and deep learning in this domain, explicitly emphasizing the utilization of CNNs for image processing and classification. The paper proposed employing two deep transfer learning techniques, VGG19 and RESNET-50, to extract features and classify data. The study findings demonstrate enhanced performance compared to the traditional methods, with a suitable level of accuracy.

The paper [19] introduces an innovative method for identifying individuals by analyzing their dynamic footprints. This methodology effectively overcomes the constraints of prior studies by integrating gait data. The suggested approach employs a hidden Markov model (HMM) and a neural network to develop a streamlined and automated system for recognizing footprints based on their characteristics. The work attains an approximate recognition rate of 80% in an experiment involving 11 people by assessing the trajectory of the center of pressure (COP) in dynamic imprints. This novel approach exhibits potential for augmenting biometric identity systems and presents opportunities for wider security and tailored services applications.

The work [20] introduces a new method for matching biometric human footprints using fuzzy ensemble learning. This methodology has several applications in attendance monitoring, banking, passport verification, travel, and other domains. The study

commences by comprehensively analyzing existing literature on conventional biometric characteristics and their correlation with human footprints. The research subsequently examines the distinctiveness, durability, quantifiability, efficiency, and acceptability of footprints as a biometric modality. The work employs a fuzzy ensemble technique to enhance the precision and efficiency of identification. The findings demonstrate that footprints are a dependable and resilient biometric characteristic for identifying individuals. The paper finishes by examining potential practical applications of this research in biometric identification and security.

Numerous other studies have explored human FR, predominantly employing traditional techniques or leveraging deep learning for classification [4, 21-24]. This paper introduces an innovative approach, utilizing pre-trained CNNs to extract feature vectors. Subsequently, we use the cosine similarity method to confirm the degree of similarity among these feature vectors.

3 Proposed Method

3.1 Cosine Similarity

Cosine similarity (CS) is a mathematical measure that quantifies the similarity between two items, typically vectors. Mathematically, it computes the cosine of the angle formed by two vectors projected in a space of multiple dimensions. This strategy is advantageous in diverse domains, including data analysis, natural language processing, and image recognition [25]. The formula to determine the CS between two vectors, labeled as A and B, is given by:

$$CS(A,B) = (A \cdot B) / (||A|| * ||B||) \quad (1)$$

This formula includes:
$(A \cdot B)$: The dot product between vectors A and B.
$||A||$: The Euclidean norm, or length, of vector A.
$||B||$: The Euclidean norm, or length, of vector B.
This calculation yields the cosine of the angle between the two vectors, indicative of their level of similarity [11].

3.2 Pre-trained CNN Models

Pre-trained CNNs have significantly transformed the domain of computer vision by offering a fundamental framework that enables developers and researchers to construct more specific image processing systems without requiring extensive training data or processing resources [8]. Notable models in this category include MobileNet, ResNet, and EfficientNet, each specifically designed to enhance performance, efficiency, and scalability. MobileNet excels because of its efficient architecture, rendering it well-suited for mobile and embedded devices with restricted computational resources. It utilizes depth-wise separable convolutions, effectively decreasing the parameters while maintaining model performance [26]. EfficientNet distinguishes itself by scaling the model parameters depth/width/resolution using a compound coefficient that results in

models that attain reasonable accuracy while efficiently utilizing resources [27]. ResNet, short for Residual Network, is a revolutionary deep learning architecture that introduces the concept of residual learning to facilitate the training of networks substantially deeper than previously used. There is a significant improvement in performance across various image recognition tasks because of its revolutionary design, which makes it possible to train deep neural networks effectively [28]. These pre-trained CNN models can be used for various applications, such as analyzing images in real-time on smartphones or using efficient models in cloud environments that allow powerful computer vision technologies to be used on different platforms and devices.

3.3 Problem-Solving

The FR method that we have presented is designed to use the distinctive and consistent features of footprints to achieve true biometric verification that is both secure and accurate. We have established a systematic strategy encompassing numerous essential steps, from image acquisition to decision-making. These steps are shown in Fig. 1.
In the first step, high-resolution photographs of an individual's footprint are collected using specialized scanners or imaging equipment. This stage of the procedure is referred to as image acquisition. At this point, the primary focus is on acquiring images with a high level of clarity and detail, which is essential for the later stages of recognition.

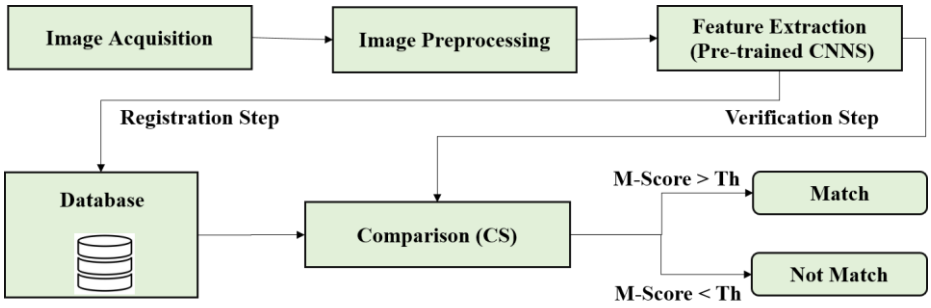

Fig. 1. The structure of the proposed technique.

The acquired image is prepared for feature extraction during the preprocessing stage. In this stage, the image is resized to the standard square size of 224 by 224 pixels, and padding is applied to keep the height and width ratios the same. These preprocessing processes are necessary to improve the image's consistency and make it more suitable for the feature-extracting process.
One of the most critical steps in the FR approach is feature extraction. The capabilities of advanced CNN models that have already been pre-trained are utilized in this stage. Some examples of these models include MobileNet, ResNet, and EfficientNet. These models are trained on the mentioned dataset in the discussion and results section to efficiently learn and extract hierarchical and abstract features from the footprint. The

extraction process results in feature vectors that capture each footprint's unique attributes, laying the foundation for effective individual verification.
Once the features have been extracted, the CS technique is utilized for the comparison of footprint images. This method calculates the cosine of the angle between the feature vectors of two footprint images to determine the degree of similarity between the two individual footprints. This similarity measure is ideal for this application because it is dependable and simple to understand and compute.

The outputs of the CS approach are used as the basis for the decision-making process. This step considers a threshold value for the CS score to classify the images as either a match or a non-match. If the CS value between the feature vectors of two footprint images is greater than this threshold, the algorithm will recognize them as a match, which indicates that they belong to the same individual. On the other hand, if the CS score is lower than the threshold, this implies that the footprint images belong to different individuals.

Finally, the steps of Registration and Authentication are essential components of the technique that has been proposed. The feature vector derived from an individual's footprint is safely saved in a database during the phase referred to as registration. During the subsequent phase of authentication, a new feature vector obtained from a footprint image is compared to the vectors stored in the database using the CS approach. The authentication process is considered to have successfully confirmed the individual's identification if the comparison results in a match score higher than the previously established threshold.

In summary, the proposed FR method incorporates image processing techniques, feature extraction based on deep learning, and intelligent decision-making algorithms to develop a reliable and effective system for footprint-based biometric verification. Identifying infants and forensic science are two examples of applications well-suited to this technology.

4 Results and Discussions

4.1 Dataset

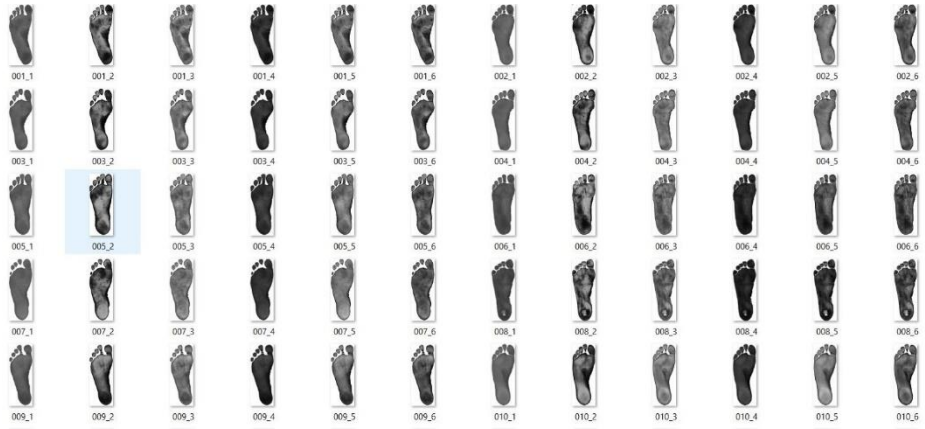

Fig. 2. The first ten categories within the dataset as an example [29].

The dataset employed in our evaluation of the proposed technique is called "BIOMETRIC 220X6 HUMAN FOOTPRINT". Its primary purpose is to establish the legal recognition of human footprints. This dataset was created using an EPSON 5500 Scanner alongside a conventional PSC machine. It consists of six multispectral footprints for each participant, gathered from 220 volunteers at different times [29]. Fig. 2 illustrates the first ten categories within the dataset as an example.

4.2 Implementation and Results

Our computational setup for the development of models encompassed a robust eight-core Intel i7 processor, allied with 16 GB of RAM and a 1 TB SSD, to ensure swift data access. The graphical computations were entrusted to an NVIDIA GeForce GTX 3070 Ti. We meticulously organized our dataset into distinct sets for training and evaluation. The training of the selected models—EfficientNetB0, MobileNetV2, and ResNet18—was conducted under uniform conditions to uphold the integrity of the results. We employed the Adam optimizer [31] with an initial learning rate of 0.001, spanning 5 epochs for the entirety of the training regime.

We have leveraged the powerful capabilities of PyTorch [30] to implement and fine-tune pre-trained CNN models for human footprint recognition. Utilizing PyTorch's comprehensive model zoo, we selected EfficientNetB0, MobileNetV2, and ResNet18 each pre-trained on the ImageNet dataset and adapted their architectures to the specific requirements of footprint classification. The implementation process involved modifying the models' final layers to correspond with the number of footprint categories and employing data augmentation to enhance the models' generalization abilities.

We fine-tuned the models and significantly reduced training and validation times by utilizing GPU acceleration while closely monitoring the models' performance to mitigate overfitting. This PyTorch-based approach resulted in high validation accuracies for all models, with ResNet18 being the standout in accuracy and speed.

Table 1. Performance comparison of three pre-trained CNN models for FR

	Val Accuracy	Train Accuracy	Train and Val Time	Model Size
EfficientNetB0	98.45	99.27	12m 40s	20.1 MB
MobileNetV2	98.72	99.44	9m 50s	12.19 MB
ResNet18	98.90	99.47	6m 43s	46.3 MB

Evaluating three pre-trained CNN models for human (FR) has yielded important findings. As Table 1 delineates, all models demonstrated high accuracy, indicating the viability of employing such networks for FR.

The EfficientNetB0 model showed a validation accuracy of 98.45% and a training accuracy of 99.27%. Its performance is noteworthy given its relatively small model size of 20.1 MB, which suggests that EfficientNetB0 is highly efficient regarding the trade-off between size and accuracy. The compactness of this model could be particularly advantageous in scenarios where deployment on edge devices with limited storage and computational capacity is necessary.

On the other hand, MobileNetV2, with its smallest model size of 12.19 MB, achieved a validation accuracy of 98.72% and a training accuracy of 99.44%. This model's design is optimized for mobile devices, balancing efficiency and accuracy. It is an attractive option for mobile or embedded applications where footprint recognition needs to be performed on-device.

ResNet18, while the largest model at 46.3 MB, achieved the highest validation accuracy of 98.90% and a training accuracy of 99.47%. It also had the shortest training and validation time of 6 minutes and 43 seconds, demonstrating its efficiency in processing and its capability to achieve high accuracy, which could be essential for time-sensitive applications.

The differences in performance and model characteristics highlight the importance of context when selecting a model for FR tasks. If accuracy is paramount, ResNet18 stands out as the superior choice. However, for applications requiring a balance between size, speed, and accuracy, MobileNetV2 and EfficientNetB0 present themselves as compelling alternatives.

These results also open avenues for future work, which may include further optimization of the models for even greater efficiency, investigating their performance with different sizes and compositions of FR datasets, and exploring their real-world applicability in various conditions and environments.

In conclusion, selecting a pre-trained CNN model for FR should be guided by the specific requirements of the task at hand, considering factors such as model size, speed, and accuracy. This study provides a foundation for making such decisions and underscores the potential of CNNs in revolutionizing the domain of human footprint recognition.

5 Conclusion

In this paper, our exploration into applying pre-trained CNN models for footprint recognition has unveiled their considerable potential in transforming this specialized domain. We have achieved remarkable accuracy by meticulously fine-tuning renowned CNN architectures, specifically MobileNet, ResNet, and EfficientNet, on the BIOMETRIC 220X6 HUMAN FOOTPRINT dataset. This work has inspired the adaptability of pre-trained CNN models to the challenges of footprint recognition, emphasizing their capability to determine complex patterns and variations with precision. Our findings prove the strategic leverage of deep learning technologies in enhancing the accuracy and efficiency of footprint analysis. In our study of pre-trained CNN models for human footprint recognition, we have identified distinct strengths across the models tested. EfficientNetB0 delivered high efficiency, achieving 98.45% validation accuracy with a modest model size, suggesting suitability for environments with resource constraints. MobileNetV2 offered a compelling balance of footprint recognition accuracy at 98.72% and a minimalistic design optimal for mobile and on-device applications. ResNet18 emerged as the top performer in accuracy with 98.90%. It was the fastest in training and validation time, making it a prime candidate for time-critical and accuracy-focused tasks. These findings articulate the trade-offs between accuracy, computational efficiency, and model size, guiding the appropriate model selection for specific footprint recognition applications and setting a precedent for future research to further refine these models for enhanced performance.

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Secure Mobile Application

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Abstract. This paper provides a comprehensive review of threats, measures, international standards, and case studies on cybersecurity in mobile applications. Furthermore, a secure mobile application has been created to assist employees at a company with a high production volume and numerous employees in accessing basic company information. The goal of the application is to provide employees with quick and easy access to necessary information without relying on company computers. Our findings show that vulnerabilities in mobile applications can lead to serious risks. Therefore, in our case security is a top priority, as the application contains personal employee data. Therefore, various security controls have been implemented to protect against cyber-attacks. These controls include measures to safeguard personal information, establish authorization mechanisms, and ensure communication security. The application is specifically designed to enhance employees' daily routines and streamline access to information. By prioritizing security, the application aims to facilitate more efficient and secure internal processes.

Keywords: Mobile application, Security, Secure Mobile Application, Flutter, Cyber Security, Cyber Attack, Cross-platform.

1 Introduction

The increasing common use of mobile devices, the increasing use of mobile applications, and the increasing trust in these applications have also increased the security risks as they may contain personal information and sensitive data. Recently, the need to secure mobile applications has been growing rapidly [5].

The widespread use of mobile applications has greatly increased cyber security issues. The expansion of the population has led to an increase in internet usage, and with everyone having easy access to the internet, cyber threats have increased significantly. Mobile applications are of particular importance in this context because they often contain personal and sensitive data, making cybersecurity a critical requirement for these applications.

Today, mobile applications allow people to perform a wide range of activities, from communicating and shopping to banking and health tracking. However, the widespread use of these applications has allowed cybercriminals to expand their targets. Individuals' personal information, financial data and other sensitive information have become valuable targets for cyber attackers [7].

Mobile app security should include encryption techniques, strong authentication, periodic security updates, and user awareness training. In addition, incident monitoring and detection capabilities are also important to respond quickly to cyber-attacks. In this context, mobile application security is not only the responsibility of developers but also of users. Using strong passwords, choosing trusted apps, and being wary of requests from unknown sources are important steps to mitigate cybersecurity risks [12].

This study aims to provide a general understanding of mobile application security while reflecting the latest technological developments and the current state of the art in cybersecurity.

This project will be an example of a mobile application that meets cyber security standards, stores user data securely and includes security measures. With the knowledge gained in the light of the concept of mobile application security, all steps of secure mobile application development will be explained in detail. It aims to emphasize the importance of developing a secure mobile application by combining knowledge in the field of mobile application security with a practical example.

2 Overview of Mobile Apps

Mobile apps are software that run on portable devices and usually serve a specific purpose to users. Mobile apps run mostly on portable devices such as smartphones and tablet computers and usually fulfill a specific function. In today's digital age, mobile apps are an essential part of most people's daily lives. From social networking and entertainment to productivity and business, mobile apps play an essential role [8].

Mobile apps are created using various programming languages and frameworks and are available for download from app stores such as the Apple App Store or Google Play. The two most popular operating systems in today's mobile world are Android and Apple iOS. While both operating systems have a significant presence in the consumer space, Android holds the majority of the market share [7].

Mobile apps are designed to provide a wide range of functions and services, taking into account the demands, constraints, and capabilities of the devices on which they are built. For example, a gaming app can take advantage of the iPhone's accelerometer. Other examples include games, social media platforms, email clients, and banking applications. They can also be used to access information such as news and weather updates and perform tasks such as online shopping and travel booking [5].

2.1 Mobile Apps Use Cases

Mobile applications have become an integral part of our lives, thanks to the widespread use of smartphones and easy access to the internet. They provide practical solutions and enhance our daily routines. While communication remains a key feature, mobile apps serve various purposes in different areas. Social media applications enable us to stay connected with friends globally, while e-commerce apps make shopping convenient and effortless [7]. Additionally, mobile apps are widely used in sectors such as health, education, finance, and entertainment, enriching user experiences and adding value to our lives. Figure 1 illustrates the most popular categories of mobile applications. Overall, they have transformed the digital landscape, offering a wide range of functionalities and enhancing our day-to-day activities [5].

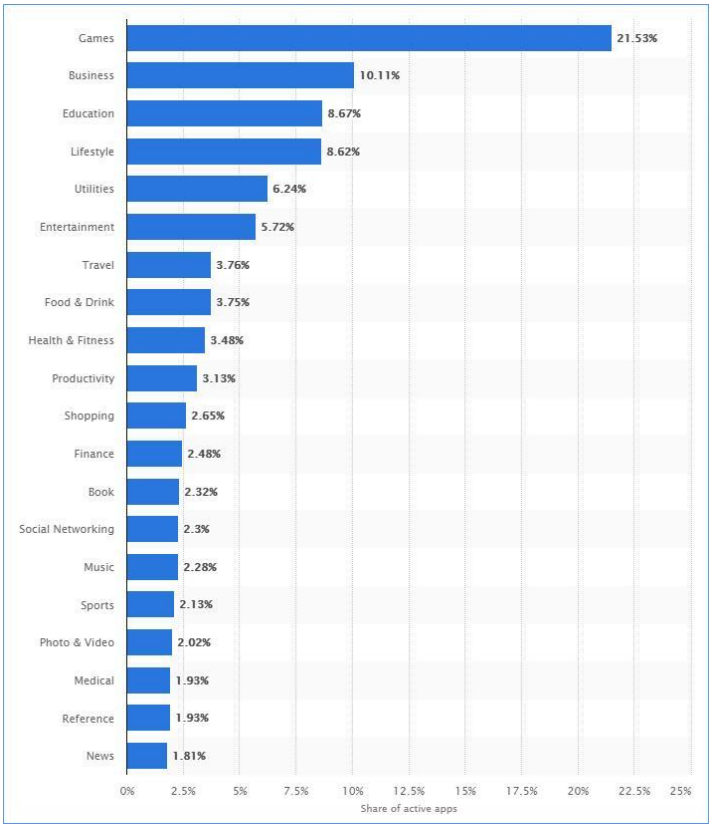

Fig. 1. Mobile application usage rate by category

2.2 Mobile Application Development Platforms by Technology

Mobile application development platforms are sets of software that provide developers with a framework and tools to create applications that run on mobile devices. Different platforms offer development tools specifically designed for different operating systems and devices. Before deciding to develop a mobile app, it is an important step to choose the platform and language that best suits your needs. In this context, mobile app types can generally be categorized into three categories based on software languages and development platforms. These are native apps, hybrid apps and cross apps. Each platform has its advantages and disadvantages. Developers choose the most suitable mobile app development platform by considering the target audience, complexity of the project, budget and other factors [2] [7].

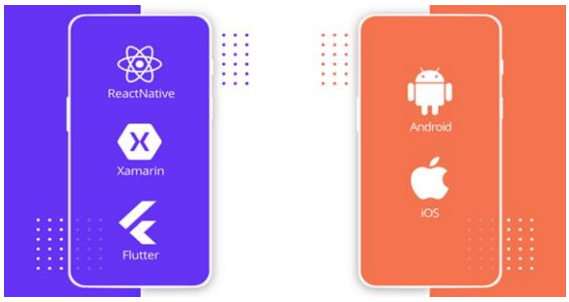

Fig. 2. Cross platfroms and native platforms. Cross platforms on the left, native platforms on the right

3 Cyber Security

Today, with the rapid increase in internet usage, mobile applications have become an integral part of our lives. These applications allow us to fulfill many important functions from communication to shopping, from financial transactions to health monitoring. However, the fact that these applications contain more and more personal data has made the issue of cyber security even more critical [6].

Storing personal data in these applications brings new responsibilities in terms of security. Cyber security means protecting the sensitive information that users share in these applications and providing a secure environment against cyber threats. With the ever-increasing number of internet-based services, the targets of cybercriminals are expanding and protecting valuable assets such as personal information and financial data becomes even more critical [10].

At this point, cyber security measures have become a major responsibility not only for application developers but also for users. Basic security measures such as using strong passwords, downloading reliable applications, and paying attention to requests from unknown sources play an important role in protecting personal information.
Cyber security is the practice of protecting computers, servers, mobile devices, electronic systems, networks and data from malicious attacks. It is also known as information technology security or electronic information security. The term applies in a variety of contexts, from enterprises to mobile computing, and can be divided into several common categories [1].
Cybersecurity measures offer businesses a range of benefits. They enhance information security, strengthen customer trust, maintain business continuity and minimize reputational damage. They also play an effective role in ensuring legal and regulatory compliance and protecting data confidentiality and integrity. Therefore, cybersecurity is critical to the sustainability and competitive advantage of businesses in today's digital world.

3.1 OWASP

The Open Web Application Security Project (OWASP) is a global initiative focused on improving web application security. It was founded in 2001 and is made up of a community of volunteers who work to develop best practices and share knowledge in this area. OWASP's main mission is to create a secure environment for web applications and protect internet users.

One of OWASP's most well-known contributions is the OWASP Top 10, which is a list of the most common web application security risks. This list is regularly updated and serves as an important reference for developers and security professionals. The text presents a comparison of the OWASP Top 10 lists from 2016 and 2024.

Overall, OWASP plays a crucial role in web application security by providing guidelines, project tools, and educational resources. Its efforts contribute significantly to the field of cyber security and help ensure the safety of internet users.

Comparison Between 2016-2024		
OWASP-2016	OWASP-2024-Release	Comparison Between 2016-2024
M1: Improper Platform Usage	M1: Improper Credential Usage	New
M2: Insecure Data Storage	M2: Inadequate Supply Chain Security	New
M3: Insecure Communication	M3: Insecure Authentication / Authorization	Merged M4&M6 to M3
M4: Insecure Authentication	M4: Insufficient Input/Output Validation	New
M5: Insufficient Cryptography	M5: Insecure Communication	Moved from M3 to M5
M6: Insecure Authorization	M6: Inadequate Privacy Controls	New
M7: Client Code Quality	M7: Insufficient Binary Protections	Merged M8&M9 to M7
M8: Code Tampering	M8: Security Misconfiguration	Rewording [M10]
M9: Reverse Engineering	M9: Insecure Data Storage	Moved from M2 to M9
M10: Extraneous Functionality	M10: Insufficient Cryptography	Moved from M5 to M10

Fig. 3. OWASP list of types of cyber-attacks between 2016-2024

3.2 Cyber Security in Mobile Apps

Mobile applications are important tools that facilitate the daily lives of users in almost every field and bring many services to their fingertips. However, the fact that these applications process and store user data brings cyber security threats. Cybersecurity in mobile apps is critical to protecting users' personal information, financial data and other sensitive information [10].

The first important point is for mobile app developers to focus on security. Security should be considered throughout the app development process and security measures should be integrated from the outset. If vulnerabilities are not identified and fixed early in the development process, serious security weaknesses can occur once the application is deployed [1].

Strong encryption methods used in mobile applications are also important to enhance cybersecurity. User data, communication channels, and storage should be protected with strong encryption algorithms. This serves the purpose of protecting users' privacy by securing their information against unauthorized access.

The use of up-to-date and secure software is also an important defense mechanism against cyber threats in mobile applications. Regular security updates by developers and integration of these updates by users help to minimize security vulnerabilities.

Security measures such as two-factor authentication should also be implemented in mobile apps. This prevents unauthorized access to users' accounts and adds a layer of security. During users' transactions within the app, especially financial transactions, two-factor authentication can reduce the security risk.

Finally, cybersecurity in mobile apps should be combined with user education. Users need to pay attention to basic security principles such as using strong passwords, downloading trusted apps and avoiding unknown sources. User awareness reduces the weak links in cybersecurity and promotes more secure mobile app usage.

In conclusion, cybersecurity in mobile apps is a combination of developers, encryption technologies, up-to-date software, and user education. This unity enables users to safely use mobile apps and protect their sensitive information [11].

Fig. 4. OWASP list of types of mobile cyber-attacks

3.3 Common Security Vulnerabilities in Applications

For effective protection against cybersecurity issues in mobile applications, it is crucial to continuously review and update security measures, not only during the application development process but also throughout the usage phase [3].

1. Data Leaks: One of the most common cybersecurity issues in mobile applications is the unauthorized acquisition of users' personal information. Among these pieces of information are usernames, passwords, financial data, and other sensitive details.
2. Weak Password Policies: The use of weak passwords by users or the absence of secure password policies in applications can lead to easy compromise of accounts.
3. Poor Network Security: Mobile applications are often accessible from various networks. However, networks with open or weak security protocols provide opportunities for attackers to interfere with user data.
4. Lack of Updates: If mobile app developers fail to update their applications regularly, security vulnerabilities in older versions may become targets for attackers.
5. Poorly Designed Authentication and Session Management: Weak authentication methods or poorly designed session management can allow attackers to gain access to user accounts.

3.4 Types of Cyber Attacks in Mobile Apps

In mobile apps, various types of cyber-attacks can pose security threats. Here are some common types [11]:

1. Phishing Attacks: Phishing attacks often involve the use of deceptive communication to trick users into divulging sensitive information. This can include fake emails, messages, or websites that mimic legitimate sources [3].
2. Man-in-the-Middle (MitM) Attacks: In a MitM attack, an unauthorized third party intercepts and potentially alters the communication between two parties without their knowledge. This can lead to data interception or manipulation.
3. Insecure Data Storage: Insecure data storage occurs when mobile applications fail to adequately protect sensitive information stored locally on the device. This could involve storing passwords, authentication tokens, or other sensitive data in plaintext or with weak encryption.
4. Malware (Malicious Software): Malware can take various forms, including malicious apps, adware, or spyware designed to compromise the security of a mobile device. It can be spread through app downloads, email attachments, or compromised websites.
5. Security Vulnerabilities and Exploits: This involves exploiting weaknesses in the application code or design. Common vulnerabilities include injection attacks, buffer overflows, and other coding errors that can lead to unauthorized access or data breaches.

3.5 Potential Solutions for Combating Cyber Attacks

In an era dominated by digital connectivity, the escalating threat of cyber-attacks poses a significant challenge for individuals, businesses, and organizations. Developing a robust cybersecurity strategy is imperative to safeguard sensitive data, maintain business continuity, and protect against evolving cyber threats [4][6].

Security Training and Awareness Programs

1. Phishing Awareness: A significant portion of security training should focus on phishing awareness. Employees need to be able to identify phishing emails, malicious links, and potentially harmful attachments. Simulated phishing exercises can be conducted to test employees' ability to recognize and respond to phishing attempts.
2. Password Management: Training should cover the importance of strong, unique passwords and the risks associated with password reuse. Employees should be encouraged to use password management tools and enable multi-factor authentication whenever possible.
3. Device Security: Employees should be educated on the importance of keeping their devices (computers, smartphones, etc.) updated with the latest security patches. Mobile device security, including the risks associated with using unsecured Wi-Fi networks, should also be part of the training.
4. Data Protection and Privacy: Employees should understand the organization's policies regarding data protection and privacy. Training should cover the proper handling and disposal of sensitive information, as well as the potential consequences of data breaches.
5. Regular Updates: The threat landscape is constantly evolving, so it's essential to provide regular updates and refresher courses to keep employees informed about new threats and security best practices.

Using Strong Passwords

In today's digital world, our online accounts and personal information are increasingly under threat from various risks such as cyberattacks, data breaches, and phishing attempts. Therefore, using strong passwords is of vital importance as the first line of defense in cybersecurity. Using strong passwords is the foundational step in cybersecurity [6].

1. Length: The length of a password is a fundamental factor in enhancing security. It is recommended to use a password of at least 12 characters.
2. Complexity: The complexity of a password is determined by the inclusion of uppercase letters, lowercase letters, numbers, and special characters. This feature makes it harder for the password to be guessed.

3. Avoid Personal Information: Ensure that the password does not contain easily guessable information such as personal names and birthdates.
4. Regular Updates: Regularly updating passwords helps minimize potential damage in case of a security breach.

For users to use strong passwords, developers should design their applications to encourage users to use strong passwords.

Use of up-to-date Software

Keeping operating systems, applications, and antivirus software up to date and enabling the automatic update feature of your software are important steps to combat cybersecurity [6].

Trusted Networks and VPN Usage

Mobile users often connect to open Wi-Fi networks, exposing them to security risks. Using a VPN (Virtual Private Network) can help users encrypt their data, creating a secure network traffic environment.

Security Testing and Audits

Regular security testing during the app development process is crucial. This helps identify and rectify potential security vulnerabilities early on. Network security audits assess whether security measures function effectively during the application's operation.

4 Application

Based on the findings obtained from the conducted literature reviews, an application project has been developed on mobile application cybersecurity. In this project, some of the cybersecurity measures have been implemented and tested. The project was developed using the Flutter framework. Flutter is a cross-platform framework for developing high-performance apps and native interfaces. Launched in 2016 by Google as open source and free of charge, Flutter can run on Android and iOS as well as Fuchsia. Google has chosen Flutter as an application-level framework for its next-generation operating system [9].

The application created within the scope of the project was developed on the Flutter framework based on the Dart programming language with its unique features and user-friendly interface. This resulted in a powerful and interactive mobile application that provides high performance and consistency on various platforms.

Cybersecurity Measures Within the Application

1. Create a strong password
2. Not showing the user detailed information
3. Encryption of sensitive data
4. Pinning the SSL certificate
5. Up-to-date library usage
6. Broken URL verification
7. SQL injection prevention

Conclusion

This paper provides a comprehensive review of threats, measures, international standards, and case studies on cybersecurity in mobile applications. Our findings show that vulnerabilities in mobile applications can lead to serious risks. Personal data and passwords in many applications such as social media, finance, e-government, etc. make security in mobile applications extremely important, so cybersecurity of mobile applications is a major concern in many industries. Our research has revealed that security weaknesses in mobile applications are caused by a variety of factors. The mobile application developed as a result of this research provides a secure environment against many types of cyber attacks. These include weak encryption methods, authorization and authentication deficiencies, failures in software update processes, and the use of outdated libraries. The results of this study will help to understand the vulnerabilities in mobile applications and clarify the steps to be taken to contribute to the provision of more secure services.

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Information Management Systems In Increasing Anytime Anywhere Access To Information With Covid-19

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Abstract. The most important resource for businesses to maintain their existence and achieve sustainable competitive advantage is undoubtedly the unique knowledge they have. Just having this knowledge is not enough. Storing information, keeping it ready or use at anytime, and sharing and evaluating it areas important as information. For this purpose, every business uses various information management systems. Especially with the developing technology, speed, reliability, and flexibility come to the fore in studies carried out electronically. Due to the pandemic, we have experienced since 2020, it has become clear how important these systems are in working and education life and the need to react quickly to any changes that may occur. In this study; The view of the use of time-space independent information access processes, which were previously known under various names such as working from home, smart working, e-working, distance education, and online education and whose application was relatively less, but entered the lives of a larger segment of people with the pandemic, from the information management systems window and the current information The reaction of management systems to changes will be examined.

Keywords: information access, anytime anywhere access, KMS, Covid-19,e-learning, remote working

1. Introduction

In a world undergoing globalization where borders are disappearing due to rapidly advancing technology, the most crucial tool for businesses to gain a competitive edge is undoubtedly their knowledge. In today's economy, which is ruled by knowledge, managing, sharing, protecting, and ensuring the availability of information for meaningful use at any time is as important as the existence of the knowledge itself. To achieve this, businesses, institutions, and universities develop and utilize fast, reliable, effective, and cost-efficient information management systems.

Due to the extra ordinary rapid advancements in communication technologies, access to and usage of information are also changing. Mainly, the increasing prevalence and speed of the Internet, the development of mobile and smart devices, and various innovations within the realm of Industry 4.0 (such as Cloud Computing, Internet of Things (IoT) etc.) are creating a phenomenon of independence in terms of accessing information regardless of time and space.

In the business and education sectors, especially in recent years due to the COVID-19 pandemic, traditional practices such as physically attending work, classes, or training have been replaced by online or remote work and education. Although the so-called new normal has been established with changes in pandemic conditions, it is evident that remote work and education will now be an undeniable reality as a result of the experiences gained during this process.

During this period, meetings, lessons, and interviews were conducted via online platforms. Email services were used more for communication compared to the previous period. Reporting achieved online, and many other services were provided virtually.

During such an unexpected crisis, the most helpful element is technology and the opportunities and capabilities it provides. Throughout the pandemic, technology was once again used to minimize the effects of closures, restrictions, and other measures taken. It is believed that all these developments put an extra burden on existing information management systems and that businesses, institutions, and universities that are prepared for such an extraordinary situation and react quickly are ahead of the competition. For this purpose, firstly, access independent of time and space and issues related to distance education and working will be discussed, followed by an examination of the use of processes for accessing information independent of time and space within the scope of information management systems and the response of existing information management systems to these changes.

2. Anytime, Anywhere Access To Information

The term "information retrieval" was first used in his master's thesis by Moors, who made many innovations in the fields of computers and information[1]. "Information retrieval" is defined as the technique and process of collecting, classifying, cataloging, storing, and searching for desired information from large amounts of data[2]. Increased mobility through the use of mobile technologies has provided both individuals and organizations with the ability to work in previously unexpected and new ways. The rapidly developing technological infrastructures and products offered by technology contribute immensely to this development.

These developments are expected to further enhance mobile working and distributed collaboration in working arrangements [3]. According to Tarasewich and Merrill (2002), although existing technology is limited in certain aspects (bandwidth, battery life, etc.),communication is no longer restricted by cables or physical boundaries. People can communicate with each other at any time of the day or night, and users can access their data and systems from anywhere in the world. Devices can communicate with other devices or systems without the need for human intervention[4].

However, thanks to the extraordinary development in information and communication technologies and the resulting speed of change, such constraints have now been eliminated. Users can access information independently at any time without being restricted by time or location [5]. The term "access from anywhere, anytime, and from any device" (Anytime, Anywhere, Any Device), explained by Xavier Dalloz as the equivalent of the concepts of mobility and ubiquity, refers to the user's ability to connect to a network and therefore access information without anytime, location, or device restrictions [6].

When it comes to information access independent of time, space, and even device, processes such as accessing social networks, e-commerce applications, game/music/entertainment applications, surfing the internet, performing e-banking transactions, and messaging with mobile and smart devices, which are an integral part of daily life, come to mind. In this study, apart from these mentioned applications, two other areas related to the subject will be examined. The first is distance learning (e-learning, online learning, etc.), which is a phenomenon frequently encountered in literature studies and is now widely adopted. The other field is remote work (e-work, remote working, etc.), which has become widespread with the pandemic period, although its history is much older.

REMOTE LEARNING (E-LEARNING)

E-learning is a method that facilitates learning and teaching activities in educational environments using information technologies such as intranet, extranet, and the internet. This method, which enables the management of all kinds of information and facilitates access to information assets for everyone, is especially effective when the teaching and learning elements are geographically distant and in separate environments [7].

Distance Learning, on the other hand, refers to education that is delivered synchronously or asynchronously using more than one technology, where the student and the instructor are in different places. The technologies used here include the Internet, which enables one-way or two-way transmission via open broadcasts, closed circuits, broadband lines, fiber optics, satellite, or wireless communication devices [8].

The learning environment in which information and communication technologies are used to distribute and apply all kinds of resources related to the course over the Internet is called online learning. In this type of learning, physical boundaries disappear, and communication between students, as well as with teachers, becomes online. This learning environment, where communication can be synchronous or asynchronous, is favored by many institutions for reasons such as low cost and ease of access regardless of time and place [9]

Despite the differences between these types of learning that categorized as distance learning, e-learning, or online learning, the common point is using information and communication technologies to access these environments [10]. Online learning, as discussed in this study, is defined as access to learning experiences through applying technology.

REMOTE WORKING, TELEWORKING, TELECOMMUTING

The concept of remote working has emerged due to the flexibility afforded by information technologies in the workplace. Working from home, which involves performing part or all of one's work from house for reasons such as cost or time, is known as telecommuting in foreign literature [11] .

In remote working, also known as working from home or teleworking, employees do not need to gather and work in a central location such as an office, warehouse, or store. More companies are allowing remote work thanks to advancements in cloud computing, online meeting software, and private virtual networks [12] .

This form of work, commonly referred to as 'telecommuting' in the United States and 'telework' in Europe, is facilitated by information and communication technology, and jobs in these fields appear to be more suitable for remote work. It has been widespread in various fields for many years, especially in the IT sector, banking, education, insurance, etc. [13] .

The evolution of teleworking can be seen as intelligent working, which is expected to have positive potential for both employers and employees. Smart working involves individuals performing remote work smartly and innovatively using communication devices. From this perspective, employees will adapt positively to the latest information technology environment without time and space restrictions. Thus, employees with the title of intelligent will be able to reach maximum value, be more productive, have temporal and spatial flexibility, and increase their creativity in better working conditions [14].

3 Information Manegement and Information Management Systems

Information is the most valuable resource an organization has [15]. Since information forms the basis of information management [16], it needs to be managed properly.

Knowledge management (KM) helps businesses deliver better products and services in response to customers' ever-increasing demands for flexibility, speed, and quality. Due to all these features, it constitutes an important part of general business management.. Knowledge management includes systematic analysis, planning, acquisition, creation, development, storage, and use of information [17]. The biggest challenge in information management is storing and making available information, that is, integrating it, rather than producing it. If information is not shared, it creates limited organizational value. The ability of employees to incorporate and apply the knowledge derived from their expertise is the basis for businesses to achieve sustainable competitive advantage [18].

Information management is the management of an organization's information resources to increase performance [16]. Using the knowledge management process not only increases staff productivity and the effectiveness of decision-making processes, but also increases commitment through flexibility and participation [19]. The creation and transmission of knowledge are defined as classical methods such as face-to-face meetings (planned or unplanned), personnel development, and rotation. However, the globalization and virtualization of markets and businesses reduce the effectiveness of these classical methods. Therefore, these methods should be supported by more efficient technologies. However, this support does not mean the free circulation of information within the business [18].

For achieving proper information management in an organization, the main factor is the developing and implementing an information management system (KMS) that manages the organization's information naturally [17]. "From a technical perspective, information systems are an integrated system consisting of the combination of technology, procedures, software, and personnel that carry out the activities of collecting, processing, storing, organizing, and transmitting the information necessary for decision-making and control operations in the organization" [20].

KMS has been defined in different dimensions by different scientists. According to one definition, it is a tool or technology that supports information management. Another definition of IMS is the creation of information repositories, improving information access and sharing, as well as communication through collaboration, improving the information environment, and managing information as an asset for an organization.

In this context, IMS can be defined as tools or Information and Communication Technologies (ICT) that can be used to store, disseminate, collaborate, and identify information resources to support the production, acquisition, sharing, retrieval, and use of information to increase access [21].

Information management systems, whose principal goal is to shorten the decision-making process by increasing the information processing capacity of the enterprise, serve the following purposes: to access information easily, to process the obtained knowledge and make it usable, to contribute to the formation of new strategies with statistics, analysis, and reporting functions, to create cost and time efficiency, to increase customer satisfaction by helping to provide better quality service [22].

Information management systems have three widespread stages: (a) Coding and sharing best practices to transfer them internally. (b) Creating corporate information directories by identifying, classifying, and coding their existing internal capabilities, as organizations have a lot of confidential and uncodified information.(c) To create information networks that enable users to communicate quickly and simply [23].

Technology is the most effective element in facilitating information management as long as it is effective. The technology in question may consist of both software and hardware elements. For example, technologies that provide environments that facilitate information sharing, such as Web 2.0 and video conferencing, can serve this purpose [21].

4 Covid-19, Information Access And Information Management Systems

Changes have begun occurring in all these definitions of distance working, online learning, knowledge management, and knowledge management systems. The Covid-19 pandemic has had a major impact on healthcare systems, businesses, schools, and the economy. Telemedicine, remote work, and online education have become essential to help slow the spread of corona virus in the community. The pandemic has created a rapid demand for efforts to use innovative technologies to deal with the harms of COVID-19 in our lives [24].

Throughout this period, many aspects of daily life were interrupted by long-term quarantines. There have been unprecedented effects both on people's personal lives and on the activities of businesses that want to maintain their existence. While many businesses have had to stop or reduce their operations, others have evolved to use new digital systems to adapt their working conditions and models to pandemic conditions [25]. A crisis requires rapid response. In this intervention, it is undoubtedly necessary to use fruitful information management activities.

Effective information management activities both support decision makers in the efficient use of strategic resources and develop policies that will help the organization survive by minimizing the damage of the crisis. In doing this, information management functions to facilitate crisis management [26].

For this purpose, some measures have been taken, particularly to sustain education and business life. In countries such as Japan, India, and Russia, learning continued through pre-recorded/interactive video lessons shared on online platforms such as Zoom, Google Meet, YouTube, Classi, Google Classroom, and Google Drive. In England, schools with the means turned to online platforms, while those with lower budgets used low-cost systems such as Class Dojo and Google Classroom. In Turkey, primary and secondary education was continued with the Education Information Network (EBA) [27].

According to UNESCO's 2020 report, more than 90% of students worldwide have been directly or indirectly affected by lockdowns and the emergency shift to online learning. According to the organization's 2021 report, almost 1.5 billion students worldwide were affected by these changes in education provision, and approximately 800 million students experienced critical difficulties due to educational disruptions[28,29]. UNESCO also launched an organization in March 2020, bringing together partners from various sectors under the name of the Global Education Coalition. The aim is to mobilize support to alleviate these disruptions by coordinating local, national, regional, and global interventions to ensure the continuity of learning. For example, the Global Learning House provides 1 million students access to free additional education anytime, anywhere[28].

In the field of higher education, the Council of Higher Education (YÖK) in our country stated in its statement that there are currently Distance Education Centers (UZEM) in 123 universities, and that the necessary training on distance education is given to faculty members and students in newly established universities with the Learning and Teaching in Higher Education in the Digital Age course. It has been stated that as of March 23, 2020, universities with UZEM infrastructure will be able to start distance education simultaneously/asynchronously, and for universities that do not have the opportunity, the open course materials pool created within YÖK can be used [30].

Durak et al. (2020) and whose participants included UZEM officials and personnel in the IT department, they conducted a study on the efforts of universities to convert to online education at the beginning of the pandemic. Among the universities participating in the study, only six held courses simultaneously. Most universities use live course software and learning systems. Another striking observation is that faculty members have difficulties adjusting to distance education. The study also suggests that universities need a solid infrastructure for distance education [31].

Karadağ et all. (2021) examined distance education in a total of 30 universities in Turkey, 20 whom are state and ten foundation universities, as service providers of distance education. The study examined software and hardware infrastructure, support staff and human resources, distance education budget, and future projections. It concluded that there are inadequacies in the participating universities in terms of human resources, software and hardware infrastructure, content production capacity, and distance education budget [32].

Abdellatif et al. (2023) conducted a study with 381 university students in the United Arab Emirates concluded that while the necessary infrastructure and facilities for distance learning existed, there was a general lack of digital competence among the students, and they had difficulties using the learning tools required for distance learning [33].

In online learning, dependency on technological devices and the internet is at the highest level and instructors and students with poor connection quality face access barriers. The study highlighted the problems encountered by a retired faculty member regarding the effects of COVID-19 and online learning on instructors and teaching. The faculty member gave the example of a student who wanted to take an online semester exam, stating that students with old technological devices have difficulty meeting some of the technical requirements of online learning. He also mentioned that one student sent an e-mail asking whether the course would still be held on the specified date [34].

The success of online learning from the student's perspective is assessed by accessibility(i.e., having appropriate devices/connection/software) and autonomy (i.e., ability to set goals, manage time, and avoid distractions). However, the focus of success is on the instructors. Student-centered design, social activity, and peer collaboration are crucial in creating online learning [35].

The Covid-19 pandemic has initiated a comprehensive, sudden, and dramatic digital transformation in society. The pandemic has caused an extraordinary digital leap in daily life, including education. Suddenly, entire generations of children had to manage and master digital tools to attend their mandatory principal education. Teachers and schools have been forced to lead this sudden, unexpected digital transformation of children's principal education without being well prepared. Although digitalization in education has been a current issue in different disciplines for ages and digital tools are widely used in schools, teachers, schools, and education management are inadequately prepared to act as leaders and change agents in digital transformation [36].

While many organizations began developing strategies for a digital workplace before the COVID-19 pandemic, the outbreak of the disease has forced many organizations to launch new initiatives that enable them to accelerate the transformation to a digital workplace. Organizations have rapidly implemented various digital infrastructures and tools to provide uninterrupted service to their customers [37]. Digital transformation efforts have been increasingly ongoing for a certain period via increasing use of innovative technologies to replace or improve traditional transaction processes. However, with the onset of the pandemic, which almost eliminated physical interaction, these transformation processes accelerated. These regulations have created a ripple effect on other processes and production factors in businesses [38].

The rapid transition to a remote working environment has presented many challenges, as the implementation of remote working during the pandemic is broader and deeper than most organizations realize [39]. Although remote work does not involve physically going to the workplace, employees perceive that they are working more than before and have encountered some difficulties. These difficulties include disruptions in effective communication with other employees, problems with internet or printer-like systems that enable remote working, and the inability to spare time for private life and the inability to manage time effectively [40].

Remote workers will face communication problems in case of internet disruptions. Additionally, since they will not be part of the one-on-one meetings and meetings that routinely take place in the physical working environment, will be delays in communicating decisions and transferring information. This way of working will also be a problem for older employees who are not knowledgeable about technology [41].

While there was centralization in businesses before the pandemic, remote access had to be provide during this period. Therefore, it was necessary to make fundamental changes regarding structural regulations and security. All personnel working remotely, must be ensured with safe access to the system and work. However, the increase in cybercrime within the European Union during the pandemic, should also be taken into consideration [39].

Remote working is a practical way for many organizations to maintain environment-independent operations. The business requires to have the proper network infrastructure to support a remote workforce. A sudden increase in remote workers can cause a massive, quick increase in traffic, straining overall network resources. In this situation, increasing connection qualities and enabling wireless connections with commercial-grade network connections, providing employees with mobile devices and access points for remote connection may be invaluable solutions [37].

The concept of using and increasing an organization's intellectual capital is one of the fundamental pillars of knowledge management and is directly related to the future of work. One of the elements of intellectual capital is structural capital, which includes existing technologies, systems, and information resources. To overcome the disruptions caused by the pandemic, businesses both used their existing intellectual capital and had to create new intellectual capital. The result of these efforts has generally been an increase in structural capital. That is, using/increasing existing information resources, understanding technological interactions and technologies used, and increasing stakeholders' knowledge of organizational capabilities, which may include how new technologies can be used [38].

This process we are experiencing has been a period when the word 'digital' came to the fore in every field, from health to economy, from treatment to education, and these fields aimed to find a place for themselves in the new digital world. It has been cleared that employees, regardless of their field, need up-to-date and accurately processed data to be successful, these data to be analyzed and given meaning in a limited time, and the processed data using in decision-making before taking action. In this respect, information management systems will be continue to become a principal tool to ensure the functionality of societies, states, and institutions [42]

5 Conclusion

There have been some changes in our lives in this period that defined as the new normal that we have stepped into with the disappearance of the pandemic risk. Education and business life are also the areas most affected by this change. The biggest weapon used since the peak days of the pandemic to minimize the damage is undoubtedly technology and the opportunities it provides. Thanks to technology that helps change, new regulations have been made in education methods, ways of working, and ways of accessing information. When the studies are studied, it is understood that KM infrastructures can react to this change even if there are problems, but there are more issues on the user side in terms of problems such as digital literacy, readiness, and the end device owned. However, the difficulties experienced during the change, the problems encountered, or the positive aspects identified were largely examined from the eyes of employees, students, or those who benefited from these opportunities. There are few studies examining the extra workload imposed by the change on the information management/learning management systems used, technical competence/competence status in these areas, design/budget capacities, and whether existing systems can effectively respond to this crisis caused byte pandemic. It has concluded that investigations and studies in these areas can help to create an productive distance learning/working infrastructure.

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Digitalization of the Forwarder System

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Abstract. The project is a system for the digitalization of the forwarder system, which provides the connection between the carrier and the customer in the logistics sector. The problem addressed in the project is the lack of effective communication between stakeholders. Carrier and customer companies will be able to create their demands through the system and the suitable ones will be matched through the forwarder. In this way, transactions will be managed more efficiently. In the project, it will be ensured that the forwarder will be able to communicate with other stakeholders through the system and that the transportation operations will be monitored by each stakeholder and intervened, when necessary, in order for the operations to proceed more smoothly. Demand forecast and risk assessment will be made by analyzing data with artificial intelligence technology. Today, in a period where digital transformation is rapidly progressing, this transformation is among the priority targets in the logistics sector.

Keywords: Logistics, Communication, Software.

1 Introduction

1.1 Project Description

The project aims to revolutionize the logistics industry by addressing critical communication gaps and inefficiencies prevalent among forwarders, carriers, and customers. In today's globalized market, the movement of goods across borders necessitates streamlined communication channels and transparent processes. However, existing challenges such as fragmented communication, data discrepancies, and complexities in logistics management hinder the industry's potential for seamless operations.

To counter these obstacles, the project proposes the development of a comprehensive web-based platform. This platform will act as a unified hub where registered entities, including forwarders, carriers, and customers, can seamlessly interact, submit requests, receive quotations, and track transportation routes. By harnessing advanced

technological solutions, the platform will facilitate real-time communication, ensuring swift and transparent information exchange among stakeholders.

Carriers are companies that provide transportation services for both domestic and international shipments, utilizing various modes such as road, sea, and air transport. Carriers are responsible for delivering goods safely and on time during transportation. Customers, often small-scale businesses looking to send their goods securely at a lower cost, provide detailed information about their goods and communicate with forwarders to arrange their transportation. Forwarders are professionals who conduct market research, find customers, and coordinate international transportation and logistics operations on behalf of their clients. They act as intermediaries, selecting suitable carriers and handling all necessary processes while providing guarantees for the security of the goods [1]. Finding customers and arranging carriers can be accomplished by conducting market research, participating in industry events, and establishing communication with them.

The platform's core functionalities include enabling users to input their logistics requirements, receive instant quotations from carriers, and visualize transportation routes via an intuitive interface and stakeholders can monitor transportation processes and intervene when necessary. In the project, data analysis will be carried out using artificial intelligence technology. Using these analyses, possible risks that may arise during transportation processes will be determined and thus, the opportunity to take precautions will be provided. Moreover, the system's database feature will serve as a repository for securely storing critical data, mitigating the risks associated with data loss or miscommunication.

Through the database used on our website, the filtering feature will present past transportation processes that occurred on specific dates and suggest similar requests within the same time frame each year. This enables more strategic management of logistics operations and allows users to review similar requests based on their past experiences.

In a landscape where effective communication and data management are imperative yet under-researched, this project endeavors to bridge the existing knowledge gap. By offering a sophisticated platform and conducting in-depth research on communication dynamics, it seeks to bring innovation and efficiency to the logistics sector, fostering smoother collaborations and optimized logistical processes.

1.2 Purpose and Importance of the Project

Digitalization of the Forwarder System project aims to revolutionize the logistics industry by addressing critical communication gaps and inefficiencies prevalent among forwarders, carriers, and customers. With a sustainability-oriented approach, it seeks to provide social benefit while driving operational excellence. At local and national levels, our project strives to transform the sector by enhancing efficiency and promoting environmental stewardship.

One of its main goals is to boost efficiency and reduce costs in logistics operations. By fostering improved collaboration among stakeholders, Digitalization of the Forwarder System aims to streamline workflows and lower transportation expenses, cru-

cial for enhancing competitiveness. Additionally, it fosters collaboration among carriers, customers, and forwarders, aiming to streamline operations, minimize delays, and elevate customer satisfaction. Through enhanced coordination, the project seeks to promote efficiency and collaboration across the industry.

Moreover, this project emphasizes data-driven decision-making, leveraging its robust database and filtering capabilities. By harnessing data analytics, businesses can optimize logistics operations, including route planning and resource allocation, enabling continuous improvement and strategic decision-making. Lastly, project democratizes access to logistics solutions, particularly for small businesses, providing them with an accessible platform to manage transportation needs effectively and unlock growth opportunities.

1.3 The Innovation Originallty Element of the Project

Our project aims to address some fundamental problems in the logistics sector by rectifying the existing deficiencies. Foremost among these issues is the ineffectiveness of collaboration and communication between carriers, customers, and forwarders. Current solutions often fall short in expediting this collaboration and making communication among these stakeholders more efficient. These shortcomings can lead to delays, data loss, and misunderstandings.

Moreover, the logistics industry frequently grapples with a lack of data. Users often cannot access detailed information about past transportation operations, which poses challenges in decision-making and process optimization. Transparency can also be limited, especially when it comes to pricing and quotation. Customers and forwarders may struggle to select the best carriers. Additionally, the complexity and accessibility issues of existing logistics platforms can be a barrier, particularly for small-scale businesses or newcomers.

By using artificial intelligence technology, the project aims to develop efficient and adaptive solutions to make logistics processes more predictable and ensure operational excellence.

Lastly, the process of finding suitable business partners can be highly inefficient. Our project aims to tackle these problems and, in doing so, aspires to offer a more efficient, competitive, and user-friendly logistics platform. This will lead to more effective collaboration and communication, the provision of data-driven insights, increased transparency, and simplified partner selection processes in the logistics sector.

2 Literature Review

Digitalization of the Forwarder System is a project that aims to strengthen cooperation in the transportation and logistics sector. A few projects with similar aims towards this goal have been examined and the relevant projects are presented in detail below.

2.1 All-forward

All-forward is a platform that stands out as a global online freight forwarder, driven by the vision of creating a world where products and services can flow freely for everyone [2]. This application offers a digital solution to freight forwarders and customers in the logistics sector, addressing industry needs by enhancing the efficiency and user-friendliness of transportation processes.

The application provides users with access to detailed shipping schedules, allows them to see shipping costs if they enter their transportation information, makes it easier for them to find affordable price offers and make reservations, and allows them to track their shipments seamlessly through the system [3].

This rapidly growing network of freight forwarders has forged a strong connection with more than 6000 companies registered from more than 150 countries [4]. This global network offers significant value to the logistics industry by contributing to optimizing supply chain processes, reducing costs and increasing cooperation between parties. All-forward aims to provide its users with a reliable, fast and efficient experience in international shipping, thus allowing logistics operations to be managed more effectively.

Our project Digitalization of the Forwarder System offers a more detailed approach, especially regarding driver information. Within the scope of this project, drivers' information will be handled in more detail and thus transportation processes can be managed in a more personalized way. Additionally, routes will be displayed on interactive maps, providing users with more visual information. Different filtering options will help users find solutions more specific to their needs. Same-time recommendations for past orders will be made on an annual basis, providing users with a constantly improved and optimized experience.

Compared to the all-forward project, our project aims to go a step further by specifically emphasizing driver-oriented details and customized routes. Thanks to artificial intelligence, risk analyzes, and demand forecasts will be made. In addition, stakeholders will be allowed to intervene when necessary during the monitored ship-ment process. These differences reflect our goal of providing users with a more comprehensive and customized logistics experience.

2.2 The Lojisoft

The Lojisoft project allows you to manage your logistics processes more effectively by providing transparent data designed specifically for the needs of the company. This application provides easy access to a wide range of information, from detailed transportation schedules to driver information, from routes to truck reports.

This application, which is particularly valuable for drivers, supports business continuity by reminding them of upcoming deadlines in case of timed documents [5]. In addition, it helps carry out logistics operations in a more planned and efficient manner by having functions such as making reservations, tracking loads and voyages, and monitoring vehicle fuel expenses.

Lojisoft offers the opportunity to make profit analysis thanks to its ability to receive detailed reports. In addition, it can manage billing processes in detail and work integrated with other systems used within the company, such as accounting systems and vehicle tracking systems [6].

These integrations and various features contribute not only to time savings but also to cost reduction. Lojisoft offers a powerful tool to efficiently and transparently manage your logistics processes, enhancing your company's performance.

Compared to the Lojisoft project, the Digitalization of the Forwarder System project includes prominent differences in displaying routes on interactive maps and making regular suggestions for past orders. These differences highlight the unique advantages and features that the two projects provide to users, so that it becomes clearer to understand the unique contributions of both projects. On the other hand, our project stands out with its artificial intelligence integration, displaying routes on interactive maps and offering suggestions for past orders.

2.3 Eta Transportation

Eta Transportation is a technological fleet management system that allows creating demand by determining all details from product features to sender and receiver locations and adds value to all parties. [7]. Carriers can also receive offers by entering their own information, routes, and vehicle features. It is also possible to track loads and access invoices and orders in detail.

Especially by ensuring that trucks do not return empty on their routes, it not only increases efficiency but also creates cost advantages for both carriers and cargo owners [8]. This platform provides solutions to the needs of both carriers and cargo owners, allowing logistics processes to be managed more efficiently and economically.

Carriers have the opportunity to analyze and plan their operations more effectively by reporting completed trip lists and defined vehicles [9]. In this way, cooperation between stakeholders in the transportation sector increases and processes become more transparent and traceable.

The Digitalization of the Forwarder System project offers distinct differences such as displaying routes on interactive maps, offering various filtering options, artificial intelligence integration, and making regular suggestions for past orders on an annual basis. In addition, another important distinction in our project is that the connection between carriers and customers in the system will be provided through a forwarder.

Table 1. Comparison Chart

Feature	All-forward	LojiSoft	eTa Tasimacilik	Digitalization of the Forwarder System
Driver Detail Information	Available	Available	Not Available	Available
Routing On Interactive Map	Not available	Not available	Not available	Available
Followable	Available	Available	Available	Available
Suggestions for Past Orders	Not available	Not available	Not available	Available
Forwarder	Not available	Not available	Not available	Available
Price Offers	Available	Available	Available	Available
Filtering Feature	Not available	Not available	Not available	Available
AI Integrated	Not available	Not available	Not available	Available

3 System Architecture

This section focuses on the architecture of the system. It elaborates on how the system operates and outlines the project requirements in detail. The use-case diagrams illustrating the requirements of Digitalization of the Forwarder System project are depicted in Figure 1 and Figure 2.

In Figure 1, the general requirements for each user and the requirements that need to be fulfilled by the system are outlined. Common requirements for all users include registering to the system, logging in, editing profiles, evaluating processes, and logging out. Key system requirements include providing recommendations and sending notifications.

Figure 2 categorizes users and specifies the features each user needs to perform. Common requirements for carriers and customers include going to the request creation page, creating request forms, and viewing requests. Carriers need to offer price quotations, while customers need to track shipments. Other requirements such as communicating with other users, detailed examination of user profiles, viewing and filtering request lists, matching customers with suitable carriers, and requesting price quotations are specific to forwarder users. The web application's pages vary according to the user type. These details emphasize the project's user-centered and functional structure.

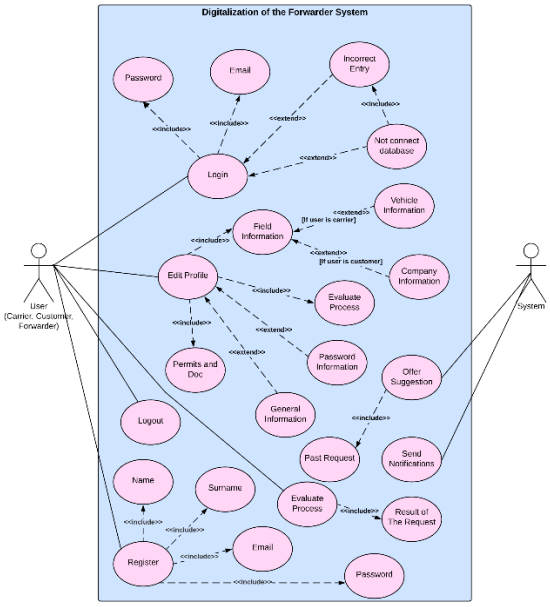

Fig. 1. User and System Use-Case Diagram

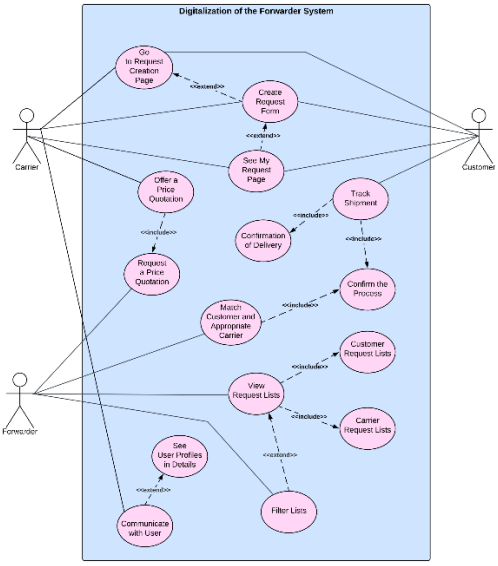

Fig. 2. Users Use-Case Diagram

The Digitalization of the Forwarder System project aims to transform the logistic industry by addressing communication gaps and inefficiencies among forwarders, carriers, and customers. It proposes a comprehensive web-based platform to streamline interactions and enhance transparency. Figure 3 shows the high-level design of the project. This design allows us to better understand the system architecture and gain information about the technologies used. Using HTML, CSS, JavaScript, React, C#, and .NET technologies, the platform enables users to submit requests, receive quotations, and track transportation routes. The reason for choosing these technologies is to create dynamic and effective user interfaces [10], provide a powerful backend [11], and offer rapid development capabilities with extensive libraries [12]. Furthermore, the platform utilizes MSSQL for its database management system, ensuring secure storage of critical data. By leveraging Google Maps API for location services and implementing the HTTPS protocol for security, the platform ensures reliable data exchange while safeguarding sensitive information.

The platform's core functionalities include inputting logistics requirements, receiving instant quotations, and visualizing transportation routes. Its database feature stores critical data securely and offers past orders as recommendations regularly, optimizing logistics processes. Through research on communication dynamics, the project aims to enhance collaboration and efficiency in the logistics domain.

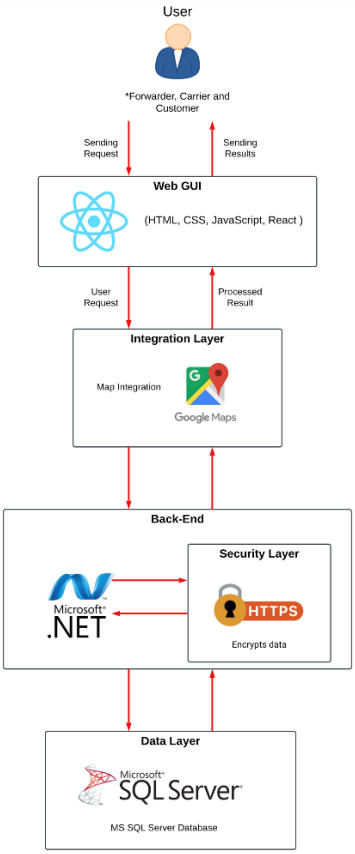

Fig. 3. High Level Design

4 Results

The results section includes evaluations based on observations in the early stages. Our project reveals that transformation and improvements in the logistics sector are possible. It shows that stakeholders here can become more productive by adopting a more collaborative approach. It is anticipated that more advantageous environments can be created with artificial intelligence-supported solutions.

In order to obtain definitive results from the project, it must be supported with more comprehensive data and analysis in the future. With ongoing studies, it is aimed to become more sustainable and to find more effective solutions to potential challenges.

As a result, our project has an effective transformation and development potential in the logistics sector. By turning this potential into reality, environmental impacts can be reduced, and resources can be used more efficiently by adopting logistics practices.

5 Discussion

The project represents a significant transformation in the logistics industry. With the integration of artificial intelligence, there is a significant transformation in logistics management. In addition to providing cost savings, this transformation allows businesses to make informed decisions. Digital transformation, which has increased especially due to the impact of the pandemic, contributes to a faster and more flexible operation in the logistics sector. For example, boutique fashion retailer Matches transformed its business into a global luxury retailer by digitalizing its business [13]. This example shows the huge opportunities that digital transformation provides for businesses.

It is possible that the project, which aims to increase cooperation and efficiency, will face some difficulties in achieving these goals. It may take time for all stakeholders in the system to adapt to this change, and the adoption and integration of innovative technologies may be required. This may cause cost and infrastructure problems. However, it highlights the expected changes and potential benefits in the sector when the project is implemented. As İbrahim Demir mentioned in his specialization thesis, by trying to make usable the theoretical information collected as a result of the studies carried out in the first phase in the technological phase [14], the real-world impact of the project will become fully understandable and will be evaluated accordingly.

6 Conclusion

The solution offered by the platform is aimed at effectively improving transportation processes and meeting industry needs. As digital transformation continues in the logistics industry, it seems that the importance of similar projects will increase. The Digitalization of the Forwarder System project can play an important role as part of this transformation and lead to innovative developments in the sector.

In the near future, studies will continue on which business areas in the project can be integrated with developing artificial intelligence technology.

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From Quantum Computing to Steganography: A Thematic Analysis Of Post - 2000 Studies at Ege University

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Abstract. The main objective of the study is to examine and summarize the studies on Cryptography conducted at Ege University after 2000. The sub-objectives are to identify different areas where Cryptography is applied at Ege University (secure communication, blockchain, etc.) and to provide resources for researchers working in the field. Fifty-eight theses obtained as a result of the search on YOKTEZ were subjected to preliminary evaluation by taking into account the title and keywords, and seven theses that were not within the scope of the research topic as a result of relevance assessment were decided not to be included in the study after reading the abstracts.In order to categorize the theses, their abstracts were read in date order, then the field titles were determined and distributed under eight main headings with a general grouping : Quantum computing algorithms, Cryptanalysis, Video Encryption, Applications of Number Theory, Applications to the Backpack Problem, Steganography Methods, Cryptology Systems and Applications, Next Generation Cryptosystems.The studies and new study proposals in all areas are summarized according to their categories and it is thought that the study will be useful for researchers who will work in the field of Cryptology.

Keywords: Cryptography, Encryption, Network Security.

1 Introduction

The ever-changing dynamics in the field of cyber security have increased the need for secure communication systems and cryptography has become an important discipline in this context. This paper aims to highlight the academic potential and scientific contributions in this field by examining the cryptography studies conducted at Ege University. The university's research in this field aims to make scientific progress in secure communication, data security, and related issues. The higher education institution's student enrolment, research and development opportunities, and educational capacity in this field make Ege University an active research center in the field of cryptography.

These original studies in the field of cybersecurity and cryptography are considered to reflect the potential of Ege University to become a reference center at national and international level. This paper aims to highlight the university's contributions in the field of cryptography and provides opportunities for future researchers to contribute to the work in this field.

2 Method

2.1 Screening of Thesis

The ever-changing dynamics in the field of cyber security have increased the need for secure communication systems and cryptography has become an important discipline in this context. This paper aims to highlight the academic potential and scientific contributions in this field by examining the cryptography studies conducted at Ege University. The university's research in this field aims to make scientific progress in secure communication, data security, and related issues. The higher education institution's student enrolment, research and development opportunities, and educational capacity in this field make Ege University an active research center in the field of cryptography. These original studies in the field of cybersecurity and cryptography are considered to reflect the potential of Ege University to become a reference center at national and international level. This paper aims to highlight the university's contributions in the field of cryptography and provides opportunities for future researchers to contribute to the work in this field.

2.2 Relevance Assessment

Fifty-eight thesis titles and keywords obtained as a result of the search on the YOKTEZ platform were subjected to a careful preliminary evaluation. Seven theses, which were considered to be inappropriate for the scope of the research topic, were decided not to be included in the study after their abstracts were examined in detail. This process helped to determine the focus area of the study more clearly.

2.3 Grouping of Theses

At this stage, the theses were systematically analysed according to the identified groups and date order. The analysis process was carried out to provide a comprehensive understanding of each thesis. The findings were expressed in summary sentences and the main points of the theses were emphasized. This method aimed to convey the content of the theses in a clear and concise manner, while at the same time ensuring that the analysis was systematized through grouping and date ordering.

3 Research Findings

1. The Number and Year Range of Theses Obtained by Keywords are presented in Table 1; however, those that did not yield results, such as <Diffie Hellman>, are not included in the table. In this context, the numerical distribution and time span of theses obtained with specific keywords were analyzed in detail.

2. The cases where the keywords we mentioned did not yield major results are not included in Table 1. This allows for a more effective evaluation by highlighting the critical points on which the analysis focuses.

3. In addition, the units in which the theses were prepared were handled with an interdisciplinary approach, with "Mathematics", "Computer Engineering", "Science and Technology", "Electrical and Electronics Engineering" among the prominent ones. This distribution is an important factor to emphasize the overall scope and diversity of the

study. This unit-based analysis provides a valuable perspective to understand the specializations and contributions of the theses in different disciplines.

Table 1. Search results by keywords.

Keyword	*Number of Thesis*	*Year Range*
cryptography	6	2006 - 2019
cryptology	5	2014 - 2022
encryption	21	2003 - 2022
RSA	5	2014 - 2017
cryptanalysis	5	2006 - 2020
AES	4	2014 – 2023
elliptical curve	1	2006
cryptographic	5	2014 – 2022
symmetric encryption	2	2017 – 2022
cryptosystem	2	2006 - 2015

4. An Analysis of Thesis Advisor Information in Relation to Historical Context: A Detailed Look at Table 2.

5. The information regarding thesis advisors presented provides a detailed account of the historical context surrounding the dissertations analyzed. The findings of this analysis indicate that all the dissertations under consideration were completed within the framework of the Faculty of Science and Literature. Each dissertation's advisor information has been meticulously examined and presented in Table 2, arranged chronologically.

6. The dissertations conducted within the Faculty of Science and Literature serve to demonstrate the significant role that academic research and scientific studies play within the context of higher education. Thesis advisors, as key figures who guide students in their academic development, contribute to the production of scientific knowledge. This analysis underscores the Faculty of Science and Literature's status as a center of education and research that offers a multidisciplinary perspective and focuses on a broad range of topics.

Table 2. Thesis and Supervisor Information.

Thesis Supervisors	Number of Thesis	Year Range
Prof. Dr. Mehmet Emin Dalkılıç	5	2002-2018
Prof. Dr. Şaban Eren	1	2006
Prof. Dr. E. Turhan Tunalı	1	2007
Prof. Dr. Burak Ordin	2	2010-2014
Prof. Dr. Urfat Nuriyev	10	2009-2022
Prof. Dr. Aylin Kantarcı	2	2014
Assoc. Prof. Dr. Arif Gürsoy	2	2015-2021
Prof. Dr. Radosveta Ivanova Sokullu	1	2023

7. Thesis topics were classified under eight main headings and this classification is presented in Table 3. In total, 19 master's theses and 5 doctoral theses were included in these categories. This categorization reflects a comprehensive classification system used in academic research and scientific studies. The categorization of these theses provides an interdisciplinary perspective, indicating that academic studies conducted at the master's and doctoral level focus on a wide range of topics. This highlights the diversity and richness of research in the academic community.

Table 3. Grouping of Thesis Topic.

Subject	Thesis Type		Date
	M	D	
Quantum Information Processing Algorithms	2	-	2002-2020
Cryptanalysis	3	-	2006-2021
Video Encryption	1	-	2007
Applications of Number Theory	5	1	2010-2019
Backpack Problem Applications	-	1	2009
Steganography Methods	1	-	2010
Cryptology Systems and Applications	6	3	2006-2023
Next Generation Cryptosystems	1	-	2015-2017

3.1 Quantum Computing Algorithms

8. Two theses are related to quantum computing algorithms. These studies are based on the claim that if quantum computers become widespread, ciphers that cannot be solved with classical computers can be broken.

9. The first study verified by simulation the accuracy of Shor's factorization algorithm, which is designed for quantum computers and predicts to reduce the breaking time of the RSA encryption algorithm. In other words, this study deals with the breaking of the RSA encryption algorithm based on the difficulty problem of factoring semi-primes [20].

10. The second study obtained positive results in terms of time through a threaded implementation of the ABC ecosystem, which is thought to be resistant to quantum computing attacks. Thread was chosen because it allows parallel computation of function and matrix operations, which can be time-consuming. This work focuses on the development of an application that is thought to be resilient to quantum computing attacks and has achieved positive results [16].

3.2 Cryptanalysis

Three theses were analyzed.

11. The first thesis focuses on determining the correct solution when decrypting ciphertext using brute force by trying all keys in the key space. In this study, different test results for Turkish and English texts are compared. The test performances are analyzed according to the language and length of the text, encryption type and decryption time, and false positive rates are also calculated [10].

12. The second study is based on automatic cryptanalysis methods for the Playfair encryption system without user intervention. In this work, new algorithms are presented that can decrypt short ciphertexts in less time than existing algorithms [23].

13. The third paper focuses on hash functions and the internal structure and cryptanalysis of systems that have passed the first screening in the NIST lightweight cryptography project. This paper is a reference for the future development of hash functions [13].

3.3 Video Encryption

14. The research argues that since video data has a different structure than plaintext encryption, a special method for encryption is required. This paper aims to develop an efficient video encryption method that provides levelizable security and scalable quality, considering the security requirements of video data [7].

3.4 Number Theory Applications

15. In the first thesis, factorization algorithms are discussed in detail and new algorithms are defined. The efficiency of these algorithms is concretely demonstrated [18].

16. In the second thesis, focusing on the large computational volume caused by the arithmetic number sizes used in cryptography, two new algorithms are proposed, especially for multiplication and division operations, and the performance of these algorithms is analyzed in detail [14].

17. In the third study, a detailed review of factorization algorithms is made, existing methods are discussed, and new factorization algorithms are developed. Furthermore, parallel versions of these new algorithms were designed and a significant increase in time efficiency was achieved [15].

18. In the fourth paper, modifications of Fermat's factorization algorithm are investigated in detail, in particular, the square remainders are restricted to powers of two and values that cannot be represented as difference of squares are considered, which significantly reduces the running time of the algorithm [3].

19. In the fifth study, the proposed formulas for prime number finding are investigated in detail, and a new formula for the representation of prime numbers is discussed. It is believed that this new formula can be used in prime number generation [21].

20. The sixth and final paper focuses on how the newly developed Nuriyev Number System is applied in the fields of data compression and cryptology by utilizing its advantages in the digital environment. In this study, a comparison with existing methods is made and it is shown that the new system achieves significantly better results in compressing binary images [11].

3.5 Backpack Problem Applications

21. This single thesis focuses on the backpack problem, emphasizing that this problem has various application areas, especially in the context of public-key cryptography.

In the study, the applications of this issue, which is frequently encountered as a subproblem of large-scale problems, in the field of encryption are particularly emphasized. Focusing on the problems in practice, the study includes solution strategies developed by methods such as dynamic programming, heuristic algorithms, and genetic algorithms, and it is observed that these solutions are evaluated through written programs. The results of the study, in addition to indicating that the solution methods obtained are effective, contain information on cooperation with various organizations [6].

3.6 Steganography Methods

22. A specific study focused on "Linguistic Steganography" and compared the strengths and weaknesses of well-accepted steganography algorithms in detail. In this context, improvements to improve the performance and security of Markov chain and DES encryption algorithms are also presented [8].

3.7 Cryptological Systems and Applications

23. The first thesis aims to solve the speed problem of using elliptic curves, which are based on cryptography, in environments with limited resources. In this context, the cost of arithmetic operations on elliptic curves is analyzed and the effect of different coordinate systems on performance is observed. As a result, it is stated that mathematical research contributes to problem solving and an application that provides identity control using smart cards with the ElGamal cryptosystem using elliptic curves is presented [5].

24. The second thesis proposes a hybrid application that includes RSA and AES algorithms. The performance of this program was improved by writing a parallel version on multi-core processors and performance analyses were performed [12].

25. In the third thesis, the AES encryption algorithm is parallelized for multi-core processors and its performance is analyzed [2].

26. In the fourth thesis, a study was conducted to improve the security of the RSA encryption system against Fermat's Factorization Method and methods based on this method. With the proposed method, it is stated that it is possible to select primes that

are resistant to Fermat's method by utilizing the criterion for prime number selection for RSA [17].

27. The fifth paper addresses the problems in the implementation of lightweight cryptography algorithms arising from the security requirements of embedded microprocessors. In this context, cryptographic software has been developed especially for 8-bit versions of the PIC microcontroller and the performances obtained are compared with the existing ones [19].

28. In the sixth thesis, the problems faced by existing encryption systems in practice are analysed in detail and messages are encrypted and then decrypted using DES, 3DES, AES, Blowfish and RSA algorithms. Based on the results obtained, a Java security package was created and successfully integrated into the Java security library [1].

29. In the seventh thesis, new models called AESX and AESX+ are evaluated in terms of performance and security in comparison with AES-128 and AES-256. In the analyses, it is stated that the speed performance of the new models is between AES-128 and AES-256.

In the security analyses, it is stated that they have a similar security level with AES-256 and the resistance of AESX against key attacks is close to AES-256 [22].

30. The eighth study investigates the cryptographic algorithms used in contactless smart cards and their defense mechanisms against side-channel analysis attacks [9].

31. In the ninth study, a new framework for a blockchain architecture that provides traceability and confidentiality while balancing anonymity and transparency is established. In this framework, a digital signature is implemented in the contract and the integrity and non-repudiation of the system are ensured.

3.8 Next Generation Crypto Systems

32. This single thesis examines lattice-based cryptography, focusing on data security issues that may arise after quantum computing. In particular, a solution to the ring structure problem is proposed and used to improve the efficiency of lattice-based structures [4].

4 Conclusions and Suggestions

In this research, the Cryptography thesis studies conducted at Ege University between the years 2000-2023 are examined in detail and the results obtained are summarized. The studies were grouped according to their topics and an analysis was made with recommendations on similar topics. It is observed that the two studies were directed by the same thesis director.

This study is considered to be a valuable summary resource for academics and researchers who are planning to conduct research in the field of cryptography. Organizing similar studies on the basis of field and year may allow previous research to make a more effective contribution to new resear.

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Mathematical Model Driven Decision Support System Proposal for Selecting Wireless Technologies After a Natural Disaster

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Abstract. Natural disasters have caused many losses of life and property from past to present. Continuity of communication is critical in natural disasters and emergencies. The main problems that may occur in these cases are damage to the telecommunication infrastructure and disruptions that may occur in the telecommunication network. Due to problems that may occur in the telecommunication infrastructure in natural disasters and emergencies, continuity of communication should be ensured by creating a wireless network independent of the mobile network as an alternative to the telecommunication infrastructure. In this study, a decision support system model was created to design a communication network with different wireless technologies, independent of the mobile network, based on disaster scenarios experienced in mobile networks. In the proposed model, Zeytinburnu district of Istanbul was chosen as the pilot region. Post disaster gathering areas of the district were evaluated as demand points, and all neighborhoods were evaluated as candidate points. Candidate points are weighted according to certain criteria. A two stage integrated model is proposed for the problem under consideration. In the first stage, a cluster coverage model was developed to determine the number of wireless technologies that should be installed according to their coverage areas in the candidate neighborhoods of the district where wireless technologies are planned to be installed. The second stage is designed with the p-median problem to minimize the distance to weighted demand points. Our study, which is a decision support system model that we propose for the effective use of wireless technologies with optimum resources in natural disaster scenarios, is of great importance in terms of communication and continuity of communication in disaster situations. The model produced with various assumptions will produce different scenarios by revising the parameters.

Keywords: Wireless Technologies, Set Covering Problem, P-median Problem, Facility Location, Decision Support Systems

1 Introduction

According to AFAD, a disaster is defined as "a nature, technology or human induced event that causes losses, stops or interrupts normal life and human activities, and for which the affected society has insufficient coping capacity". Natural disasters are

events that harm people and the environment. Global warming and environmental degradation are leading to an increase in natural disasters worldwide. Natural disasters can generally be classified as geological (earthquake, landslide, tsunami, volcano) and meteorological (flood, avalanche, storm, forest fire, tornado) (1). When disasters occurring in our country are analyzed, earthquakes always come first in terms of the number of people affected by disasters (2).

Disaster management is a concept that aims to prevent the consequences of disasters or reduce their damages. Disaster management; It consists of four steps: risk and harm reduction, preparation, intervention and recovery stages and is shown in figure 1. In the process of mitigating damages, plans are made to reduce risks. During the preparation process, the focus is on education. In the intervention part, it is necessary to benefit from effective intervention technology. Finally, in the recovery section, damage estimates and necessary plans for the recovery process are made (3).

Fig. 1. Disaster Management, *https://catalyst2030.net/disasters group/*

One of the most critical issues during and after a disaster is the continuity of the communication process. It is necessary for vital tasks such as protecting communication systems after a disaster, organizing search and rescue efforts, managing evacuations, and identifying and meeting emergency needs. In order for these processes to be carried out effectively, rapid cooperation should be ensured between teams and a strong communication network should be created for this purpose (4). The inability of traditional wired telecommunications infrastructure to effectively cope with disaster processes has greatly increased the interest in wireless based technologies. Thanks to advantages such as widespread access, quick installation and freedom of connection, wireless systems can play a life saving role in disaster areas (5).

Within the scope of this study, a communication network model with different wireless technologies will be proposed as an alternative to the mobile network during disaster processes. Within the scope of the study, Zeytinburnu district of Istanbul was determined as the pilot region. 29 post disaster assembly area demand points determined by AFAD and Zeytinburnu Municipality and 13 neighborhoods of the district were accepted as candidate points.

A two stage integrated model is proposed for the problem under consideration. In the first stage, a set covering model is proposed that determines the minimum number of wireless technologies planned to be installed for wireless technologies with different coverage distances. In the second stage, a p-median model was developed for distance minimization by taking into account the weights of the demand points. In addition, in the proposed two stage integrated model, the capacities of candidate and demand points are taken into account and candidate points are weighted with multiple criteria decision making methods. In addition, analyzes will be carried out for 3 different scenarios for the model in question: congested network, partial network and isolated network scenario, which are the most common in disaster situations.

In the second part of the study, studies carried out in previous years within the scope of cluster coverage and p-median problem were examined, in the third part, information about wireless technologies and disaster scenarios was given, and in the fourth part, a model proposal was made by including a problem definition and the proposed methodology. In the last section, results and discussions are included.

2 Set Covering and P-Median Problems

When we look at the literature, we see that there are many studies on set covering and the p-median problem. The set covering problem model aims to determine the minimum number of serving facilities that will cover all demand points at a given service level. In this model, each demand point must be assigned to at least one facility (6). The p-median problem is the problem of placing p facilities at minimum cost on a network consisting of n nodes and determining the demand points that will receive service from these facilities. Minimum cost is usually determined in terms of time, money, total distance, or a similar metric. This problem is also called the Weber problem because it aims to minimize the total cost. In this problem, solution strategies are developed to determine the optimal locations of a certain number of facilities and to define the demand points that will receive service from these facilities (7).

The p-median problem is the most well known among facility layout and assignment models and has been examined in many studies in the literature (8). The p-median problem was first formulated in detail by Hakimi in 1964 (9). The p-median problem aims to minimize the weighted cost of the entire system by determining the optimal locations of p facilities on the network that will serve n demand points (10).

In addition to the literature studies on the set covering problem, fire station placement by Walker in 1974 (11), clustering of solar energy potentials by Güngör in 1999 (12), fuel station placement by Kuby et al. in 2009 (13), and Coskun and Erol in 2010. Determining ambulance location points may indicate problems (14).
When the studies on the p-median problem on disasters are examined, Kumru and his colleagues conducted a study on p-median problem based logistics warehouse location selection before a possible earthquake disaster in Erzincan province in 2019 (15). Ergin,

on the other hand, worked on solving the warehouse location selection problem in disaster logistics with optimization and clustering techniques in 2016 (16). Temur and his colleagues carried out a logistics network design for post earthquake planning in 2017 (17). Şahin and Altın carried out an assignment problem for tent city location selection in Isparta province in 2016 (18). In addition, Çetinyokuş and his colleagues conducted studies on the AHP (Analytic Hierarchy Process) method, which is a multiple criteria decision making problem that includes many criteria regarding the installation of an earthquake recording station and the decision on where to locate it, and requires these criteria to be evaluated together. It is considered that the article in question will help in weighting the candidate points in our study (21).

As a result of the literature review, this study focused on set covering and p-median problems. To our knowledge, the developed integrated model is used for the first time in the literature for the application of wireless technologies in disaster situations. In addition, this is the first time such a study has been carried out in Zeytinburnu, one of the earthquake risky districts of Istanbul, which is located in an important earthquake zone and where a major earthquake is expected in the coming years. In this respect, it is hoped that the study will support the studies to be carried out for the continuity of communication within the scope of disaster management.

3 Wireless Technologies and Disaster Scenarios

3.1 Wireless Technologies

In recent years, it has been evaluated that the use of long distance wireless communication technologies with low power wide area networks (LPWAN) with wide coverage areas can be very useful in disaster situations. In particular, LPWAN technologies such as LoRa, NB-IoT (Narrowband IoT) and Sigfox can play an important role in addition to the communication infrastructure in disaster situations. These technologies can communicate in large areas thanks to their long range and low power consumption. Short distance wireless communication technologies were not evaluated within the scope of this study due to their low coverage areas. In Figure 2 below, the coverage and data rates of wireless technologies are compared (19). It is considered that the use of LPWAN technologies with wide coverage areas will be of great benefit in disaster situations when the mobile network infrastructure is damaged and there are communication problems.

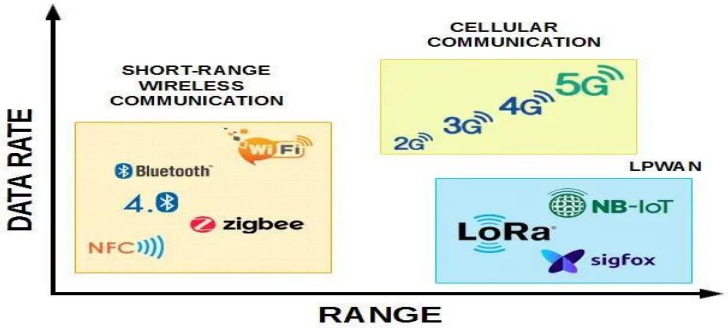

Fig. 2. Disaster Management: *Duman, E. Altıntaş, M. E., Gül, İ., & Dolu, M. (2022). LPWAN Comparative Review of Technologies and Application Areas*

3.2 Telecommunication Problems Scenarios in Disaster Situations

When looking at the literature in disaster situations, telecommunication problems are examined under three separate headings. These are congested network, partial network and isolated network.

Congested Network
In emergency and disaster situations, even in a scenario where mobile network components and telecommunications infrastructure are working perfectly, network congestion problems may unexpectedly occur. This type of congestion can strain the network's capacity or even cause overload, especially with a sudden increase in data and voice traffic. Congestion may become more evident, especially in densely populated areas and places where information sharing increases rapidly (20).

Partial Network
In disaster situations, the telecommunications infrastructure may suffer serious damage, especially to critical components such as base stations and turnkey centers. These damages may limit communication capacity, causing connection outages. When faced with these problems, users must follow various strategies to maintain their communication. One of these is to try to optimize transmission power by communicating directly with existing base stations. Another strategy is to connect to the nearest functional base stations via surrounding users (20).

Isolated Network
In the third post disaster scenario, users became completely isolated as the backbone networks collapsed. In this case, the communication loss rate increases significantly. If no control signal is received from the base stations within a certain period of time, user devices must automatically operate in an isolated mode. In this context, it is necessary to establish a temporary wireless communication infrastructure in this isolation situation (20).

4 Defining the Problem and Establishing the Model

The coverage area of wireless technologies refers to the propagation capacity of communication signals of a particular wireless communication technology. Selection of wireless technologies to be used in natural disasters involves the process of determining the technology that provides the most effective coverage for a certain geographical region (3) Wireless technologies are of great importance for the continuity of communication, and these technologies provide the opportunity to communicate independently of mobile networks.

A decision support system model will be created for the Zeytinburnu district of Istanbul by using wireless LPWAN technologies with wide coverage areas. In the problem addressed in the first stage of the model, the minimum number of wireless technologies will be determined with the set covering problem under different coverage distances of LoRa, Nb-IoT and SigFox technologies. The important parameter here is the coverage distance of the wireless technologies that need to be installed. In the second stage, the results of the first stage will be used as input to the p-median problem. At this stage, weighted demand points and the capacities of candidate and demand points will also be taken into account. In addition, the necessary appointments will be made in 3 different disaster scenarios: congested, partial and isolated network mentioned above. In the scenarios in question, whether wireless technologies will be installed in some of the candidate points will be evaluated.

In the study, demand points are the points that should be within the coverage area of wireless technologies. In determining the demand points, places such as areas where citizens live intensively after the disaster, schools, hospitals, post disaster gathering places, stadiums and airports were taken into consideration. In this context, 29 post disaster collection area demand points were determined by Zeytinburnu Municipality and AFAD.

Candidate points in the study are the places where potential wireless technologies are located. The surface area of Zeytinburnu district is 11.31 km² and there are 13 neighborhoods in the district. Candidate points were determined as all neighborhoods in the district. First of all, the distances between demand points and candidate points will be calculated. The weighting of the neighborhoods expected to be candidate points was made according to the criteria of VS 30 ground risk value, maximum ground acceleration (PGA), maximum ground speed (PGV), elevation, soil structure, proximity to the North Anatolian fault line and night population density, and candidate points were prioritized. The locations of the demand points and, for example, the candidate points weighted according to the VS 30 ground risk value are shown below in Figure 3 and Figure 4.

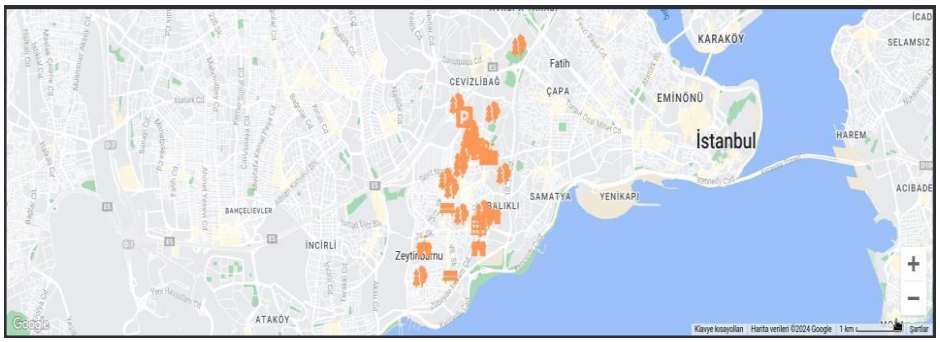

Fig. 3. Candidate points. *https://afet.zeytinburnu.istanbul/toplanmaalanlari/*

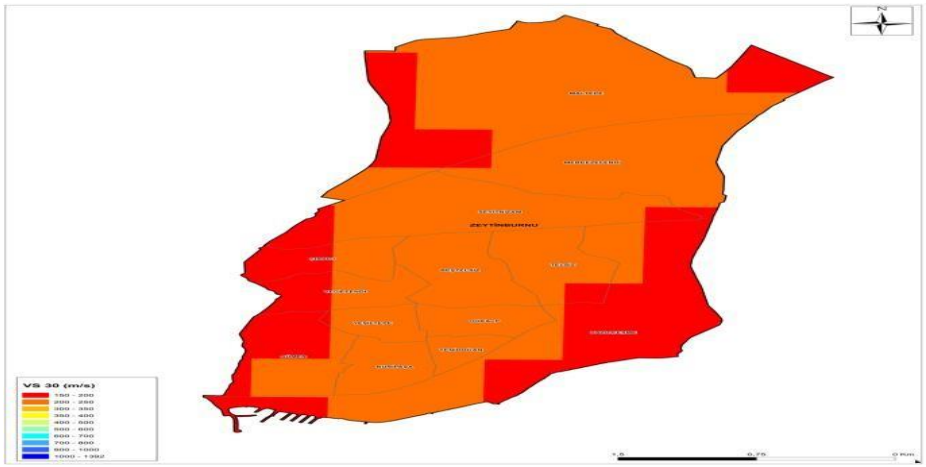

Fig. 4. Weighting of Candidate Points According to VS30 Risk Value, *https://depremzemin.ibb.istanbul/wpcontent/uploads/2020/11/Zeytinburnu.pdf*

Set covering and p-median model

The mathematical formulation of the p-median model integrated with the set covering model proposed in this study is shown below.

Indices
i: Index of demand points (post disaster assembly areas of Zeytinburnu district)
j: Index of candidate points (neighborhoods of Zeytinburnu district)

Parameters
n: Number of potential wireless technologies (Number of candidate points where wireless technologies will be installed)
s: Coverage distance of wireless technologies that need to be installed (m)

a_{ij}: 1 if the distance between request point i and candidate point j is less than or equal to S, 0 otherwise.
d_{ij}: i. Distance as the crow flies (m) between the demand point and the candidate point
j: Number of wireless technologies to serve
q_j: Capacity of the wireless technology planned to be installed at candidate point j
q_i: capacity of demand point i
w_j: Weighted values of candidate points

Decision variables
x_j: 1 if a wireless technology is installed at candidate point j, 0 otherwise
y_j: 1 if a wireless technology is installed at candidate point j, 0 otherwise
z_{ij} : 1 if request point i is assigned to wireless technology installed at candidate point j, 0 otherwise

Stage 1: Objective function

$$\text{enk } z = \sum_{J=1}^{n} x_j \quad (1)$$

$$\sum_{j \in J} a_{ij}. x_j \geq 1 \; \forall i \; (i = 1, \dots, m) \quad (2)$$

$$x_j \in \{0,1\} \; (j=1,\dots,n) \quad (3)$$

Stage 2: Objective function

$$\text{enk } z = \sum_{i=1}^{n} \sum_{j=1}^{n} w_j. d_{ij}. z_{ij} \quad (4)$$

$$\sum_{j=1}^{n} z_{ij} = 1 \; \forall i \quad i = 1, \dots, n \quad (5)$$

$$z_{ij} \leq y_j \; \forall i, j \quad (6)$$

$$\sum_{i=1}^{n} y_j = p \quad (7)$$

$$\sum_{j=1}^{n} w_j \, . \, z_{ij} \leq q_j \, . \, y_j \quad (8)$$

$$z_{ij}, \; y_j \in \{0,1\} \quad (9)$$

The objective function shown in Equation (1) aims to minimize the number of wireless technologies planned to be installed at candidate points. Equation (2) states that each demand point must be covered by wireless technology installed at at least 1 candidate point that meets the service condition. Equation (3) is the constraint of the decision

variable being a 0-1 integer. Equation (4) aims to minimize the cost incurred between wireless technologies installed at candidate points and demand points. Equation (5) ensures that each demand point receives service only from the candidate point. Equation (6) ensures that no demand points are assigned to candidate points where wireless technology is not installed. Equation (7) enables the opening of p candidate points. Equation (8) states that each demand point has a certain capacity and the demand points assigned to the candidate point can be at most the capacity of the candidate point. Equation (9) is the constraint that all decision variables be 0-1 integers.

The distances between each demand point and candidate point will be obtained from Google Maps. The capacities of the demand points to be used in the model will be calculated by the number of people per square meter based on the area covered by the disaster gathering areas determined by Zeytinburnu Municipality. The weighting of candidate points will be done using multiple criteria decision making methods. The solution of the model, results and evaluations will be included in the thesis.

5 Conclusions

Communication problems experienced during and after disasters in our country and other countries lead to many losses of life and property. Utilizing science and technology based methods and studies as much as possible in the planning of activities to be carried out after natural disasters plays a major role in both execution and reducing the risks to be encountered. In this context, the use of wireless technologies, which is one of the effective components in disaster situations, is of great importance in terms of communication and coordination. Utilizing wireless technologies to provide fast and effective communication in situations where the traditional communication infrastructure is broken or unusable is one of the current rational solutions. Our study, which is a decision support system model that we propose for the effective use of wireless technologies with optimum resources in natural disaster scenarios, is of great importance in terms of communication and continuity of communication in disaster situations. The model produced with various assumptions will produce different scenarios by revising the parameters. In this form, a model based system proposal is put forward. In the study carried out within the scope of the thesis, it is planned to develop the problem with model variables, parameter and constraint revisions that determine the appropriate solution area, and support it with sensitivity analysis. Next, it is aimed to design and execute the proposed model with its components. Thus, an information system that provides support to the decision maker will be created.

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Long Short-Term Memory Networks In The Effects Of Recession On Short-Medium Term Crude Oil Prices

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Abstract.The financial industry is increasingly interested in predictive analysis and forecasting using time series data. Understanding the complex relationship of recessions on oil markets is an important factor in developing financial forecasts and strategic decisions. Using advanced deep learning models, this study examines the dynamic interaction of the short- and medium-term relationship between recession signals and crude oil prices. In this context, data covering recession periods include important economic indicators such as Gross Domestic Product (GDP) fluctuations, unemployment rates, consumer spending trends, business investments and housing market dynamics. By focusing on feature selection, the study aims to identify patterns from historical data and relationships between economic recession signals and subsequent oil price movements. To this end, Long Short-Term Memory networks (LSTMs) are used to predict crude oil prices in designated recession intervals. The study aims to understand the subtle relationship between economic recessions and oil markets and to present forecasting models that will enable a better understanding and prediction of short and medium-term fluctuations in crude oil prices during economic recessions.

Keywords: Deep Learning, Time Series Analysis, Recession Indicator, Crude Oil Prices, Macroeconomic Indicators

1 Introduction

Accurately forecasting crude oil prices is important for understanding the dynamics of energy markets and reacting appropriately to future price movements. Traditional methods focus on crude oil price predictions using fundamental analysis and economic indicators. However, using these methods alone may have limitations in fully capturing complex price movements.

The purpose of this work is to demonstrate how deep learning algorithms can be used to forecast crude oil prices. Deep learning systems could produce predictions that

are more detailed by combining different deep learning techniques and other traditional prediction methods.

In addition, the study aims to take economic indicators and energy policies into account in estimating crude oil prices. It has been examined how economic indicators such as GDP change, inflation rates, unemployment rates, household expenditures can affect crude oil prices.

This study emphasizes achieving higher accuracy and performance by using LSTM networks in crude oil price prediction. In addition, this study, which also takes economic indicators and energy policies into account, will help decision makers in the financial and energy sectors develop better strategies, improve risk management, and react more effectively to market movements.

Forecasting crude oil prices plays a critical role in determining economic indicators. It is important to estimate crude oil prices accurately, especially in the preparation of inflation reports. Inflation is considered an important indicator that determines the stability of an economy and is effective in shaping monetary policies. Crude oil prices often have a direct impact on inflation, because it constitutes a large part of energy costs in many countries. An accurate and reliable crude oil price forecast can help understand and predict inflation and ultimately make economic decisions. Therefore, forecasting crude oil prices can contribute to the general health of the economy and especially to the establishment of effective monetary policies on inflation.

2 Literature Review

The relationships between recession and crude oil prices have long been a focus in economic research. In recent years, the integration of deep learning methodologies has offered a new perspective on understanding the complex relationships between recessions and crude oil markets.

Studies using deep learning techniques in financial forecasting have shown remarkable potential. Bhandari et al. (2022) [1] demonstrated the adaptability and predictive power of deep learning models in financial markets by applying LSTM networks to predict stock prices. Although the application of these methods in the field of crude oil prices during recessions has not yet been sufficiently investigated, the potential of these models to capture nuances in complex data is emphasized.

Studies investigating the effects of economic recessions on commodity markets, especially crude oil, generally use statistical models and econometric techniques. However, Wang et al. (2019) [2] highlighted the limitations of traditional models in capturing complex nonlinear relationships during economic recessions. This presents a potential opportunity in understanding the effects of recession on crude oil prices due to the ability of deep learning models to capture nonlinear relationships.

Studies integrating macroeconomic indicators such as GDP growth, inflation rates and unemployment, together with deep learning approaches, have shown their importance in understanding oil market dynamics. Ameur et al. (2023) [3] emphasized the importance of considering multiple economic indicators in predicting commodity

prices during volatile economic periods and suggested the integration of these indicators into deep learning frameworks.

Panella et al. (2012) [4] looked into the use of machine learning, or neural networks, to forecast pricing for coal, natural gas, crude oil, and electricity. The authors demonstrate that a hierarchical constructive approach may be used to identify the ideal model through the use of various algorithms based on a blend of Gaussian neural networks.

Al-Shabi (2019) [5] discussed the potential of deep learning algorithms, such as autoencoders, in identifying fraudulent activities and mitigating risks in financial transactions.

Nguyen et al. (2015) [6] showed that incorporating sentiment analysis of social media data can enhance the predictive accuracy of financial models, providing valuable insights into investor sentiment and market trends.

3 Methodology

This section details the working process on deep learning model and time series data to be used to predict crude oil prices. Determining whether a study is a regression or classification study depends primarily on the nature of the target variable or the outcome it is intended to predict.

In the case of forecasting oil prices, this is often considered a regression task. This is because the price of crude oil (or any commodity) is a continuous variable that can take on a wide range of numerical values. Regression studies are concerned with estimating continuous numerical values and making them suitable for predicting prices, quantities, temperatures, and similar continuous variables.

Classification studies, on the other hand, are concerned with predicting discrete categories or classes. For example, predicting whether an email is spam, classifying pictures of cats and dogs, or identifying different types of diseases based on symptoms are classification exercises where the output is a categorical variable.

In the context of forecasting oil prices, the goal is to predict the future price (a continuous variable) based on historical data and various economic indicators. Therefore, it is compatible with a regression study in which the model predicts a numerical value (e.g., oil price) rather than classifying it into separate categories. In general, predicting the real price level is a regression problem.

The choice of performance metrics in deep learning depends on the specific task at hand. Different metrics are used for classification, regression, or other studies. Some commonly used metrics are:

3.1 Regression Studies

RMSE (Root Mean Square Error). Calculates the mean of the squared discrepancies between the actual and anticipated values. Regression tasks generally employ lower RMSE, which denotes greater performance.

MAE (Mean Absolute Error). Calculates the mean absolute discrepancies between the values that were predicted and the actual values. Compared to RMSE, it might be easier to read and more resilient to outliers.

R^2 (Coefficient of Determination). It calculates the ratio of the dependent variable's variance that the independent variable can predict. Better performance is indicated by a number nearer 1.

3.2 Classification Studies

Accuracy. Calculates the percentage of all samples that are properly predicted. For balanced datasets, it is typical, but for imbalanced datasets, it might not be the best option.

Precision, Recall, F1-Score. Helpful for datasets that are not balanced. The ratio of accurately anticipated positive observations to the total number of predicted positive observations is known as precision. The ratio of accurately anticipated positive observations to all genuine positives is known as recall. The harmonic mean of recall and precision is known as the F1-Score.

ROC-AUC (Receiver Operating Characteristic - Area Under the Curve). Calculates the area under the ROC curve and assesses the performance of the model at different thresholds.

For deep learning models in regression studies, RMSE and MAE are widely used due to their interpretability. Accuracy, precision, recall or F1 score are often used in classification studies, especially when dealing with unbalanced data sets.

Ensemble Methods. Involves combining predictions from multiple models to obtain a final prediction. One way to do this is to average each model's predictions.

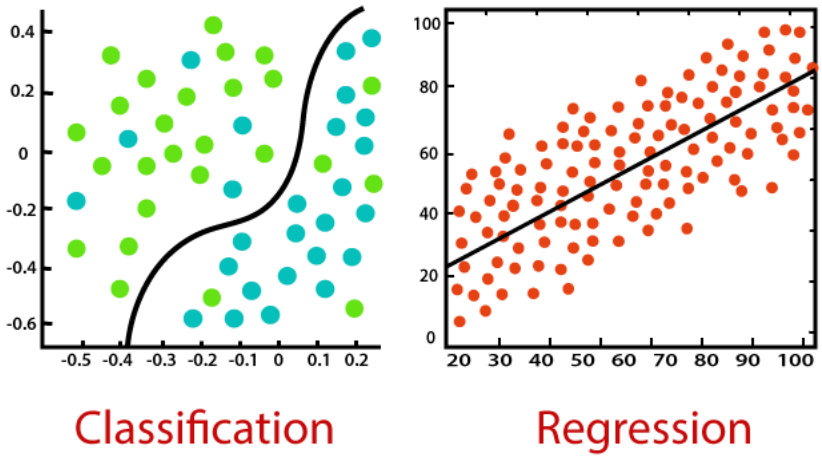

Fig. 1. Classification vs Regression [7]

Methodology of our Work. The method steps are as follows:

1. Data Collection: As a first step, basic economic indicator data was obtained from FRED [8], which contains economic data provided by the Federal Reserve (Central Banks System-FED). Leveraging FRED's comprehensive database, relevant data sets such as Gross Domestic Product (GDP) data, crude oil prices, unemployment rates, retail sales and consumer confidence indices are retrieved. GDP data comprehensively measures the country's economic health; Crude oil prices are critical to understanding energy market dynamics. In addition, unemployment rates, retail sales and consumer confidence indices provide important insights into labor market conditions and consumer spending trends. These data sets, obtained from FRED's data repository, provide the basis for conducting comprehensive analyzes and investigating the complex relationships between economic indicators and oil market dynamics.
2. Data Pre-Processing: It is important to process the collected data accurately and consistently. In this step, data cleaning, text preprocessing for sentiment analysis, and other necessary data preprocessing techniques were applied. MinMaxScaler was used to scale the data and convert time series data into a supervised learning problem. Handling missing values on the data set and converting them to the appropriate data format was also carried out in this step.
3. Training Deep Learning Models: The training dataset contains a subset of the collected and preprocessed data. LSTM algorithm have been used and trained.

Long Short-Term Memory. Hochreiter and Schmidhuber introduced Long Short-Term Memory (LSTM), a kind of Recurrent Neural Network (RNN) architecture, in 1997. The goal of LSTM's design was to address the drawbacks of conventional RNNs, specifically the issue of vanishing and exploding gradients, which makes it challenging to learn and maintain long-term dependencies in a sequence [9].

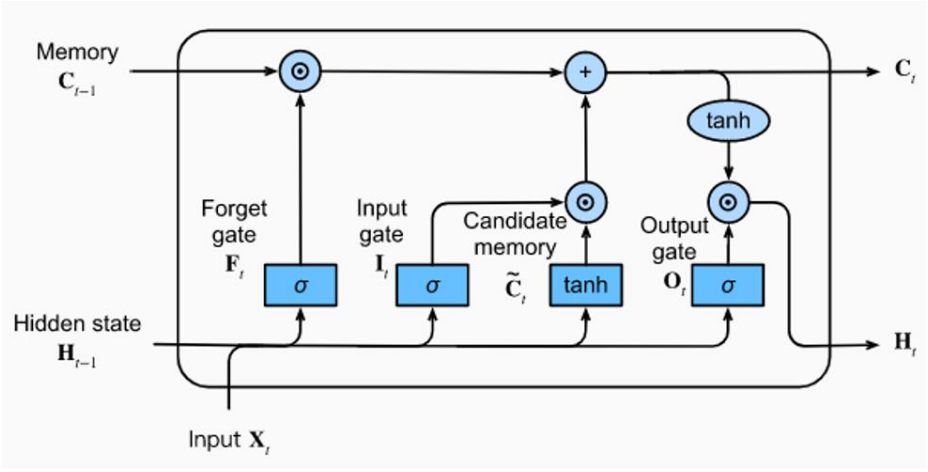

Fig. 2. Long Short-Term Memory Architecture [9]

The cell state, a horizontal line that passes across the top of the LSTM unit, is the main innovation of the device. Information may be efficiently sent over great distances in the cell state with little modification. This is made possible by carefully controlled interactions that are managed by gate-like structures. An LSTM unit has three different kinds of gates:
1.Forget Gate (f_t): This gate determines which data from the cell state should be removed. The sigmoid function is utilized to generate values ranging from 0 to 1. "Keep" is indicated by a value near 1, and "forget" is indicated by a value close to 0..
2.Input Gate (i_t). This gate adds fresh data to the cell state update. It consists of two layers: a tanh layer that generates a vector of new candidate values, and a sigmoid layer that determines which values to update.
3.Output Gate (o_t). This gate determines the value of the subsequent concealed state. Previous input information is contained in the concealed state. Predictions can also be made using the hidden state.

$$f\_t = \sigma(Wf*[h\_(t-1), x\_t] + bf) \quad (1)$$

$$i\_t = \sigma(Wi*[h\_(t-1), x\_t] + bi) \quad (2)$$

$$c't = tanh(Wc*[h(t-1), x\_t] + bc) \quad (3)$$

$$c\_t = f\_t * c\_(t-1) + i\_t * c'\_t \quad (4)$$

$$o\_t = \sigma(Wo*[h\_(t-1), x\_t] + bo) \quad (5)$$

$$h\_t = o\_t * tanh(c\_t) \quad (6)$$

The sigmoid function is represented by σ, the hyperbolic tangent function by tanh, element-wise multiplication by *, the concatenation of the previous hidden state with the current input by [h_(t-1), x_t], and the time step is indicated by t. LSTMs have demonstrated efficacy in numerous applications using sequential data, including speech recognition, natural language processing, and time series prediction. Therefore, it was thought to be the better choice to use that algorithm.
4. Model Optimization and Validation: Trained deep learning models are optimized to increase prediction capabilities and prevent overfitting. In this step, techniques such as tuning hyperparameters, cross-validation methods and evaluating model performance were used. Evaluations were made on the accuracy, sensitivity, specificity, and other performance metrics of the models.
5. Forecast and Result Analysis: Crude oil prices were predicted using trained deep learning models. In this step, test dataset's model performance is evaluated, and the prediction results are analyzed. The results obtained are presented through statistical metrics, graphs, or other visualization methods.

As a methodology, we first extract GDP time series data from the FRED database and find the date ranges in which GDP decreased for 2 consecutive quarters. Afterwards,

we pre-process this data and process it if there is NA data. In the found date ranges, we fetch macroeconomic indicator data that will indicate a recession and thus filter again the ranges that meet the conditions. We fetch the Brent Oil prices within the last date range we obtain, scale the data, and turn it into a Supervised Learning problem. After training LSTM networks on this data, we make the Brent Oil price prediction and evaluate the success and test dataset's model performance. As a result of all these processes, we obtain more accurate oil price forecast data to use in the inflation report.

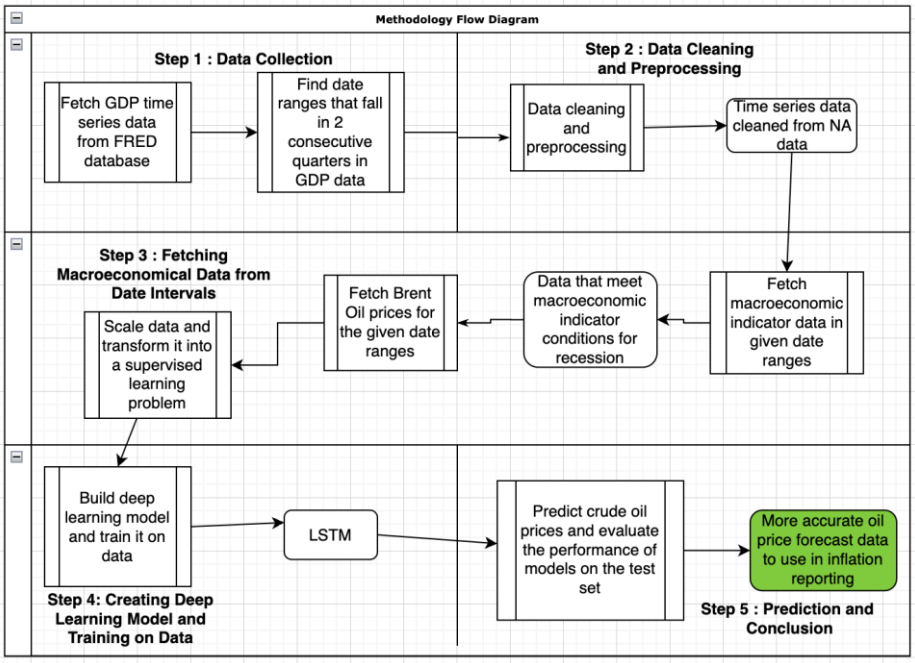

Fig. 3. Methodology Flow Diagram

4 Data Sets

In this study, various data sets were used to predict crude oil prices.

1. Crude Oil Prices Data Set: A data set containing historical data on crude oil prices was used. This data set contains daily, weekly, or monthly values of crude oil prices. Brent oil data obtained from the Federal Reserve (FED) was used.

2. Economic Indicators Data Set: Economic indicators are factors that can affect the movements of crude oil prices. Therefore, a data set was created to examine the relationship of economic indicators (GDP growth, inflation, unemployment rate, interest

rates, etc.) with crude oil prices. In this context, Economic indicators data provided by the FED were used.

5 Results

As discussed before, we fetched Brent Crude Oil Prices data for specified intervals, and we filled any missing values in the data using forward fill and backward fill methods. All the oil prices dataframes are concatenated into one and converted to a 2D array. The data is then scaled using the MinMaxScaler from sklearn.preprocessing to bring all values into the range [0, 1]. This is done because neural networks converge faster on [0, 1] data.

The data is split into a training set and a test set, with 70% of the data used for training and the rest for testing. We transformed the time series forecasting problem into a supervised learning problem. For each element of the training set, it creates a sequence of previous look_back number of data points as input and the next data point as output. We took look_back value as 5. The input data is reshaped into the format expected by LSTM layers, i.e., [samples, time steps, features].

A Sequential model is created using Keras [10]. The model has two LSTM layers with 8 units each. The first LSTM layer returns sequences, making it possible to stack LSTM layers. The final layer is a Dense layer with a single unit, used for predicting the next oil price.

The model is compiled using the Adam optimizer with a learning rate of 0.001 and the mean squared error loss function. Adam is a popular choice of optimizer because it combines the advantages of two other extensions of stochastic gradient descent: AdaGrad [11] and RMSProp [12]. The model is trained on the training data for 100 epochs with a batch size of 10. The test data is used to evaluate the model after each epoch. The model is used to make predictions on the training and test data.

A number of metrics, such as the R2 score, Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE), were used to assess the model's performance. It was discovered that the RMSE for the test set was 2.99 and for the training set was 4.84. These numbers represent the residuals' (prediction errors') standard deviation. Better data fit is indicated by lower RMSE values. The test set's MAE was 1.77 and the training set's was 2.17. Without considering the direction of the errors, MAE calculates the average magnitude of the errors in a series of forecasts. It is the mean, with each individual difference carrying equal weight, of the absolute differences between the observed and predicted values over the test sample.

The test set's R2 score was 0.91, whereas the training set's was 0.97. The coefficient of determination, or R2 score, gives an indication of how well the model is expected to predict future samples. Because the model may be arbitrarily worse, the best achievable score is 1.0 and it may even be negative. An R2 score of 0.0 would be assigned to a constant model that, in the absence of input feature information, consistently predicts the predicted value of y. Figure 4 displays the R2, MAE, and RMSE values for the test and training sets.

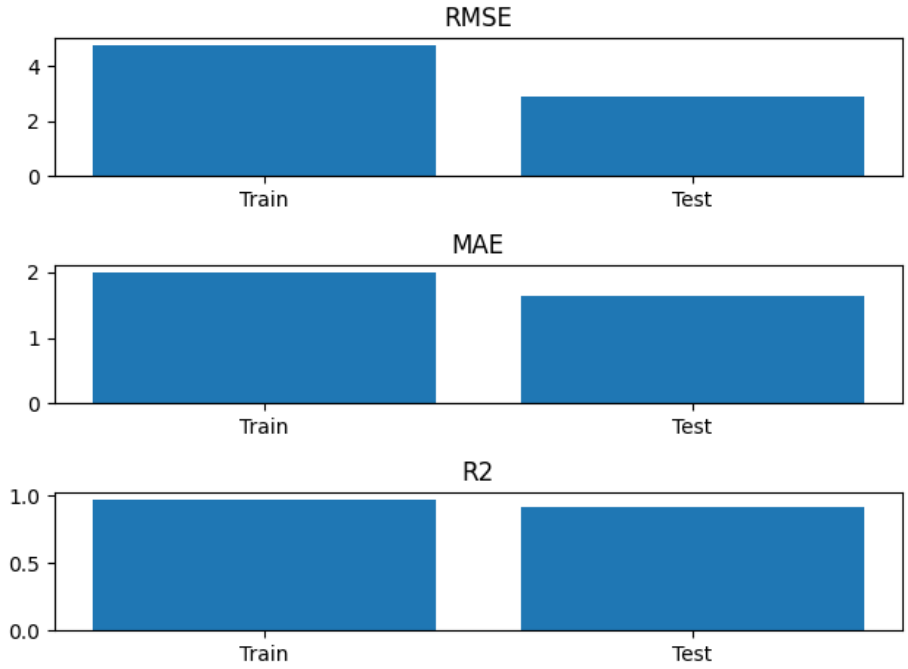

Fig. 4. RMSE, MAE and R2 Results

Table 1 shows RMSE, MAE and R2 results for training and test set in a tabular form.

Table 1. RMSE, MAE and R2 Results in a Tabular Form

	RMSE	MAE	R2
Training Set	4.75	1.99	0.97
Test Set	2.89	1.64	0.91

In the implementation of future predictions, the model uses the last look_back number of observed values to predict future values. The look_back parameter is a hyperparameter that determines how many previous steps to use as input for the model to predict the next time step.

The last look_back values are extracted from both the training and testing predictions. If the length of the last look_back values from the training predictions is less than look_back, the remaining values are filled up with the last look_back values from the testing predictions. This ensures that the model always has look_back number of values to base its predictions on.

The future predictions are made for 3 months. For that time horizon, a loop is run for the number of steps corresponding to the time horizon. In iteration of the loop, the model makes a prediction based on the last look_back values. This predicted value is then appended to the list of last look_back values, and the oldest value is dropped to

maintain a length of look_back. This process is repeated until predictions have been made for the entire time horizon.

The predicted future values are initially in the scaled form that was used to train the model. Therefore, the inverse transformation of the scaler is applied to these values to convert them back to their original scale.

The future predictions are then printed out. This approach of using the model's own predictions as input for future predictions is known as the autoregressive method. It allows the model to generate a sequence of predictions for multiple steps into the future.

The 3-month forecast generated by the model exhibits an interesting pattern. Initially, the model predicts a significant increase in oil prices, predicts a brief dip into low prices, at 22.97, before stabilizing and gradually increasing.

After these initial fluctuations, the model's predictions become more stable, hovering around the 30 mark. This could be indicative of the model predicting a period of relative stability in oil prices after the initial fluctuations.

Towards the end of the 3-month period, the model's predictions become extremely consistent, with the predicted price remaining at approximately 30.23.

6 Conclusion

The LSTM model used for forecasting oil prices over a 3-month period demonstrated a pattern of stability after initial fluctuations. The model's predictions, after the initial period, hovered around the 30 mark, indicating a period of relative stability in oil prices. This insight is significant because it implies that the model has discovered a potentially significant pattern in the historical data that it was trained on.

The model's forecasts grew remarkably stable at the end of the three-month period, with the anticipated price staying at roughly 30.23. This might occur from the model reaching a point where, given its inputs, it keeps predicting the same value for subsequent stages. When there is no discernible trend or seasonal component in the input data, autoregressive models frequently exhibit this behavior.

It's crucial to interpret these findings cautiously, though. Although an effective tool for time series forecasting, the LSTM model is not perfect. The model architecture and hyperparameters' suitability, the training data's relevance and quality, and the underlying process's intrinsic predictability all have a significant impact on how accurate these predictions turn out. RMSE, MAE, and R2 score were among the metrics used to assess the model's performance for both the training and testing sets. These metrics' outcomes gave important information about the model's functionality and generalizability to new data.

In conclusion, the LSTM model has shown promising results in forecasting oil prices. However, further improvements can be made by tuning the model's hyperparameters, using a larger and more diverse dataset for training, and incorporating additional features that could influence oil prices. Future work could also explore the use of other types of models and compare their performance with the LSTM model.

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11. Adagrad | https://keras.io/api/optimizers/adagrad/, last accessed 2024/01/17
12. RMSprop | https://keras.io/api/optimizers/rmsprop/, last accessed 2024/01/17

Bibliometric Analysis of Graduate Thesis Prepared in Turkey in the Field of Management Information Systems Science

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Abstract. The aim of this study is to examine the reflections and developments of the Management Information Systems discipline, which is fed by different disciplines, on postgraduate thesis topics in Turkey. The study population consists of 920 postgraduate theses (Master's-f:820 and PhD-f:100) prepared in the field of Management Information Systems between 2006-2023, which are accessible through the YÖK National Thesis Center website. (https://tez.yok.gov.tr/UlusalTezMerkezi/). For our purpose, 920 postgraduate theses were examined with the bibliometric analysis method. Bibliometric analysis; It is one of the research methods in which certain characteristics of publications such as subject, field, institution and author are examined quantitatively. It enables the quantitative description of the publications produced in a certain period in the field of research and the relationships between them (Yılmazel, 2019). In this way, a general perspective can be provided on the development of the scientific process in the field. In analyzing the accessed theses, bibliometric parameters such as type, year, subject, institution, publication language and keyword were used, and their frequencies and graphs were prepared with data visualization techniques. The findings obtained as a result of these investigations are shared in sub sections.

Keywords: Management Information Systems, Classification, Clustering, Bibliometric Analysis

1. Introduction

In this era, called the "Information Age", a rapid change process is experienced in parallel with the developments in information and communication Technologies, and the structures of societies are being reshaped. One of the concepts that emerged with this rapid change is the concept of "Information Society". The basis of the information society is people and technology, and the source of information is scientific thought. Increasing the level of education, strengthening the human capital that plays a key role in the production of information and technology through university education, shifting the entire weight of the economy to the technical and researcher class, and basing all kinds of policies and innovations on intellectual technology fed by scientific knowledge are the most basic features of the information society.

This paper is based on the master's thesis whose author is Göktuğ İlısu and supervisor is Prof. Dr. Nursal Arıcı.

The Information Society, where modern technology and scientific knowledge are highlighted, is based on principles such as equipped and qualified human capital, brain power, sustainable development, closely monitoring global developments and implementing them, lifelong learning, and adapting to rapid change and transformation (Özden 2002; Uğur, Okursoy & Turan 2016).

According to Bell and Tonta, *"The institutions that undertake the most important duties in the information society are universities, academic institutes, and research centers. Because these institutions are the basic institutions responsible for the production and distribution of scientific knowledge. "(Bell 1976; Tonta 1999).*

Based on this mission, one of the scientific fields that has an important place on the path to becoming an Information Society and continues to develop is Management Information Systems. Educational activities continue by opening Management Information Systems departments at the undergraduate level both in our country and in many Higher Education Institutions around the world. At the same time, at a higher level of these activities, training and scientific studies are carried out at postgraduate levels (Master's and Doctoral), and contributions are made to the field of Management Information Systems science.

"*Management information systems is a field of science that focuses on producing solutions to the information needs of states, societies, organizations, groups, and individuals at strategic, managerial, and operational levels through information systems and technologies. It is a multidisciplinary field that develops methodologies to develop solutions to real-life problems in an application-oriented framework and to manage information technology resources in the most appropriate way, making use of various reference disciplines such as computer science, management science, statistics, organization theory, and operations research*". This field is also related to issues in sociology, economics, and psychology, such as the use and effects of information technologies. (Culnan 1987; Baskerville ve Myers, 2002; Laudon & Laudon 2006; Yarlıkaş 2015; Damar&Bölen 2021).

Considering the multidisciplinary structure of Management Information Systems, understanding the identity formation of the field and evaluating the knowledge in the field has become a subject of interest for researchers in both international and national communities In these researches, it is aimed to periodically reveal the picture of the literature. For the purposes, inferences have been made through methods such as systematic compilations and reviews that provide in-depth information, and bibliometric analysis.

The main purpose of this paper is to examine the reflections and developments of the Management Information Systems discipline, which is fed by different disciplines, on graduate thesis topics in Turkey. For this purpose, postgraduate theses conducted in the field of Management Information Systems between 2006 and 2023, which are

accessible through the YÖK National Thesis Center website, were included in the scope of the research. (https://tez.yok.gov.tr/UlusalTezMerkezi/)

For this purpose, answers were sought to the following questions:

- What is the distribution of theses according to their types (Master's/Ph.D.)?
- What is the distribution of master's and doctoral theses by year?
- What is the distribution of theses by universities?
- What is the distribution of theses according to publication language?
- What is the distribution of theses according to topics?
- What is the distribution of the keywords of the theses?

The remaining sections of the paper are structured as follows. In the second part, the studies compiled from the literature within the scope of our study will be summarized. In the third part, the method applied to achieve the main purpose will be explained, and in the fourth part, the findings will be interpreted and the results will be evaluated.

2. Method

The aim of this study is to examine the reflections and developments of the Management Information Systems discipline, which is fed by different disciplines, on postgraduate thesis topics in Turkey. The study population consists of 920 postgraduate theses (Master's-f:820 and PhD-f:100) prepared in the field of Management Information Systems between 2006-2023, which are accessible through the YÖK National Thesis Center website. (https://tez.yok.gov.tr/UlusalTezMerkezi/). For our purpose, 920 postgraduate theses were examined with the bibliometric analysis method. Bibliometric analysis; It is one of the research methods in which certain characteristics of publications such as subject, field, institution and author are examined quantitatively. It enables the quantitative description of the publications produced in a certain period in the field of research and the relationships between them (Yılmazel, 2019). In this way, a general perspective can be provided on the development of the scientific process in the field.

In analyzing the accessed theses, bibliometric parameters such as type, year, subject, institution, publication language and keyword were used, and their frequencies and graphs were prepared with data visualization techniques. The findings obtained as a result of these investigations are shared in the sections below.

This paper is based on the master's thesis whose author is Göktuğ İlısu and supervisor is Prof. Dr. Nursal Arıcı.

2.1. Distribution of theses according to their types (Master's/Doctorate)

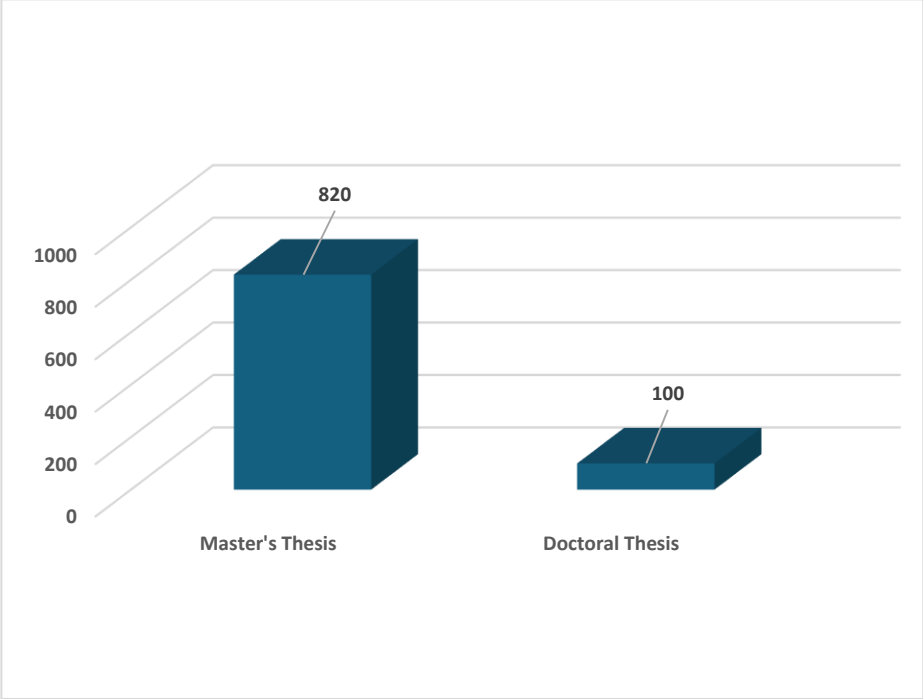

Fig. 1. Distribution of theses according to their types (Master's/Doctorate)

There exist 820 master's theses and 100 doctoral theses accessible through YÖK National Thesis Center website.

2.2. Distribution of master's and doctoral theses by year

2.2.1. Distribution of master's theses by year

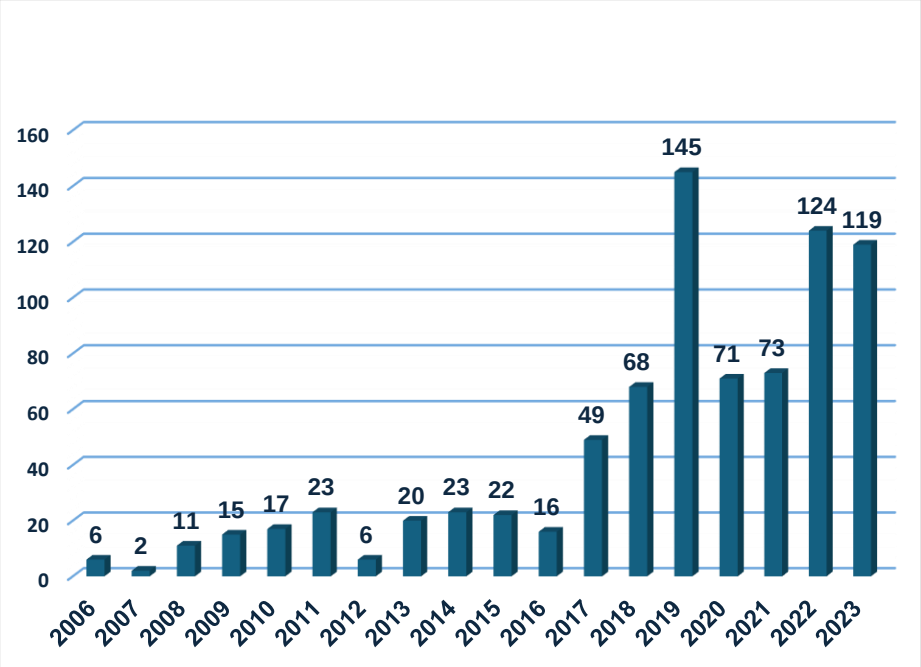

Fig. 2. Distribution of master's theses by years

It is seen that the first master's thesis writing in the main discipline of management information systems took place in 2006. The number of master's theses, which did not change much between 2006-2016, has increased significantly since 2017. In 2019, the number of master's theses reached its peak with 145 theses, and as of 2020, it decreased to approximately half of the number of theses written in 2019. However, in 2022, the number of master's theses recorded a new increase and reached 124.

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2.2.2. Distribution of doctoral theses by year

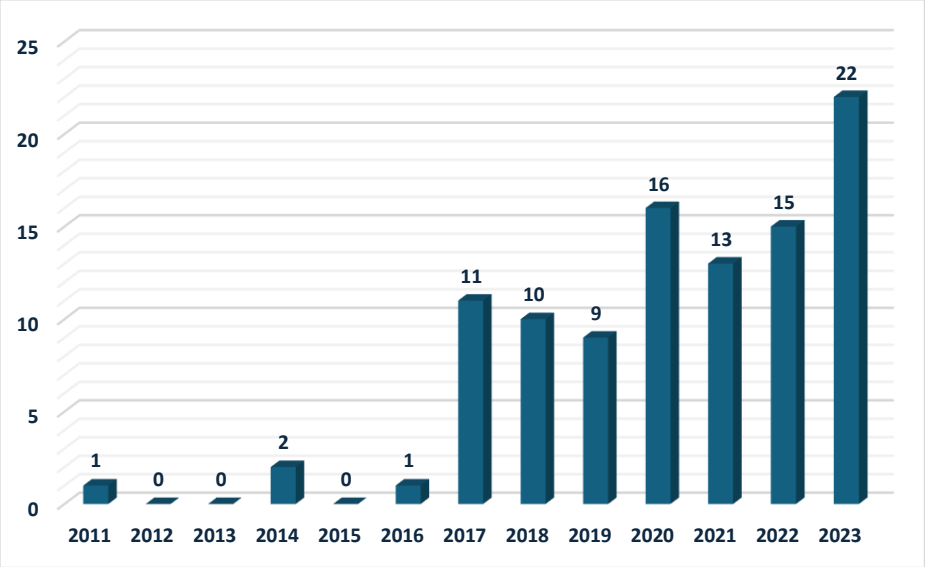

Fig. 3. Distribution of doctoral theses by years

It is seen that the first doctoral thesis writing in the main discipline of management information systems was realized in 2011. The number of doctoral dissertations, which did not change much between 2011-2016, has increased significantly since 2017. In 2023, the number of doctoral theses reached its peak with 22 theses, followed by 2020 with 16 doctoral theses.

2.3. Distribution of the universities where the theses were conducted

2.3.1. Distribution of the universities where the master's theses were conducted

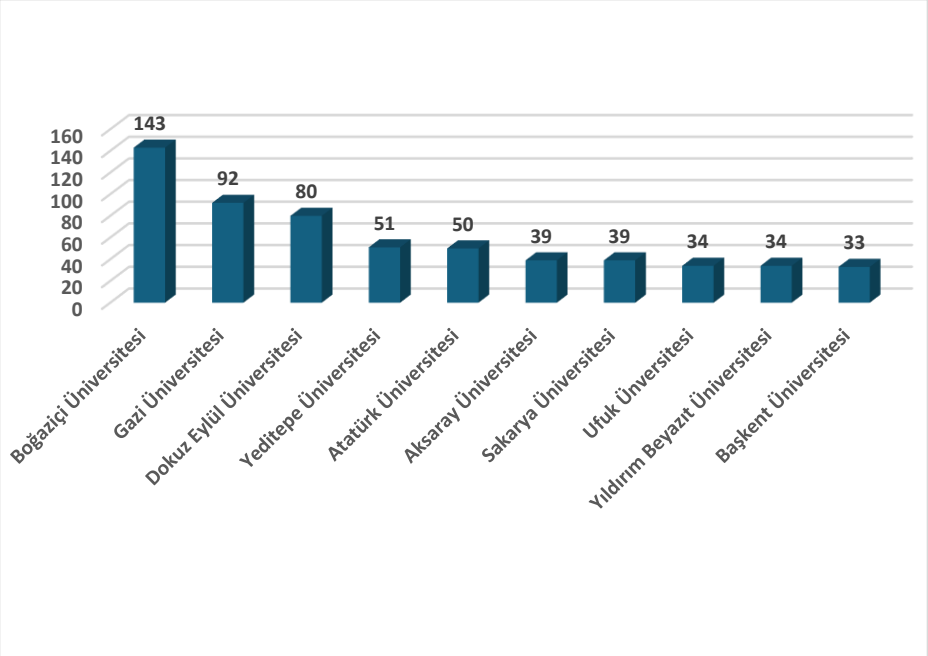

Fig. 4. Distribution of master's theses according to top 10 universities

If the universities with the highest number of publications in terms of master's theses written in the main discipline of management information systems are examined, Boğaziçi University comes to the forefront with 143 master's thesis publications. With 92 master's thesis publications, Gazi University ranks second, while Dokuz Eylül University ranks third with 80 master's thesis publications.

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2.3.2. Distribution of the universities where the doctoral theses were conducted

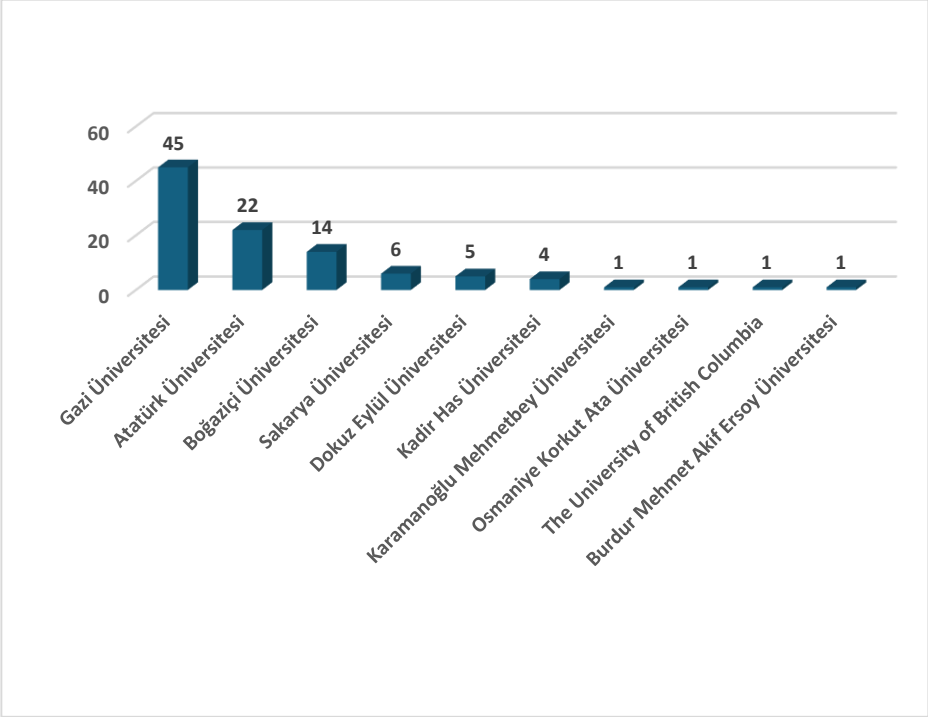

Fig. 5. Distribution of doctoral theses according to universities

If the universities with the highest number of publications in terms of doctoral dissertations written in the main discipline of management information systems are analyzed, Gazi University comes to the forefront with 45 doctoral dissertation publications. With 22 doctoral thesis publications, Atatürk University ranks second, while Boğaziçi University ranks third with 14 doctoral thesis publications.

2.4. Distribution of theses according to language of publication

2.4.1. Distribution of master's theses according to language of publication

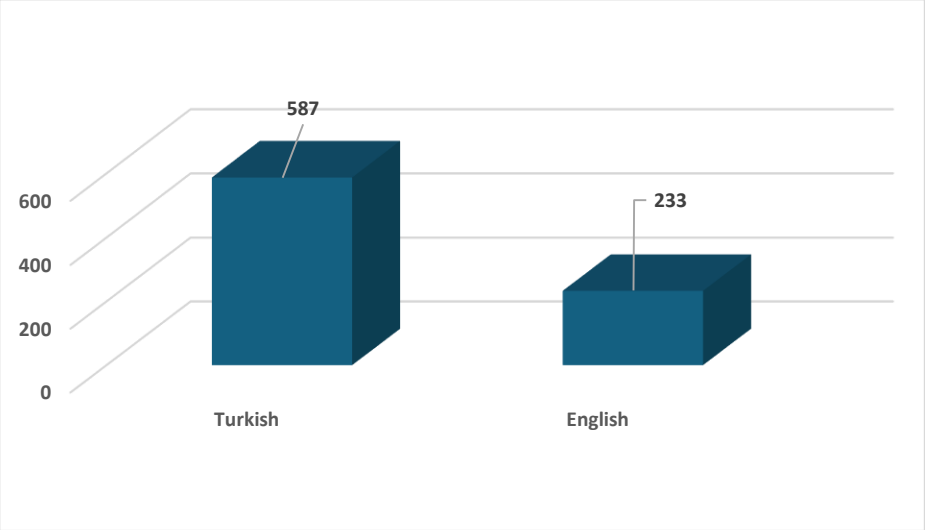

Fig. 6. Distribution of master's theses according to language of publication

587 master's theses were written in Turkish and 233 master's theses were written in English.

2.4.2. Distribution of doctoral theses according to language of publication

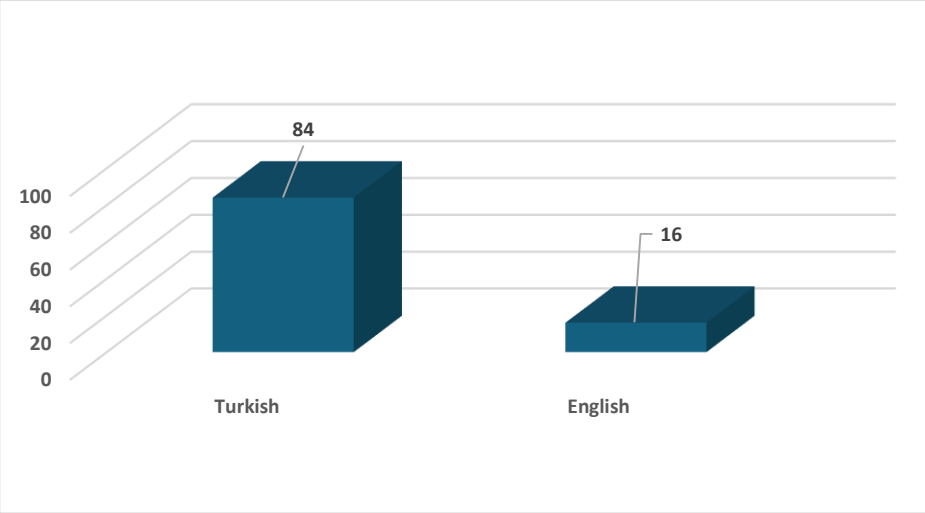

Fig. 7. Distribution of doctoral theses according to language of publication

This paper is based on the master's thesis whose author is Göktuğ İlısu and supervisor is Prof. Dr. Nursal Arıcı.

84 doctoral theses were written in Turkish and 16 doctoral theses were written in English.

2.5. Distribution of theses according to topics

2.5.1. Distribution of master's theses according to Turkish topics

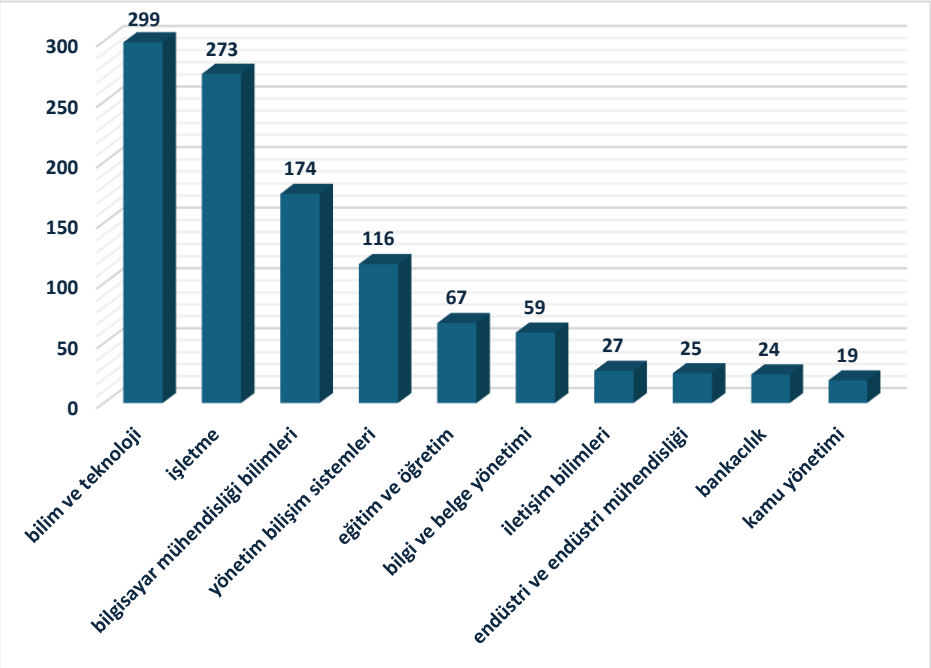

Fig. 8. Distribution of master's theses according to top 10 Turkish topics

"Bilgisayar bilimleri mühendisliği- bilgisayar ve kontrol", "İşletme", "Bilim ve Teknoloji" come to the forefront when the Turkish topics on which the most master's theses were written in the main branch of management information systems are examined. "Bilim ve teknoloji" is at the top due to the fact that it was covered in 299 master's theses. 273 master's theses on "işletme" ranked second, while 174 master's theses on "Bilgisayar bilimleri mühendisliği- bilgisayar ve kontrol" ranked third.

2.5.2. Distribution of master's theses according to English topics

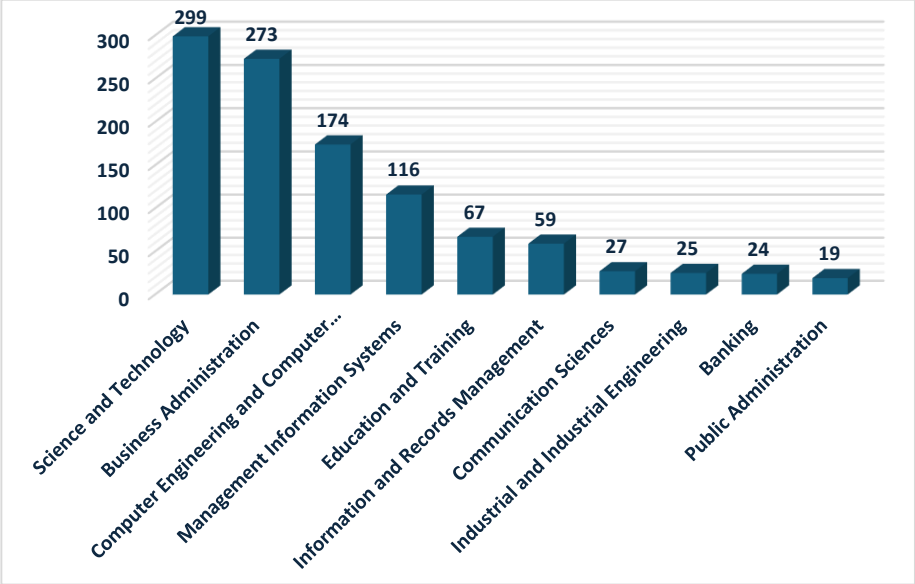

Fig. 9. Distribution of master's theses according to top 10 English topics

"Computer engineering and computer science and control", "Business administration", "Science and Technology" come to the forefront when the Turkish topics on which the most master's theses were written in the main branch of management information systems are examined. "Science and Technology" is at the top due to the fact that it was covered in 299 master's theses. 273 master's theses on "Business administration" ranked second, while 174 master's theses on "Computer engineering and computer science and control" ranked third.

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2.5.3. Distribution of doctoral theses according to Turkish topics

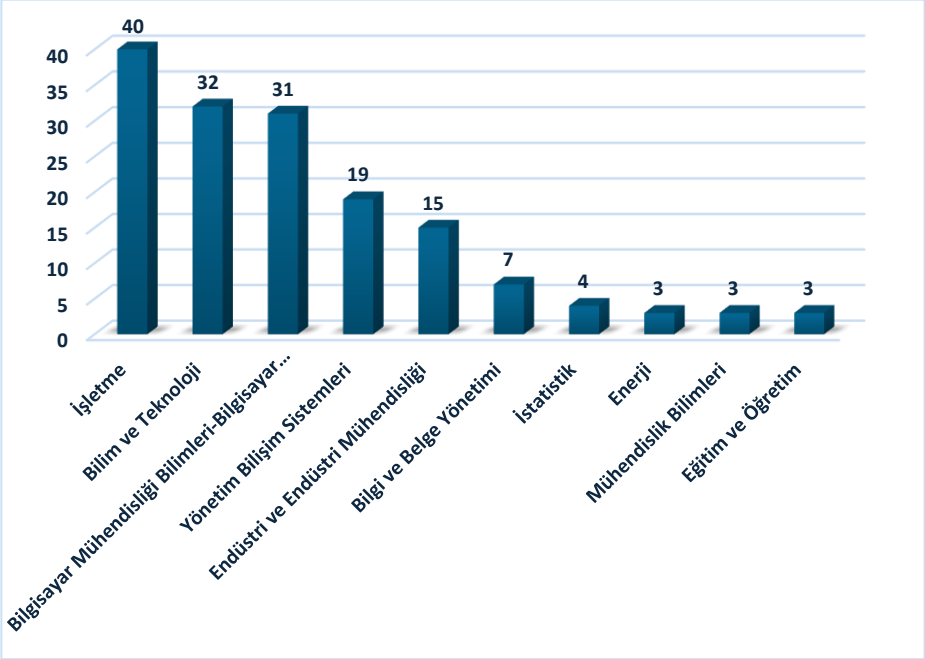

Fig. 10. Distribution of doctoral theses according to top 10 Turkish topics

"Bilgisayar bilimleri mühendisliği- bilgisayar ve kontrol", "İşletme", "Bilim ve Teknoloji" come to the forefront when the Turkish topics on which the most doctoral theses were written in the main branch of management information systems are examined. “İşletme” is at the top due to the fact that it was covered in 40 doctoral theses. 32 doctoral theses on “bilim ve teknoloji” ranked second, while 31 doctoral theses on “Bilgisayar bilimleri mühendisliği- bilgisayar ve kontrol” ranked third.

2.5.4. Distribution of doctoral theses according to English topics

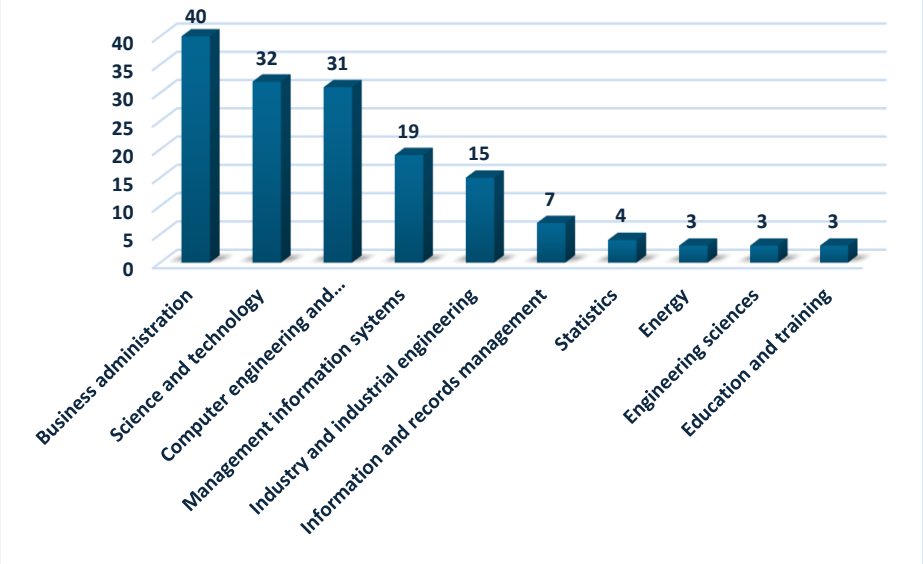

Fig. 11. Distribution of doctoral theses according to top 10 English topics

" Computer engineering and computer science and control ", "Business administration", "Science and technology" come to the forefront when the English topics on which the most doctoral theses were written in the main branch of management information systems are examined. “Business administration” is at the top due to the fact that it was covered in 40 doctoral theses. 32 doctoral theses on “science and technology” ranked second, while 31 doctoral theses on “Computer engineering and computer science and control” ranked third.

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2.6. Distribution of keywords of theses

2.6.1. Distribution of Turkish keywords of master's theses

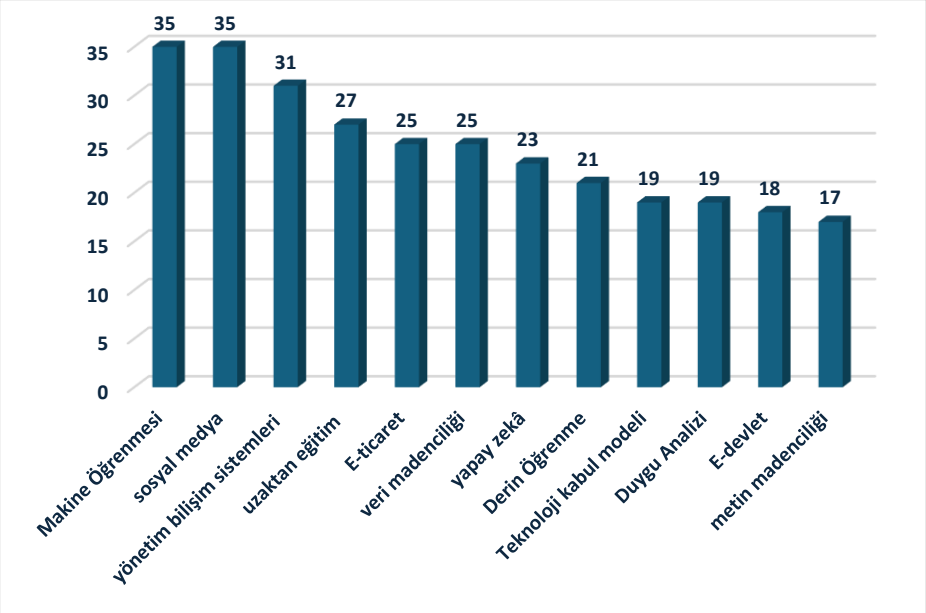

Fig. 12. The most commonly used Turkish keywords in master's theses

If the most commonly used Turkish keywords in master's theses written in the main discipline of management information systems are analysed, both the keywords "makine öğrenmesi" and "social media" which are used 35 times, comes to the forefront. 31 times "yönetim bilişim sistemleri" is in the second place and 27 times "uzaktan eğitim" is in the third place.

2.6.2. Distribution of English keywords of master's theses

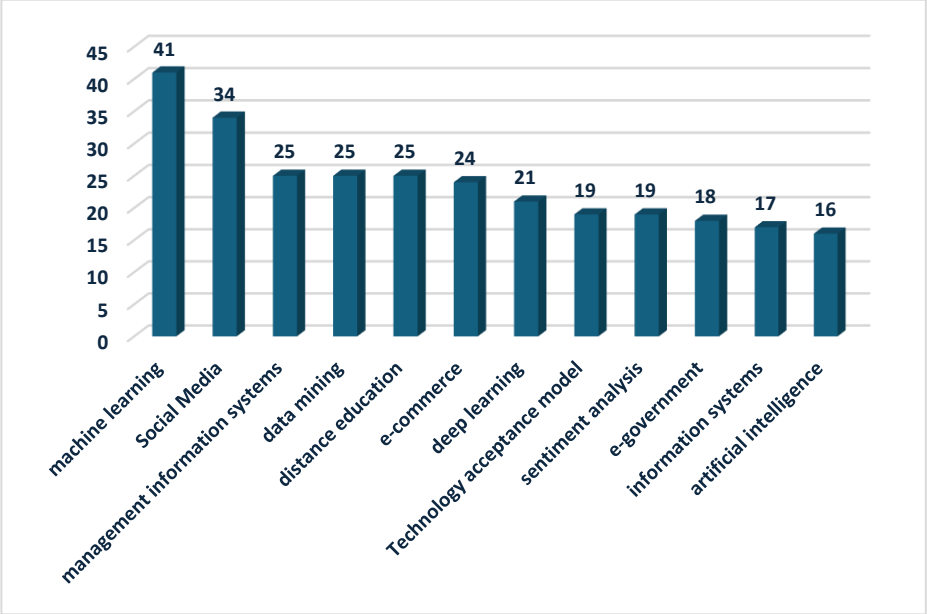

Fig. 13. The most commonly used English keywords in master's theses

If the most commonly used English keywords in master's theses written in the main discipline of management information systems are analysed, the keyword "Machine Learning", which is used 41 times, comes to the forefront. The keyword "social media" used 34 times, which is the second most used keyword, while the keywords "Management Information Systems", "Distance Education" and "Data Mining" which are used in 25 master's theses each, are the third most used keywords.

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2.6.3. Distribution of Turkish keywords of doctoral theses

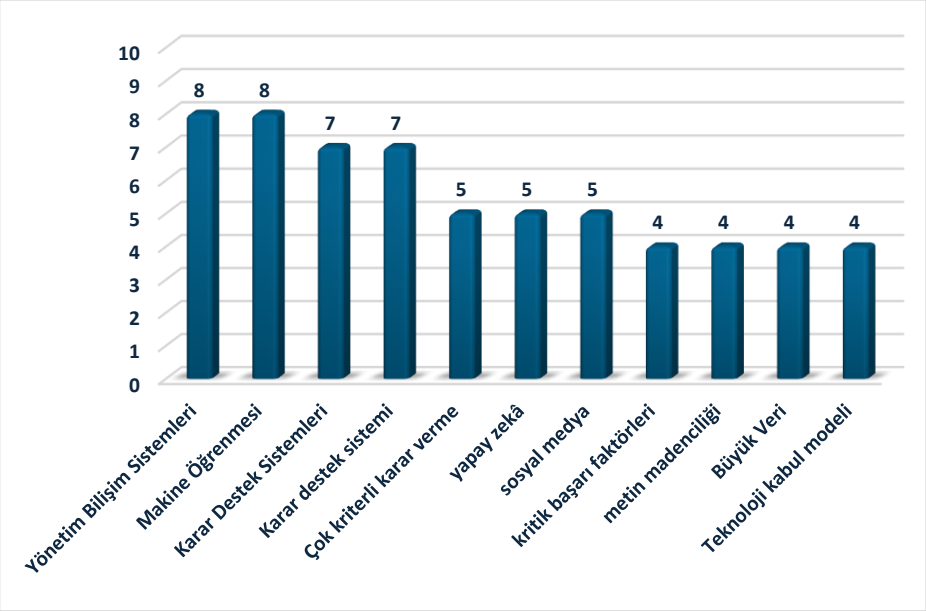

Fig. 14. The most commonly used Turkish keywords in doctoral theses

If the most commonly used Turkish keywords in doctoral theses written in the main discipline of management information systems are analysed, the keywords " yönetim bilişim sistemleri" and "makine öğrenmesi", which are used 8 times each, come to the fore. While "karar destek sistemleri" and "karar destek sistemi", which are used 7 times each, are the second most used keywords, the keywords "çok kriterli karar verme", "yapay zekâ" and "sosyal medya", which are used in 5 master's theses each, are the third most used keywords.

2.6.4. Distribution of English keywords of doctoral theses

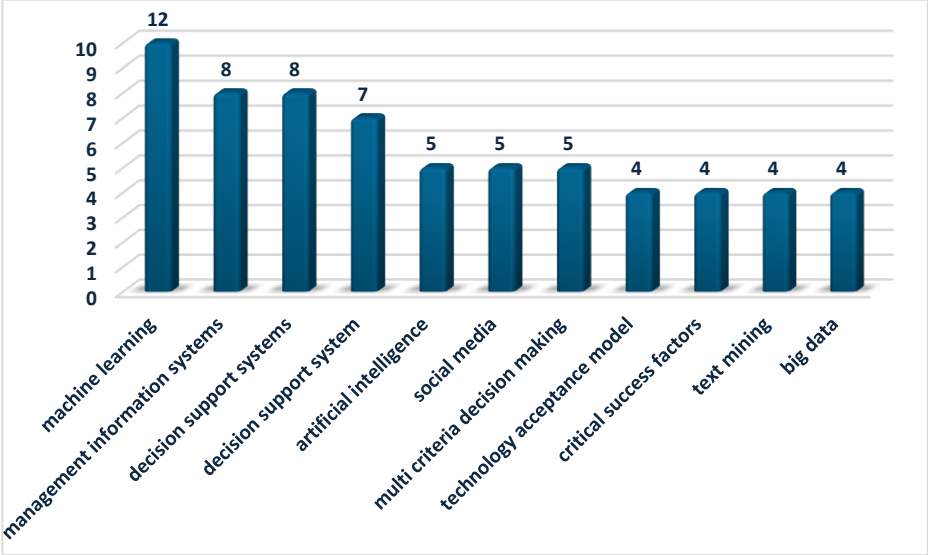

Fig. 15. The most commonly used English keywords in doctoral theses

If the most commonly used English keywords in doctoral theses written in the main discipline of management information systems are analysed, the keyword "machine learning", which is used 12 times, comes to the forefront. While "decision support systems" and "management information systems", which were used 8 times each, were the second most used keywords, the keyword "decision support system", which was used in 7 master's theses, was the third most used keyword.

3. Results And Conclusion

In this paper, the developments in the field of Management Information Systems have been revealed by evaluating the postgraduate (Master's and Doctoral) theses carried out in universities in Turkey. In this way, the productivity of our universities in the field of Management Information Systems at the graduate level has been evaluated.

Year	Master's Theses Count	Doctoral Theses Count
2006	6	-
2007	2	-
2008	11	-
2009	15	-
2010	17	-
2011	23	1

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2012	6	-
2013	20	-
2014	23	2
2015	22	-
2016	16	1
2017	49	11
2018	68	10
2019	145	9
2020	71	16
2021	73	13
2022	124	15
2023	119	22

Tab 1. Number of postgraduate theses with respect to years

According to Table 1, the year in which the most master's theses were prepared is 2019, and the year in which the most doctoral theses were prepared is 2023. However, it is seen that the publication of doctoral theses in management information systems has increased since 2017. The situation is similar for master's theses. Except for a doctoral thesis published before 2011, there is no other doctoral thesis published before 2014.

University	**Master's Theses Count**	**Doctoral Theses Count**
Boğaziçi Üniversitesi	143	14
Gazi Üniversitesi	92	45
Dokuz Eylül Üniversitesi	80	5
Yeditepe Üniversitesi	51	-
Atatürk Üniversitesi	50	22
Sakarya Üniversitesi	39	6
Aksaray Üniversitesi	39	-
Ufuk Üniversitesi	34	-
Yıldırım Beyazıt Üniversitesi	34	-
Başkent Üniversitesi	33	-
Osmaniye Korkut Ata Ünversitesi	31	1
Kadir Has Üniversitesi	27	4
Karamanoğlu Mehmetbey Üniversitesi	26	1
Düzce Üniversitesi	21	-
Sivas Cumhuriyet Üniversitesi	20	-
Burdur Mehmet Akif Ersoy Üniversitesi	20	1
Necmettin Erbakan Üniversitesi	12	-
Akdeniz Üniversitesi	9	-
Haliç Üniversitesi	8	-

Bursa Uludağ Üniversitesi	8	-
Adana Bilim ve Teknoloji Üniversitesi	7	-
Adana Alparslan Türkeş Bilim ve Teknoloji Üniversitesi	7	-
Uluslararası Kıbrıs Üniversitesi	4	-
Ankara Bilim Üniversitesi	3	-
Aydın Adnan Menderes Üniversitesi	3	-
Bandırma Onyedi Eylül Üniversitesi	3	-
Selçuk Üniversitesi	3	-
Mehmet Akif Ersoy Üniversitesi	3	-
İzmir Bakırçay Üniversitesi	3	-
Erciyes Üniversitesi	2	-
Pamukkale Üniversitesi	2	
İstanbul Topkapı Üniversitesi	1	
University of London	1	-
Muğla Sıtkı Koçman Üniversitesi	1	-
The University of British Columbia	-	1

Tab 2. Number of post graduate theses with respect to universities

According to Table 2, it is seen that 30 different universities published master's theses and 7 different universities published doctoral theses. It is seen that Boğaziçi University is at the forefront in terms of master's thesis publications and Gazi University is at the forefront in terms of doctoral thesis publications. University of London, which is not located in Turkey, is included in the YÖK National Thesis Centre website database with 1 master's thesis publication and The University of British Columbia with 1 doctoral thesis publication.

Master's Theses			
Mostly used Turkish Keywords	**Numerical Values of Turkish Keywords**	**Mostly used English Keywords**	**Numerical Values of English Keywords**
makine öğrenmesi	35	*machine learning*	41
sosyal medya	35	*social media*	34
yönetim bilişim sistemleri	31	*management information systems*	25
uzaktan eğitim	27	*distance education*	25
veri madenciliği	25	*data mining*	25
e-ticaret	25	*e-commerce*	24
e-devlet	18	*e-government*	18
yapay zeka	23	*artificial ıntelligence*	16
derin öğrenme	21	*deep learning*	21

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teknoloji kabul modeli	19	*technology acceptance model*	19
duygu analizi	19	*sentiment analysis*	19
		information technology	13

Tab 3. Keywords most used in master's theses

According to Table 3, the most commonly used keywords in master's theses are "makine öğrenmesi" and "machine learning". The reasons for the differences in the number of words whose Turkish and English equivalents have the same meaning are; in some theses, there is no English keyword section, and in some theses, there are translation differences. The reason why the expression "Information technology", which is the Turkish equivalent of the keyword "information technology", is not included in the table is the use of different Turkish expressions such as "information technology", "information technologies" due to translation differences.

Master's Theses			
Mostly Issued Turkish Topics	**Numerical values of Turkish Topics**	**Mostly Issued English Topics**	**Numerical values of English Topics**
Bilim ve Teknoloji	299	*Science and Technology*	299
İşletme	273	*Business Administration*	273
Bilgisayar Mühendisliği Bilimleri-Bilgisayar ve Kontrol	174	*Computer Engineering and Computer Science and Control*	174
Yönetim Bilişim Sistemleri	116	*Management Information Systems*	116
Eğitim ve Öğretim	67	*Education and Training*	67
Bilgi ve Belge Yönetimi	59	*Information and Records Management*	59
İletişim Bilimleri	27	*Communication Sciences*	27
Endüstri ve Endüstri Mühendisliği	25	*Industrial and Industrial Engineering*	25
Bankacılık	24	*Banking*	24
Kamu Yönetimi	19	*Public Administration*	19
Ekonomi	17	*Economics*	17

Tab 4. Topics most issued in master's theses

Table 4 presents the subjects on which the most master's theses were written. It is seen that the number of topics that are equivalent to each other in Turkish and English are equal. "Science and Technology" in terms of Turkish subjects and "Science and Technology" in terms of English subjects have been the most frequently covered subjects in master theses.

Doctoral Theses			
Mostly used Turkish Keywords	**Numerical Values of Turkish Keywords**	**Mostly used English Keywords**	**Numerical Values of English Keywords**
Makine Öğrenmesi	8	Machine Learning	9
Yönetim Bilişim Sistemleri	8	Management Information Systems	6
Karar Destek Sistemleri	7	Decision Support Systems	6
Karar destek sistemi	7	decision support system	6
Çok kriterli karar verme	5	Multi-criteria decision making	4
yapay zekâ	5	Artificial Intelligence	4
sosyal medya	5	Social media	5
kritik başarı faktörleri	4	Critical Success Factors	4
metin madenciliği	4	text mining	4
Büyük Veri	4	Big Data	4
Teknoloji kabul modeli	4	Technology acceptance model	4

Tab 5. Keywords most used in doctoral theses

According to Table 5, the most commonly used keywords in doctoral theses are "machine learning", "management information systems", "yönetim bilişim sistemleri" and "makine öğrenmesi". The reasons for the differences in the number of words whose Turkish and English equivalents have the same meaning are the lack of an English keyword section in some theses and translation differences in some theses.

Doctoral Theses			
Mostly Issued Turkish Topics	**Numerical values of Turkish Topics**	**Mostly Issued English Topics**	**Numerical values of English Topics**
İşletme	40	Business Administration	40

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Bilim ve Teknoloji	32	Science and Technology	32
Bilgisayar Mühendisliği Bilimleri-Bilgisayar ve Kontrol	31	Computer Engineering and Computer Science and Control	31
Yönetim Bilişim Sistemleri	19	Management Information Systems	19
Endüstri ve Endüstri Mühendisliği	15	Industrial and Industrial Engineering	15
Bilgi ve Belge Yönetimi	7	Information and Records Management	7
İstatistik	4	Statistics	4
Enerji	3	Energy	3
Mühendislik Bilimleri	3	Engineering Sciences	3
Eğitim ve Öğretim	3	Education and Training	3
İletişim Bilimleri	2	Communication Sciences	2
Reklamcılık	2	Advertising	2
Sağlık Kurumları Yönetimi	2	Health Care Management	2

Tab 6. Topics most issued in doctoral theses

Table 6 presents the subjects on which the most doctoral theses were written. It is seen that the number of topics that are equivalent to each other in Turkish and English are equal.

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