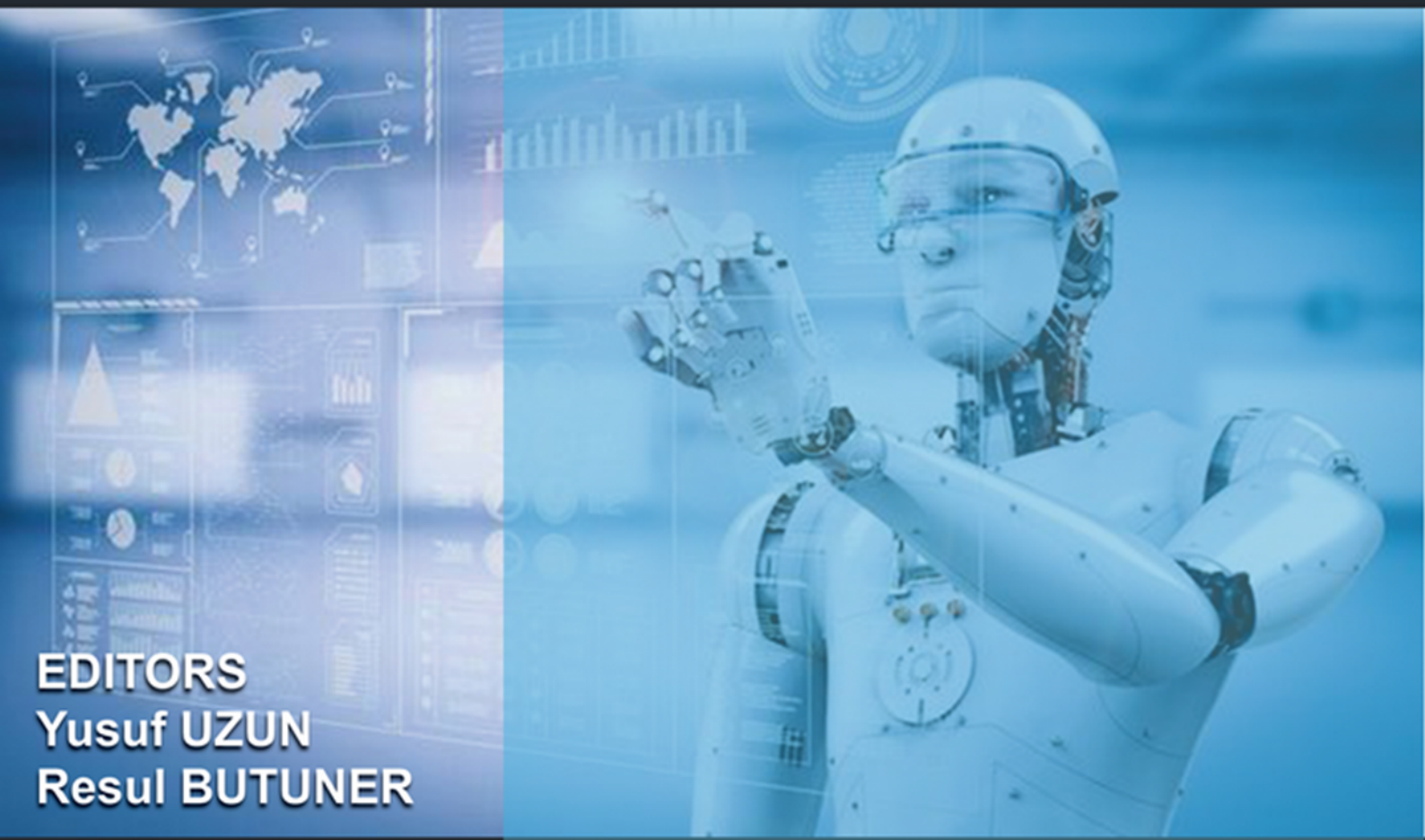
Current Studies in Artificial Intelligence, Virtual Reality and Augmented Reality



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ISRES Publishing

Current Studies in Artificial Intelligence, Virtual Reality and Augmented Reality

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PREFACE

Mankind is the most intelligent creature ever created. The ability to think, understand, reason, decide, find solutions, learn and draw conclusions in life is called intelligence in humans. Recently, some studies called artificial intelligence technology have been carried out to imitate human intelligence. Artificial intelligence is a scientific research branch that examines and analyzes the mental functions and abilities of human intelligence with the help of computer models and aims to apply them to artificial systems. Today, it gives successful results in solving problems in many fields such as education, military, health, and security.

Virtual reality is a field of study carried out for the use of objects such as models, text, and video produced in computer-generated environments. Especially with the development of portable and mobile device technologies, the usage areas are increasing day by day. Effective and efficient applications have been developed in a field such as simulation, games, and education.

Augmented reality technology is a current field of study for the use of objects such as computer-generated models, text, and video in the real world. With the production of smart glasses and mobile devices, the usage area is increasing day by day. It has been used successfully in many fields of study, especially in the education sector, especially during the pandemic process.

This book has been developed as a research resource for the use of artificial intelligence, virtual reality, and augmented reality technologies in different disciplines. We wish you the best of luck in contributing to the literature.

November 2022

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IN THIS BOOK

In Chapter 1, almost all technological developments are reflected in the provision of health services at a rapid pace. The nursing department, which is one of the professional health disciplines, is decisively increasing its interest in artificial intelligence technologies. On the one hand, artificial intelligence technologies are integrated into patient care services, and on the other hand, they are used in nursing education. In this section, the use of artificial intelligence technologies in the field of nursing is examined, and professional concerns and the ethical dimension of the issue are discussed.

In Chapter 2, virtual reality applications, which have entered our lives with the developments in technology in the twenty-first century, are also frequently used in the field of health. The use of virtual reality technologies in nursing education and applications, which is an applied health discipline, provides convenience in many areas in transferring theoretical knowledge to practice. In the study; the use of virtual reality applications in areas such as education, diagnosis, treatment, rehabilitation were examined and interpreted by supporting the studies.

In Chapter 3, the conveyor belt system was designed and fault detection was performed on the fabrics by using the image processing method. An artificial intelligence approach was designed to solve an important problem in the textile industry. A successful study was carried out to determine the defects in fabrics.

In Chapter 4, moans were made about the use of augmented reality in the field of rehabilitation. Augmented reality technologies are widely used today to solve many problems. Augmented reality applications are an innovative study that will contribute significantly to the rehabilitation programs of patients with emotional and physical problems.

In Chapter 5, the conceptual design and usage areas of augmented and virtual reality are examined. The purpose of these technologies is to create virtual environments for users. In virtual reality technology, everything is designed in the computer environment, while in augmented reality, models are created on the real physical environment. With augmented reality, people can interact with 3D objects without breaking away from the real world, while in virtual reality they interact completely in the virtual world.

In Chapter 6, Artificial intelligence is among the trends of today's technologies and artificial intelligence technologies in education field are examined in the study. Educational materials developed with these technologies and studies on the use of these materials have been examined. It has been observed that there has been a rapid increase in the number of studies conducted on the use of artificial intelligence technologies in education in recent years. The results of the studies were examined with analyzes and the results emphasized by the researchers were obtained.

In Chapter 7, artificial intelligence technologies are used in many fields today. One of these areas has been the material and manufacturing sector. With the development of technology, the analysis programs required for efficiency, delivery material production and analysis in the field of industrial production, as well as the prediction of the damage, which is a step after these, have become very important. In the study, the studies on artificial intelligence technologies in the field of industrial design and production were examined and the results were interpreted in detail.

In Chapter 8, the diversity of materials, production methods and experiments used in the industry has led to the transfer of a lot of data to materials science in the production of materials suitable for needs. In this chapter, studies of different artificial intelligence techniques in the field of microstructural characterization, optimization, and prediction of mechanical properties of metallic materials used in the industry were examined.

In Chapter 9, it was described the use of key matrices on encryption with matrices while encrypting. First, the basic definitions and history used in encryption are introduced. In the second part, the terminology is briefly explained, the history of cryptography is mentioned and the characteristics of encryption systems are mentioned. In the third part, classical, private and public key encryptions and mixed encryption methods are explained. In the fourth part, mathematical basic information is explained. Finally, an example was made for the encryption system with matrices, and encryption and decryption processes were applied with a two-dimensional key matrix on a selected Turkish text.

In Chapter 10, artificial intelligence methods are examined in the wood identification field. The classical wood identification process is labor-intensive and requires relatively long preparation and inspection times. Also, some tree species are difficult to distinguish from each other microscopically. Therefore, these challenges can be overcome by using image processing and artificial intelligence approaches to quickly and accurately diagnose wood.

In Chapter 11, due to the increasing use of microstrip antennas in satellite communication systems and their adaptability to the place where they are used, antenna designers try unique design methods with different geometries. New production methodologies are being developed by making different variations in the physical and electrical parameters of the antennas to improve the features such as narrow bandwidth and low gain, which are the disadvantages of microstrip antennas. Approaches that do not require much calculation time by using artificial intelligence methods have enabled the realization of different microstrip antenna designs working with high efficiency in the literature. In this section, artificial intelligence methods used in microstrip antennas and microstrip antenna designs designed using artificial intelligence methods are examined.

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CHAPTER 1

Application of Artificial Intelligence Technologies in the Field of Nursing

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Application of Artificial Intelligence Technologies in the Field of Nursing

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Introduction

Nursing discipline, an indispensable part of healthcare delivery, has a critical role for the professional healthcare team, and furthermore, it is in a testing process with AI (AI) technologies in the century we are in, to once again prove its claim to be an agent of change. With a multidisciplinary approach, nurses can use AI technologies as a tool and improve nursing science, moving care service much further than it is today (Kikuchi, 2020). It would be useful to briefly address the issue across health services before moving on to the issue of implementing AI technologies in the field of nursing.

Artificial Intelligence Technologies and Healthcare

The prolongation of life expectancy brings with it an increase in chronic diseases, treatment, and care costs. Limiting costs is critical for sustainable health systems. AI has the potential to provide strong support for the sustainability of healthcare systems by keeping costs at more affordable levels (Higgins & Madai, 2020; Kumar & Chauhan 2021). AI technologies that mimic the cognitive functions of mankind using analytical techniques on massive data with superhuman power are bringing a paradigm shift to healthcare. We have only just begun to see the effects of AI on healthcare. In the coming years, this effect is expected to increase and deepen (Jiang et al., 2017). Healthcare is an area full of opportunities for AI applications. For example, AI technology can do in seconds a complex process that demands a long period of time and labor of humans, such as the analysis of huge sizes of data belonging to millions of patients. AI applications save health professionals from vexatious procedural work, enabling them to further divert time, energy, and capabilities to people while performing risk assessments of clinic inpatients and accelerating the implementation of measures. All of this means a better patient experience with healthcare, lower costs, and rational use of resources. AI technologies and algorithms can be a unique support tool for overcoming limitations in the diagnosis of diseases and prediction of risks. Therefore, there is a growing interest in AI applications in the healthcare field. AI applications and research in healthcare generate a

wide range, and the field attracts the attention of service providers and consumers as well as investors. Today, there are examples of AI applications in use, and many of them are in the process of pilot work and development (Ross et al., 2019; Davenport & Kalakota, 2019). Some of the applications of AI in the field of health include: (Alugubelli, 2016; Big data, 2016; Nahid & Kong, 2017; Rong et al. 2020; Thakur et al., 2020):

- Retinopathy screening
- Staging in breast cancer
- Reduction of postpartum depression
- Risk assessment in patients and predicting negative health outcomes
- Estimating the effectiveness of treatment in cancer patients
- Workflow applications that will save time for clinicians
- Mission control-command centers
- Virtual clinical assistants
- Robot surgeon assistants
- Radiology, pathology

Artificial Intelligence Technologies and Nursing

It is necessary to address the place and importance of nursing care in health systems before moving on to the issue of the use of AI technologies in nursing services. Human beings are the focus of nursing care and are its only area of interest. The care service offered by the nursing discipline includes holistic and often personalized scientific and professional initiatives offered to healthy and sick individuals. The physiological requirements of the healthy person are often unchanged, although the content and presentation of nursing care, which has a strong relationship with the physiological condition, is highly variable from patient to patient. The various requirements of a person that can be met by nursing care are formed within the framework of his/her cultural, religious, social, psychological, physiological, and many other characteristics. This in turn leads to the care offered to each patient/healthy individual becoming specific, not resembling that of another. The discipline of nursing offers such specialized care to a wide range of people (indeed all age groups and all people with varying health conditions) at any time. Moreover, this service is provided in line with values and principles such as respect, protection of human dignity, privacy, compassion, justice, and equality. Failure of nursing service delivery could mean blockage or even collapse of the entire healthcare system (Erim & Cevirme, 2018; Unsal, 2017; White, 2002).

Over time, many factors have caused nursing care to take shape. Changing human requirements and expectations, as well as technological advancements, are at the forefront of these factors. AI, yet a new technology for many disciplines, is also discussed with a poor interest in nursing. It is apparent that AI technologies will contribute to nursing care, but there are strong objections to proficiency to replace nurses over time and deliver personalized care in line with the needs of the patient and values/principles (Akgerman et al., 2022; Buchanan et al., 2020). Many questions arise such as whether AI can provide emotional support to a patient diagnosed with a deadly illness, if a robot nurse can communicate therapeutically, and how and how much this pattern of communication can affect the patient. Every new technology inherently holds risks. It is recommended to examine the application outputs at hand for the integration of AI technologies into nursing care. Nurses must be present in the assessment of how outputs offer value/contribution based on clinical experience. Training in the field of AI is needed for nurses to be ready for multidisciplinary studies (Frith, 2019). The perception of nurse groups on AI is generally positive. A study conducted in Turkey revealed that health workers, including nurses, have a positive perception of AI. According to the study, 85.4% of respondents said that AI is useful for healthcare, 52.3% had high hopes for AI applications in healthcare, and 64.3% did not see any AI-related risk related to their jobs (Ankara et al., 2021).

Locsin & Ito (2018) proposed a 5-item categorization so that technologies used in healthcare can be easily identified;

- Human-complementing technology such as mechanical prosthetics and biological organs.
- Technological machines that assist the nursing activities to improve the quality of patient care in operating rooms and clinical settings.
- Robots that work directly to meet nursing care demands, mimicking nurses' activities.
- Sampling human qualities in the potentials of cybernetic organisms.
- Technology that increases the human abilities of organic/biological versions in Chimeras.

For AI applications to become part of nursing care, nurses first need to know about AI technologies and embrace their use in the field of nursing. The realization of this is possible if the pioneer nurses, who are interested in technology, turn their attention to AI and participate in research and studies in this field. The integration of AI into nursing care undoubtedly requires the cooperation of different disciplines (Akgerman et al., 2022). To make full use of AI technologies in the future, starting from today, scholars, clinician nurses, and IT specialists should work together from the very beginning of the technological design process. Thus, using the power of AI technologies, a better, faster,

and safer care service can be introduced (Sensmeier, 2017).

How AI practices will affect the nursing profession is a topic that has been talked about. As humanoid robots are popular today, it is debated whether they can replace nurses. If we look at this discussion from a broader perspective, the potential impacts of AI on the nursing profession can also be discussed. Robert argues that AI technologies are not an alternative for nurses, but a support tool that will ease the workload and improve the quality of care. While nurses have already failed to reach the desired number of employment, AI technologies could become a new area of work, perhaps in order not to dislodge them. The nurse may be a quality control specialist who provides feedback to designers in the development of technological care systems/tools, assessing their care experience and outcomes. Whether patient outcomes are meaningful, whether there is an unexpected outcome, whether there are variables that remain lacking in the decision mechanism, whether the results are reliable, or whether the practice is sufficient, can be answered most accurately by a nurse (Robert, 2019). Here are some of the expectations and drawbacks of the integration of AI technologies into the nursing field (Locsin & Ito, 2018; Pepito & Locsin, 2019; Sendir et al. 2019).

Expectations

- Increasing the care safety
- Diversification of methods and tools used in care
- Increasing efficiency in nursing practices
- Creating more time for face-to-face interaction of nurses as AI technologies lighten work
- Increasing the time allocated directly to the patient by reducing the time spent on routines

Drawbacks

- Will devices/systems using AI technologies, in practice, have autonomy like nurses? Will the robot nurse, for example, work independently of the human nurse?
- Will nurses be held responsible for technological errors related to AI applications? / To what extent will they be held responsible?
- Can AI technologies replace nurses in the future? For example, would humanoid robot nurses put real nurses out of business?
- Can AI give the “human touch” the nurse provides, making people feel important and valuable?

Use of Artificial Intelligence in Nursing Education

AI is a relatively new concept for nursing education. Effective and therapeutic communication is one of nursing's indispensable skills. Classical nursing training can remain limited in teaching effective communication abilities to conduct with real patients in a variety of situations. In various scenarios with AI algorithms, different patterns of communication can be experienced over and over again and educational effectiveness can be assessed at short notice. Communication simulations are used as complementary training tools in the current curriculum (Cetin & Eroglu, 2020). Treatment and care processes mostly require nurses to make quick and effective decisions. This, in turn, is based on practice, observation, research, and evaluation skills. The learning environment and various factors associated with scholars can lead to the failure of targeted skills in nursing education to develop sufficiently in students. It is generally thought that AI can be used effectively in the field of education. AI-powered simulation and games make learning easier for nursing students (Akgerman et al., 2022; Harmon et al., 2021). In this book, although the topics of AI and augmented reality in the field of nursing are addressed in separate chapters, they are actually often intertwined with one another. One example is the combination of AI algorithms and augmented reality technologies that recognize student qualities in virtual reality applications used in nursing training and develop interaction accordingly (Jorissen & De Boi, 2018; Plotzky et al., 2021).

Use of Artificial Intelligence in Care Service

Questions are being discussed on what should be the role of a nurse in the R&D activities for the integration of AI technologies into the care service and how nursing practices should be shaped. These questions may require philosophical and deep debate. Nursing care in general is a systematic process consisting of steps of evaluation, diagnosis, purpose planning, implementation, and evaluation of outputs (Ay, 2008). Some of the highlights of nursing care purposes targeted by AI approaches are direct care support, support for the organization of care, risk estimation and prevention for the patient, and support for those in need of care. A deeper look at the uses of AI in the nursing care service can also list many items. Some of these include activity and health practices, care support in the geriatric population with dementia, coordination of care and communication, patient assessment and identification of nursing care needs, prediction and prevention of fallings, risk assessment for the prevention of decubitus ulcers, early identification of pathophysiological findings in the patient, preparation of nurse work lists, and health and quality of life of caregivers. Additionally, studies are being done to test the functionality of the technological tool developed in all these areas that are sampled, as well as to investigate nurses' perceptions of AI applications with the aim of enhancing and improving the real patient/nurse experiences (Seibert et al., 2021).

AI can provide support to the nurse in long procedural processes and the complex process of care. A significant portion of nurses' shifts is spent on reporting processes. AI can allow the nurse to save time in these inefficient and lengthy procedural processes. Moreover, it can provide a reliable decision support system service in care by quickly analyzing the vast number of parameters belonging to the patient (Akgerman et al., 2022; Alugubelli, 2016). In fact, real technological practices like Robear can please nurses as much as patients. Robear, the nursing care robot, supports nurses in physically exhausting and time-consuming jobs such as moving a patient out of bed, putting them in a wheelchair, and making in-bed rotations to prevent decubitus ulcers (Szondy, 2018).

Figure 1 Robear: Nursing Care Robot Designed To Serve Japan's Aging Population (Szondy, 2018)

In Robear's design, it is seen that the visual features of the robot come to the fore along with its functionality. This design may be intended to create visually positive human perceptions. On the other hand, in another project, roboticists focused more on the robot's functionality than the visual feature and developed Cody who give the patient a bed bath and simulated the nurse's hygiene application (King et al., 2010).

Figure 2. Cody who can autonomously perform the movement of wiping the patient just like a nurse (King, 2010: https://www.youtube.com/watch?v=0ac2qwStrdo).

Robots that interact directly with humans, especially AI technologies, seem to be successful in demonstrating procedural technical skills based on knowledge and promise

much better for the future. Although the developments motivate the discipline of nursing for innovative practices, the criteria for "ensuring human touch," which is at the core of nursing care, seems not to be abandoned. For this reason, the extent to which AI can learn humans, and to what extent it can understand emotions from facial expressions and develop appropriate autonomous responses will determine the future of humanoid AI technologies. (Locsin & Ito, 2018).

In healthcare systems in general, nurses' workload is intense and employee numbers are restricted. The problem of patients getting restricted services by failing to adequately see nurses can be overcome with virtual nurses. The virtual nurse application that was developed in collaboration with Boston Medical Center and Northeastern University has features that can meet patients' cognitive care requirements (Figure 3a, b).

Figure 3-a. A virtual nurse establishing health communication with the patient (Bickmore et al., 2009)

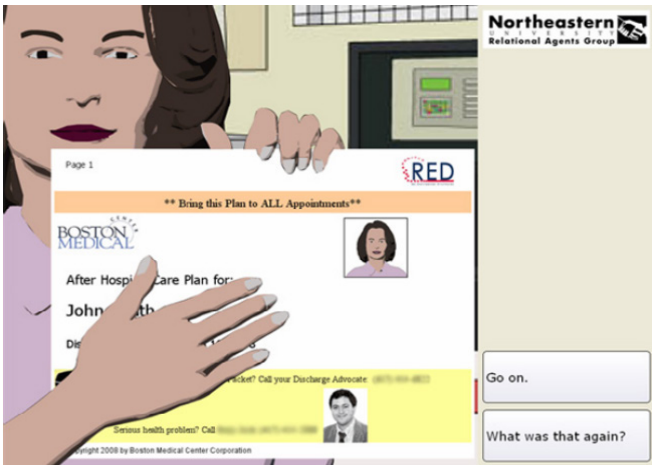

Figure 3-b. Virtual nurse application interface (Bickmore et al., 2009)

An inpatient at the clinic is able to receive services from a touchscreen and kiosk with wheels about the discharge care plan. The virtual nurse was specifically designed for health communication of patients with inadequate health literacy, and the interface included two different female nurse characters. Ninety-four percent of the patients who used the virtual nurse said it was easy to use the system and reported high levels of satisfaction. (Bickmore et al., 2009). The prominent advantages of receiving service from

such a nurse are that the patient can reach the nurse on any day and at any time of the day and has the right to repeat the service as many times as he/she wants.

The use of AI in creating electronic health records could mean lightening time-consuming clinical turnaround work for nurses. AI-powered software that recognizes the voice of the nurse rather than the keyboard is far more practical and efficient to use. With each passing day, voice and facial recognition technology are evolving. This technology can be used by the nurse to prepare a patient care report and share it with both the patient and the other nurse who will take over the shift (Clancy, 2020).

One of the most discussed topics is whether AI-based nursing care systems and tools can appeal emotionally to people. Are learning machines callous helpers that fail to emulate the skill of empathy? The results of a study conducted with elderly people who are at the forefront of the vulnerable groups are interesting and promising. Baby seal robot PARO, which works in an aged care facility, serves elderly people with dementia.

Figure 4. Baby Seal Robot, PARO (Shibata, 2012)

The elderly people were seen contacting PARO and being emotionally affected by this communication, for example laughing during communication. Elderly people's touching and fondling of PARO was considered the result of active interaction. In the study, it was concluded that PARO is effective in reducing the loneliness of the elderly, also, with its positive psychosocial effect, it can be used in the elderly with dementia (Shibata, 2012; Takayanagi et al., 2014). The capacity of AI technologies to be available to conduct nursing activities, as well as how much to adhere to the principle of "first, do no harm" is a subject of discussion in the field of nursing. Because during nursing practices, cases can arise in which sick/healthy individuals may be harmed. The nurse's taking such a risk may lead to a conflict of conscientious and professional values. An incident in the United States has also raised unease about the use of AI in healthcare. Alexa, Amazon's AI-powered virtual assistant, told a 10-year-old girl "Plug in a phone charger about halfway into a wall outlet, then touch a penny to the exposed prongs" as challenge advice (NTV Haber, 2021).

Nursing and Humanoid Robots

Whether humanoid robots can replace nurses in the future has also been debated nowadays. Today, robots can learn to imitate the various skills of nurses. Robots' mimicking capabilities are limited by simple processes for today. In the future, we may be discussing the interaction of fully autonomous humanoid robots equipped with quantum computers with biological nurses (Locsin & Ito, 2018). This possibility, combined with the problem of chronicled inadequacy in the number of nurses, brings to mind the question of whether AI technologies will take the place of nursing and nurses. The response to this problem in terms of patients can mean more nurses and better care. On the other hand, what it means for the nursing profession is the threat of unemployment. That threat seems unlikely, at least for the immediate future. Because nursing care requires subjective, interaction-based, patient-specific, and holistic performance (Coban et al., 2022; Horton et al., 2007). It is inconceivable that smart machines perform as high as "human-nurse" in performing such performance while providing services to human beings that are complex and sensitive (Sendir et al., 2019). Seeing AI technologies as a valuable tool that facilitates nurses' jobs and provides support for care, not a threat to the nursing profession, would be far more beneficial for the nurse and the vast audience of people it offers services. Otherwise, nursing discipline may have to brave a more likely and dangerous threat, such as an inability to meet customer audience expectations if it perceives AI technologies as a threat (Pepito & Locsin, 2019).

Artificial Intelligence Research in Nursing

One of the important issues in AI research in the field of nursing is that the information in the data sets used by algorithms for decision-making and implementation skills should be accurate, valid, and reliable. Considering laws and regulations regarding the protection of personal data legally, incomplete or erroneous entry of data into the system can affect the proper functioning of algorithms. Data privacy and security, the integration of the sensors used in the system, and the lack of physical care impediments are among other issues studied. Despite all these confounding factors, developed prototypes and systems produce positive results. A systematic review published in 2020 reveals the importance of AI technology to nursing science. The 17 nursing studies examined in the review study have shown that AI technology delivers high performance for research purposes. The review highlighted that AI technology is a powerful tool for developing the science of nursing (Kikuchi, 2020).

Another study conducted in Taiwan reported that the nursing diagnoses predicted by the AI-assisted system for the patient reached 87% of the compliance rate with diagnoses recommended by the nurses. Despite this high rate, the system's diagnostic deficit can lead to patient harm. On the other hand, the same study highlighted that nursing diagnoses may be incomplete or inaccurate due to the excessive workload of nurse capacity

and that the associated patient is also at high risk of harm. Research on the use of AI technologies in the field of nursing should continue and problems should be addressed to alleviate nurse workload and support quality of care. The most common problems in the field of nursing diagnostic research were reported to be the spoken language, the quality and quantity of the information, and the diversity of the values obtained (Liao et al., 2015). For the use of AI technologies in the field of nursing, we mentioned the need for nurses to have a multidisciplinary perspective and to receive training on AI technologies. Recommendations for nurses to gain experience in the integration of AI algorithms into nursing practices are listed as follows (Robert, 2019).

- The team should be ready to learn new ways and collect and use patient data.
- Nurse experiences for integration are local and specifically valuable. The usefulness of the technology implemented and other nurse interpretations of the experience should be taken into account in the development of the technology.
- Vehicles should be easy to use and an emphasis should be placed on intuitive assessment of outputs.
- Developed technological tools should provide benefits for the patient and nurse, enabling the nurse to spend more time face-to-face with his/her patient.

The Ethical Dimension of the Use of Artificial Intelligence in Nursing Care

The most prominent areas of ethical discussion are the issues such as accession to and use of data of patients through algorithms mentioned in the previous chapter, making accurate and complete care decisions, protecting the principle of "first, do no harm" and usefulness to the patient, maintaining the preferences and choice rights of those receiving services, ensuring consent, sharing responsibility for harms incurred (Kikuchi, 2020).

Technological progress always comes with new problems and challenges. A multidisciplinary approach is needed to overcome the problems experienced, as is the case with the development of AI technologies. In practice, following existing laws and new statutory regulations, necessary updates should be provided for the data at hand, the provided service, and parties (patient, care providers, physicians, nurses, etc.). The current AI practices must be strictly controlled to maintain patient-centered care that is inclusive and respectful of patients' needs, and necessary precautions must be taken. It should be ensured that the patient is actively included in the care and that the right to choose is protected, which is constantly emphasized in the nursing process (Amann et al., 2020).

It is inevitable that the use of AI-powered technological systems in healthcare will bring with it ethical problems. Biomedical ethical principles in approaching current or possible problems can provide an appropriate ethical framework. In this context, the four basic ethical principles are autonomy, benefit, "first, do no harm" and justice (Bali et al.,

2019; Gillon, 2015). Ethical discussions mostly center around the diagnosis of diseases and prediction of disease/complications based on algorithmic analysis of risk factors. The belief that algorithms are more objective than humans is expressed as an ambitious view that can lead to ethical problems. Yet most physicians are willing to use AI technologies in diagnostic and predictive processes related to their jobs in general (Morley et al., 2020). Nursing care is also carried out over-diagnoses today. There are also risk diagnoses for complications and other disturbances, which are largely based on estimates (Ay, 2008). Thus, the use of AI-based decision support systems in diagnostic and predictive processes in the field of nursing, as well as in the field of medicine, and similar ethical issues are possible.

Conclusion

AI has entered the nursing profession quite late compared to industrial organizations where routine procedures are repeated. It is also impossible to say that there is no integration yet, especially in nursing fields where the human factor is the main determinant, such as patient care and nursing education. A lot of care activities are directly related to human life, and nurses should also be part of the multidisciplinary team in the design, implementation, and evaluation processes, particularly ethical and technical dimensions, to avoid facing an outcome against people depending on the use of AI. As in any field, it seems inevitable that AI will invade the nursing field and that there will be several requests from those receiving services. Nursing discipline should not be left behind the age and should be able to produce safe and adequate answers to incoming requests.

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CHAPTER 2

Application of Virtual Reality Technologies in the Nursing Profession

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Application of Virtual Reality Technologies in the Nursing Profession

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Introduction

Nursing, which has the responsibility of determining the needs in the health and disease situations from the birth of the human to the death process and solving problems by planning the appropriate initiatives, is an applied health discipline and a scientific art that renews itself with scientific, technological, sociocultural changes from past to present and deals with the health of the individual/family and society (Yildiz, 2019:1).

In twenty-first-century education, technology is constantly coming across as an evolving and regenerating factor. As new teaching technologies are developed, different learning methods and processes are forming other than traditional learning methods. One of these emerging methods is virtual reality (VR) technology. Virtual reality is the projection of three-dimensional images animated on a computer to people like a "real world" with the help of some devices. These virtual reality-enabling devices are hardware formed by a combination of computers, glasses, headphones, and motion sensors (Dayan & Ince, 2021).

The definition of virtual reality naturally comes from both definitions of "virtual" and "reality." The definition of the word "virtual" means physically non-existent, while "reality" is what we experience as humans. Hence, the term "virtual reality" basically means "close to reality" (Turgut, 2021:19) and is basically an illusion that relies on allowing them to be in a computer-generated environment, so people feel like they're there even though they're not actually in it. VR applications aim to distract users by interacting with different senses (vision, hearing, touch, etc.) and blocking external stimuli (Sarman et al., 2021). As a result of this, any sensory and cognitive activity is possible for a person (or persons) in a digitally created artificial world that can be an imaginary, symbolic, or simulation of certain aspects of the real world (Turgut, 2021:19).

Today, VR systems can be used in different ways, such as head-mounted screens, fixed screens, and hand-held screens (Turgut, 2021:20). Virtual reality technologies offer the ability to create therapeutic environments in healthcare, surgery, assessment, diagnosis, and treatment of health problems, and are used in many areas, such as rehabilitation of patients to remove symptoms, exercise applications, and training of professional groups in medicine and healthcare.

Virtual reality is a computer simulation technique that allows individuals to hear and feel the sounds and corresponding stimuli that accompany the visual landscape through the headset, allowing them to become part of a world built in a computer environment; It is an advanced form of human-computer interaction that gives users a sense of reality and allows mutual communication between this computer-generated environment and the user (Burkay, 2021: 14-15; Sen., 2020:13).

In a study examining graduate theses conducted using virtual reality in the field of nursing between 2016-2020 in Turkey, it was stated that 54.5% of the theses were made with pediatric patients and 36.4% with adult female and male patients. The same study stated that virtual reality applications are most commonly tried for pain management and anxiety as a distraction method in our country, and virtual reality glasses are preferred by 90.9% as a virtual reality application (Sarman et al., 2021).

We see that virtual reality studies in the field of nursing are mostly aimed at the training of student nurses, and they are used for diagnosis/treatment/rehabilitation in different patient/disease groups in nursing applications, also, nurses apply virtual reality applications for themselves. In this context, the use of virtual reality applications in nursing will be scrutinized under three different headings.

Use of Virtual Reality in Nursing Training

Nursing education is an educational system where structured, theoretical, and practical training is offered as a whole with the aim of giving the student the identity of professional nursing and preparing the student for professional life. In this system, nursing students are expected to gain a good level of cognitive, affective, and psychomotor skills (Dayan & Ince, 2021; Yildiz, 2019:14).

In the nursing profession, where mock-ups and mannequins have mostly been used to create virtual reality in education, the studies in which virtual environments are created and their activities are evaluated are becoming widespread day by day with the advancement of technology and the facilitation of access to these technologies (Turgut, 2021:22). The fact that nursing is a health discipline that includes a practice-based education process, as well as, its complexity and difficulty related to patient care require many different psychomotor skills (Yildiz, 2019:14). It has become popular for instructors to overcome the difficulties experienced in transferring the theoretical knowledge to the practice by giving instructors the opportunity to reach many students in a shorter time with virtual reality applications in the training of health workers (Sarikoc, 2016).

In professional skills laboratories, students learn to turn their theoretical knowledge into skills under the supervision of instructors and then make clinical practice. These laboratory practices help to reduce students' clinical anxiety, improve communication skills, and combine theory and practice. In addition, they are safe environments for students

because they have repeat opportunities, feedback can be given by the instructor, and there is no risk of harming the patient (Ismailoglu, 2015:1).

There is a need to develop and use new tools in the training of health personnel in order not to harm the patient, but minimize errors, prevent ethical violations, adapt to the developing technology in the field of health, meet the increasing expectations of patients, and provide quality care. Therefore, virtual reality applications enable the unlimited application of clinical scenarios in a risk-free environment to reduce the student's anxiety and increase self-confidence, improve clinical decision-making skills, provide effective learning by giving feedback to the student at the end of the application, and are included as a rising value in nursing education (Gundogdu & Dikmen, 2017).

It is emphasized that virtual reality methods used in nursing basic skill training have a positive effect on increasing students' academic success and professional skill performance (Dayan & Ince, 2021).

Virtual reality applications have many benefits, for example, they create an environment as if they were real with three-dimensional audiovisual animations, however, they enable the student to take an active part in the applications by directing them to learn by experimenting, making them think to make decisions in a complicated situation, creating an educational environment very close to reality, developing the student's pre-clinical skills, integrating theory and practice, allowing the students to evaluate themselves objectively by giving feedback, increasing the motivation of the students by allowing them to avoid negative experiences, allowing them to make mistakes without harming anyone before the applications to be made to real patients (Dayan & Ince, 2021:89; Gundogdu & Dikmen, 2017; Jamison, 2006, Okutan, 2021:29; Turgut, 2021:22).

Many skills training are provided in schools that train health workers with applications from washing hands and taking a medical history, to establishing vascular access and providing basic life support. Virtual reality applications support students by giving them the opportunity to experience many skills over and over again, such as establishing vascular access properly without harming patients, providing basic life support, administering intravenous injections, interviewing patients, etc. It gives the opportunity to apply skills that students cannot concretely observe in the actual patient, such as evaluating in-body organs in the virtual environment for converting the theoretical training they receive into practice (Sarikoc, 2016).

Jung et al. (2012) examined the effect of a virtual reality simulation system on students' intravenous catheterization skill performance in first-grade nursing students, and used virtual reality, a plastic arm model, and two methods together as skill training methods; their experimental study was about intravenous skill training in a three-group model, as a result, it was stated that the rate of successful completion of the skill application of the

students using the virtual simulation method was high. As a result of this study, researchers emphasized that simulation is a useful method that can be used in nursing education together with the traditional education methods. In a different study which examined the effectiveness of the use of "SIV simulator" and "plastic arm model" in providing nursing students with the ability to apply intravenous catheters, it was found that teaching with "SIV simulator" had a positive effect on the skill level of the students and the level of satisfaction with the method used in gaining the ability to apply intravenous catheters (İsmailoglu, 2015:65). Virtual reality applications similarly make positive contributions to the ability of students to apply port catheters (Tsai et al., 2008). It is emphasized that virtual reality simulation group students learn the skill steps of urinary catheter application more easily (Smith & Hamilton, 2015) and students find the application interesting. They spend more time making more applications in urinary catheterization application (Butt, 2018). The knowledge and skill levels of the students increase in the tracheostomy care with the game-based virtual reality application, and the game-based virtual reality application can be used to teach the applications that require surgical asepsis principles such as aspiration where the order of skill application is complex and requires attention (Bayram, 2017:66). In nursing education, pelvic examination, nasotracheal aspiration, urinary catheterization, IV catheterization applications can be performed with virtual reality model simulations that provide the student with the highest level of the learning environment (Yildiz, 2019:16). It was concluded that the computer-based simulation system designed to provide subcutaneous drug administration skills in nursing education has a positive effect on the subcutaneous injection application skill performance of students and the anxiety levels that occur during subcutaneous injection administration in a real patient (Gundogdu & Dikmen, 2017: xii).

A large number of students, the lack of the number of teaching staff, and the constant renewal and increase of the skills that should be acquired by students make it difficult to evaluate students objectively. Virtual reality allows a student to easily use each skill in the created virtual environment at any time and in any number of ways. The fact that these materials in the virtual environment can be stored as recorded makes it easy for a student to be evaluated by more than one instructor (Sarikoc, 2016). In addition to providing students with psychomotor skills, virtual reality applications are coming to the agenda as a unique and useful alternative teaching method in providing students with more advanced and abstract skills such as collaboration, problem-solving, critical thinking, or communication skills.

In the vast majority of the research results, it is stated that the virtual simulation method used in the nursing education process positively affects the skill performance and academic success of the students (Gundogdu & Dikmen, 2017; Sarikoc, 2016). At the same time, virtual reality applications prevent the patient from being harmed while trying or learning a new technique (Yildiz, 2019:16).

By offering experience-based learning, virtual reality applications can contribute to reducing the anxiety students experience in their first clinical practices, increasing their self-confidence and improving clinical decision-making skills, thus enhancing their success and motivation levels. With this application, students learn in a safe environment, without fear of doing wrong and harming the patient, and by having the opportunity to live this experience whenever they want.

The Use of Virtual Reality in Nursing Practices

Recently, virtual reality applications have been used among nursing initiatives used in clinical fields to alleviate pain, anxiety, and fear, and provide comfort and convenience by diverting patients' attention (Okutan, 2021:30). While VR applications applied as a method of diverting attention are widely used in clinical medical care, especially to relieve pain, there are also studies showing their effectiveness in the management of pain and anxiety during procedures such as burn wound debridement, injection applications, wound care, toothache, endoscopy procedure, phantom, and chronic pain, and chemotherapy applications (Guo et al., 2014; Hoffman et al., 2000; Hoffman et al., 2011; Toru, 2018:16). While there are many studies indicating that virtual reality is a useful interventional tool especially in pediatric patient groups (Aydin, 2018:37; Hoffman et al., 2008; Kaplan, 2020: 61; Piskorz & Czub, 2018), we see that nurses working with adult patients also often benefit from VR practices (Karaman, 2016:38; Schneider et al., 2003; Schneider & Hood, 2007; Schneider et al., 2011; Sahin & Basak, 2020).

Cancer

Anxiety, which is not diagnosed or intervened in the patient due to chemotherapy applied to slow down the development of cancer, prevent its spread, treat and alleviate the symptoms, may adversely affect the individual's adaptation to treatment, coping with the disease, and quality of life (Toru, 2018:1). The technique of diverting attention, a method that focuses on the individual's coping with the symptoms caused by chemotherapy, increases the individual's sense of control, activity level, and work capacity, reduces pain, anxiety level, feeling of weakness, and side effects of pharmacological methods (Toru, 2018:15).

The long-term side effects of cancer and cancer treatment can include many physical and psychological consequences, such as pain, fatigue, anxiety, depression, and cognitive dysfunction. Studies report that cancer-related fatigue and emotional state changes such as anxiety and depression significantly affect cognitive functions and reduce the quality of life in cancer patients. Some of the common causes of repeated pain and anxiety in cancer patients are intravenous interventions, invasive examinations such as bone marrow aspiration, medical procedures, and chemotherapy (Ozdag & Inkaya, 2021).

Studies assessing pain and anxiety with VR technology in cancer patients have been

conducted with patients undergone establishing vascular access, blood collection, port insertion, lumbar puncture, biopsy, chemotherapy treatment, or patients hospitalized during different procedures, in addition, a study was conducted to examine the effect of radiotherapy on anxiety level before radiotherapy (Nilsson et al., 2009; Ozdag & Inkaya, 2021; Schneider et al., 2003; Schneider et al., 2011; Toru, 2018:15).

Since the anxiety experienced by individuals during the chemotherapy process causes life changes, it requires effective coping methods. As a coping method, by using virtual reality glasses, it can be ensured that the individual moves away from the hospital setting where the patient feels himself/herself in another world. Because virtual reality glasses are a tool that has the potential to address multiple senses at the same time and block the senses from environmental warnings, it can also allow individuals to feel the long chemotherapy treatment period as short and cope with symptoms such as anxiety (Toru, 2018:3).

Schneider et al. (2003) examined the effect of virtual reality glasses applied to breast cancer patients over the age of 50 who received chemotherapy treatment on symptom distress, fatigue, and anxiety levels; and during the first session of chemotherapy treatment (45-90 minutes), 16 breast cancer patients were shown undersea, museum visits and titanic videos with virtual reality glasses. After using virtual reality glasses, the patients experienced a significant reduction in symptoms, fatigue, anxiety, and perception of the time elapsed during chemotherapy (Schneider et al., 2003). Schneider et al. (2011) examined the effect of virtual reality glasses applied to patients with breast, lung, and colon cancer who received chemotherapy treatment on anxiety and fatigue levels, and a total of 137 patients of the experimental group and control group were shown videos with virtual reality glasses during chemotherapy treatment (45-90 minutes). As a result of the study, it was determined that the application of virtual reality glasses diverted attention and that the patients in the study group had a decrease in the level of anxiety and fatigue and that the time passed faster in the treatment process. In this context, virtual reality glasses can be used in the management of symptoms and reduction of anxiety in individuals undergoing chemotherapy.

Espinoza et al. (2012) made 33 metastatic cancer patients, aged 41-85 years old, who were hospitalized in the oncology service to receive chemotherapy treatment, watch the park, and nature walk with virtual reality glasses in half-hour sessions consisting of four sessions for a week. After the application of virtual reality glasses to reduce pain and distress due to medical procedures and chemotherapy, it was seen that anxiety and depression levels decreased and happiness levels increased in patients

According to Schneider and Hood (2007), individuals who benefited from VR administration during the first chemotherapy treatment with the virtual reality glasses application had significantly fewer anxiety levels compared to the control group during the second

chemotherapy treatment. These findings showed that using the distraction intervention was more effective during initial chemotherapy treatment when patients were more anxious and had a lower ability to cope with a stressful situation (Schneider & Hood, 2007). Nilsson et al. (2009) stated that the use of virtual reality during invasive procedures in the pediatric oncology unit reduced pain in children and adolescents and had a positive effect on patient relaxation.

Reducing pain and anxiety

Nurses, who are members of the profession that plan and manage care, play an active role in identifying, controlling pain, using pharmacological and non-pharmacological methods, and evaluating the results because they are with the patient longer than other health professionals (Richards & Hubbert, 2007).

Virtual reality can be used as an effective distraction method that allows daydreaming by appealing to multiple senses of the patient. Especially in acute painful applications, virtual reality allows the individual to direct his attention from the painful stimulus to the computer-based created world (Orhan, 2020:46). Virtual reality is known to not only change the way the patient interprets incoming pain signals, but also reduce the brain activity associated with pain. The effect of the virtual environment in which people enter and the videos consisting of nature and landscapes that relax people are thought to have an anxiolytic effect on patients. With this anxiolytic effect, the activity of the amygdala and adrenergic activity decrease. As a result, since the number of stimulated receptors decreases, fewer pain signals are sent to the brain, which leads to a decrease in the level of pain (Okutan, 2021:59).

Informing children about the operating room and the process in the preoperative period is important in terms of reducing anxiety before and after surgery, relieving postoperative pain, and ensuring parental satisfaction. For this reason, it is useful to give information to children, who like to use technology, in accordance with this technology (Turgut, 2021:46). It was determined that preoperative preparation and postoperative video watched using virtual reality glasses in children to be operated are effective on anxiety and parental satisfaction and a useful method to reduce postoperative pain (Turgut, 2021:47). Similarly, Chad et al. (2018) reported that VR glasses used to distract attention in children during vaccination were effective in reducing the perception of pain and fear. It was determined in a different study that the application of virtual reality before total knee replacement surgery reduced pain and anxiety, and had a positive effect on vital signs (Gunes, 2021:vii).

Burn wound dressing

The management of pain and anxiety caused by burn care involves difficult and complex processes. Virtual reality has been a method often used in nursing care abroad in recent

years as an engaging, interactive, effective distraction technique for children and adults during painful health care procedures, including burn wound treatments (Kaya, 2020:4). Dressing renewal made during burn care increases the pain and anxiety levels of patients. It is reported that the VR glasses used in this process reduce the pain and anxiety levels of patients and that patients feel more comfortable (Guo et al., 2014; Kipping et al., 2012; Markus et al., 2009; Morris et al., 2010; Scapin et al., 2018).

There are many studies in the literature that the use of VR glasses during burn wound care has a positive effect on acute pain (Hoffman et al., 2008; Kipping et al., 2012; Markus et al., 2009). Kaya (2020) determined that virtual reality is effective in reducing the level of pain, anxiety, and fear in children during burn dressing and suggested that the use of virtual reality during burn dressing should be widespread and included in the treatment process. Scapin et al. (2018) reviewed 34 studies of burn dressing renewal and reported that pain, anxiety, and stress were reduced during dressing renewal, physiotherapy, and physical rehabilitation in patients with burns, and the use of VR technologies would be beneficial.

Diagnostic procedures

Virtual reality applications, one of the methods of diverting attention, are widely used in clinical medical care to relieve symptoms by offering the possibility of creating therapeutic environments for the evaluation and treatment of medical conditions. VR glasses, which are not expensive to apply and use, do not cause side effects, can be used in the healing of the individual, and are frequently preferred in nursing practices due to these features (Toru, 2018:2).

Biopsy

The virtual reality application, which has developed with the advancement of technology, is an application that reduces the perception of pain and anxiety by using the cognitive and attention processes of people. The application, which includes music in the background with images obtained with special camera systems and multidimensionality thanks to binocular glasses, distracts people from thinking about the medical procedure. Pain and anxiety management through non-pharmacological methods such as virtual reality is among the main objectives of nursing practices (Karaman, 2016:iv). During the breast biopsy, which is one of the medical interventions, it was determined that virtual reality application was effective on pain and anxiety (Karaman, 2016:38). At the same time, it was concluded that virtual reality applied during knee arthroscopy operation reduced blood pressure and pulse rates after surgery (Sahin & Basak, 2020). Similarly, it was concluded that the application of SG glasses during the transrectal prostate biopsy procedure (TRUS-Bx) reduced the pain of the patients and positively affected their vital signs (Genc, 2021:vi).

Endoscopic procedures-colonoscopy

Colonoscopy, one of the screening tests, is considered the most reliable method with proven effectiveness in the prevention of colorectal cancers and the reduction of the death rate due to colorectal cancer and is considered the gold standard. Colonoscopy, which is an endoscopic intervention, can cause embarrassment, pain, and anxiety in patients. Procedure-related pain, also defined as procedural pain experienced during colonoscopy, develops if the procedure is invasive, the rotations in the colon that do not have a fixed shape are sharp, and the mesentery is stretched due to the delivery of air to expand the intestine during the procedure. The application of colonoscopy to a region perceived as private causes a sense of shame in patients; the fear of being embarrassed and feeling pain results in anxiety. Yilmaz (2021) determined that virtual reality glasses had positive effects on vital signs and anxiety in patients undergoing colonoscopy, and in line with these results, it was recommended to expand the use of virtual reality glasses by nurses during colonoscopy.

Childbirth

Childbirth, which is one of the important life experiences of a woman, is a natural process, but it is an important experience that affects the mother's health from a physical, emotional, and social point of view. It is extremely important that the birth experience should end positively for the woman and her family and that a satisfactory birth environment should be created. Watching relaxing images accompanied by relaxing music with VR glasses at the time of delivery allows the woman to go on a visual journey to a calmer environment, away from the work area surrounded by medical equipment. This relaxation technique (video with virtual reality glasses) increases the secretion of endorphins and oxytocin while helping to suppress adrenaline, thus causing more effective birth contractions for easy delivery. In other words, mental relaxation also provides physical relaxation that can help the birth process (Dutucu, 2019:22). Dutucu (2019) concluded that birth pain decreases with the use of VR glasses, which are applied during a normal birth experience, and does not affect delivery time, also pregnant women find glasses effective in pain control and are satisfied with watching videos.

Neuro-psychiatric problems

Virtual reality apps have been used as an effective method, especially in psychotherapy for treating many disorders (such as phobia, anxiety, post-traumatic stress disorder, and panic). Medication is not preferred by psychiatric patients for reasons such as the negative attitudes of people against psychiatric drugs and the prejudice of people in the community against those on psychiatric medication. Therefore, people with psychiatric disorders are referred by specialists to try interventions such as virtual reality.

Yilmaz et al. (2021) reviewed the studies of the last 10 years in which virtual reality and

augmented reality were used in psychiatric disorders. They determined that virtual reality and its applications improved social skills, cognition, and functioning in people with autism, an improvement was observed in attention-deficit status in people with attention deficit and hyperactivity disorder, virtual reality glasses were often preferred in case of a phobia, and there was a decrease in people's fear and anxiety situations depending on the applications. Considering all the articles covered in the study, virtual reality applications were more commonly tried on phobia as a state of psychiatric discomfort. In other cases of mental disorders, studies have highlighted the ability of people to do their daily activities more easily, improving their quality of life. But in nursing practices, we find that virtual reality applications are more limited in use in the psychiatric patient group. Related to this, such practices are proposed to be prepared and implemented under the supervision of psychiatric and psychological experts.

In relation to neuropsychiatric conditions, there are studies indicating that virtual reality can be an effective intervention for providing psycho-education to people with mood disorders, promoting relaxation and increasing positive emotions (Okutan, 2021:31), raising caregivers and nursing students of people with dementia (Hirt & Beer, 2019), and stress management in people with mood disorders (Shah et al., 2015).

Procedural pain

Many medical diagnoses and treatment processes cause acute pain, which is quite uncomfortable for the individual. Pain experienced during medical procedures is referred to as procedural pain and is among the factors playing a role in individuals' acceptance or rejection of these procedures. Procedural pain can also cause anxiety, leading to negative outcomes in the cardiovascular and respiratory systems when not controlled. It is important to control the pain that may be experienced in these procedures, which are important in the early diagnosis and treatment of diseases (Yilmaz & Dincer, 2022).

For hospitalized children, painful medical procedures such as establishing vascular access, injection process, blood collecting, vaccine administration, and dressing exchange are the biggest sources of fear. These procedures, which are also considered hospital procedures and obligatory to be performed, cause children to experience pain, anxiety, and fear (Burkay, 2021:2; Inal & Canbulat, 2015). One of the most common non-pharmacological methods used to reduce children's pain perceptions during medical processes is a distraction. Showing videos to children with VR glasses is considered among the distraction methods, and studies show that watching videos with VR glasses is effective in reducing children's perceptions of pain and anxiety (Gerceker et al., 2019; Gold & Mahrer, 2018; Jung et al., 2012; Okutan, 2021:30).

Blood collection

One of the major causes of pain for child patients is diagnosis and treatment processes

at the hospital, and children may think that these procedures, such as vaccination, injection, and bloodletting, will harm them (Goksu, 2017: 1-2). A previous study found that the majority of children in the experimental group utilizing VR glasses, which is one of the methods of diverting attention, had reduced pain after blood collection, also children thought this method worked, and children with VR glasses felt good during bloodletting, and not only children but also their parents were very happy with the practice (Goksu, 2017:50). The effectiveness of VR glasses in reducing the level of pain children feel during the bloodletting process has often been studied in the research, and the mean pain score of the children in the experimental group was lower than the children in the control group (Gold & Mahrer, 2018, Ozkan & Polat, 2020). The use of VR glasses in children was effective in reducing pain, fear, and anxiety during the bloodletting procedure (Aydin, 2018:37; Erdogan, 2018: 59; Gerceker et al., 2019; Goksu, 2017: 50; Orhan, 2020:xi; Piskorz & Czub, 2018).

Establishing vascular access

The experience of pain in diagnostic and therapeutic interventional processes during the disease process can be recorded in children's memory and reflected in the entire life process. In addition, this experience can cause fear in children. Since establishing vascular access, which is one of the interventional procedures, is a source of stress, the fear and anxiety experienced about the procedure may increase the perception of pain even more. Establishing vascular access is among the most frequent practices with high pain feedback from children in hospitals. As a distraction technique, it is recommended to be included in nursing practices and care because video viewing with VR glasses is effective in managing anxiety, fear, and pain in children (Kaplan, 2020:61; Ozdemir, 2019:60).

Lumbar puncture

Sander Wint et al. (2002) used VR glasses for 32 min during the procedure in a randomized controlled trial of 30 cancer adolescents who underwent lumbar puncture. The study found that adolescents using virtual reality glasses scored lower than those who did not use glasses, but the difference between them was not statistically significant.

Arteriovenosfistula (AVF) canulation process

It is suggested that virtual reality glasses can be used by nurses in the hemodialysis unit because they reduce the pain that occurs during the AVF cannulation process and increase patient satisfaction as an easy-to-apply and not an invasive method in patients trying to cope with pain (Sen, 2020: v).

Symptom management in chronic diseases

In a randomized controlled study of rheumatoid individuals, it was determined that dancing with a virtual reality gaming console had a positive effect on pain, depression, and

sleep quality (Unver, 2021:v). Cycling experience with virtual reality application has been reported to decrease depression levels and increase interpersonal relations in individuals with stroke. (Song & Park, 2015). A different study also reported that the virtual reality gaming app, which was also administered a total of ten times for 45 minutes in two weeks after a stroke, had a positive effect on patients' depression and anxiety levels (Adomavičienė et al., 2019). It is recommended to use virtual reality methods in the management of fear, anxiety, and pain during self-injection and testing of patients with diabetes (Aktura, 2021: vii).

Education

It is a well-known fact that pediatric epilepsy nursing is a private area, and combating seizure is the most important and serious step in combating disease, also nurse is in a key position in this step. The moment of secondary generalized tonic-clonic seizure, therefore, requires special training and attention. Using VR technology based on a secondary generalized tonic-clonic seizure scenario and correcting real-life potential errors before they are applied to the child are the main common goals of the entire team for "patient safety". Through this, families are expected to become experienced with a secondary tonic-clonic generalized seizure approach, eliminating malpractices. The method of stimulating the appropriate environment through VR technology in epilepsy training is expected to not only increase the knowledge and skill level of parents but contribute greatly to the standardization of the seizure approach, the establishment of the seizure protocol, and the use of common language. The epileptic seizure management training program, crafted with VR technology, was determined to be effective in enhancing the knowledge, skills, and motivations of parents to manage epileptic seizures (Turan, 2020:20).

Use of Virtual Reality in Nurses

We see that virtual reality applications can be used not only to eliminate the different symptoms of child/adult patient groups who are in the diagnosis/treatment process and to contribute to nursing education but also for different purposes in the health professions. A study to reveal the impact of the use of virtual reality glasses on burnout levels in intensive care nurses with a stressful occupation and a high risk of burnout has found that applying virtual reality glasses reduces the level of emotional exhaustion, increases the level of personal success, and does not have an effect on the level of desensitization subscale (Gungor, 2021: 12). In this context, it is conceivable that VR practices can be relaxing in groups of intensive working nurses.

Conclusions

It is important that nurses who are indispensable members of the health care system should be capable in terms of professional knowledge and skills in the nursing training process so that they can deliver the quality care expected of them. In this respect, it is important to use virtual simulation systems in nursing training due to the characteristics of virtual reality systems in nursing training such as integrating knowledge and skill, creating a learning environment by allowing the students to practice, giving them the opportunity to be able to repeat until they perform the right practice, reducing erroneous initiatives in clinical practice, and enhancing patient safety. It is seen that mostly virtual reality glasses among virtual reality applications are integrated into nursing initiatives, child patients are more preferred as a working group and studies are often carried out by nurses to eliminate pain, fear, and anxiety and to increase satisfaction, comfort, and adaptation to anesthesia.

Recommendations

Virtual reality applications, which are effective methods that are not expensive to apply and use, do not cause side effects, can be used in physical, psychological, social, emotional, and spiritual healing, development of education, and recovery of the individual, so may be preferred in nursing education and nursing practices. Since the variety of virtual reality applications used in nursing education is quite limited and generally considered in nursing principles, it will be useful to carry out applications for skills for different specialties such as surgical nursing, obstetrics and gynecology nursing, and internal medicine nursing. To enhance the quality of the training provided to health workers in Turkey and to adapt to the technological developments of the age, it may be suggested that virtual reality applications should be included and used in the education curricula.

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CHAPTER 3

Fabric Defect Detection through Conveyor Belt System Design and Image Processing

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Fabric Defect Detection through Conveyor Belt System Designm and Image Processing

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Introduction

In classical fabric production, the product produced by the tailor is subject to control since its production and this control process continues until delivery. While the speed of production increased as a result of the increase in machine production with the 1st Industrial Revolution that emerged in the 18th century, this situation brought some problems with it. While the fabrics started to be produced quickly by the machines, the fabric control process started to be done by the "quality control" personnel in the factories. As a result, more responsibility falls on the responsible person compared to the past. Today, the progress in software and the inventions in the world of informatics help us to understand the problems that may occur in production. The aim of this study is to approach the above-mentioned problem with the "Image Processing" techniques, which have been widely used in the field of military, production and security in the last twenty years.

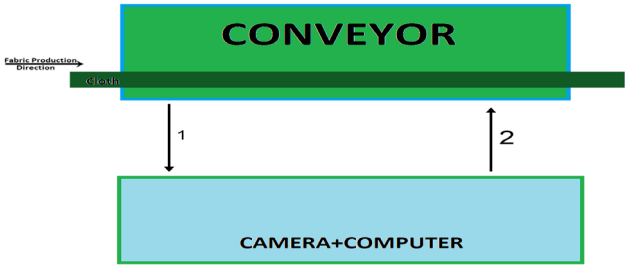

Figure 1. Modeling the system

The system included in this section, as summarized in Figure 1, consists of a computer, camera and conveyor. Represented by the number 1 arrow is the photograph of the fabric. Information will be taken from the camera as video, but this image will be analyzed on the computer as a frame, as if it were more than one photo per second. The number 2 arrow represents is the energy supply connected to the Arduino of the conveyor.

Materials Used in the Construction of the Project

Arduino UNO

Arduino UNO is a board with digital and analog inputs and outputs, as well as a development environment platform with ready-made libraries based on processing / Wiring. The Arduino board has an integrated Atmega328 model processor in its structure. It can be easily programmed with a computer by connecting to a computer with a USB cable and providing serial communication, and it can provide serial data communication (Kapusız & Uzun, 2021).

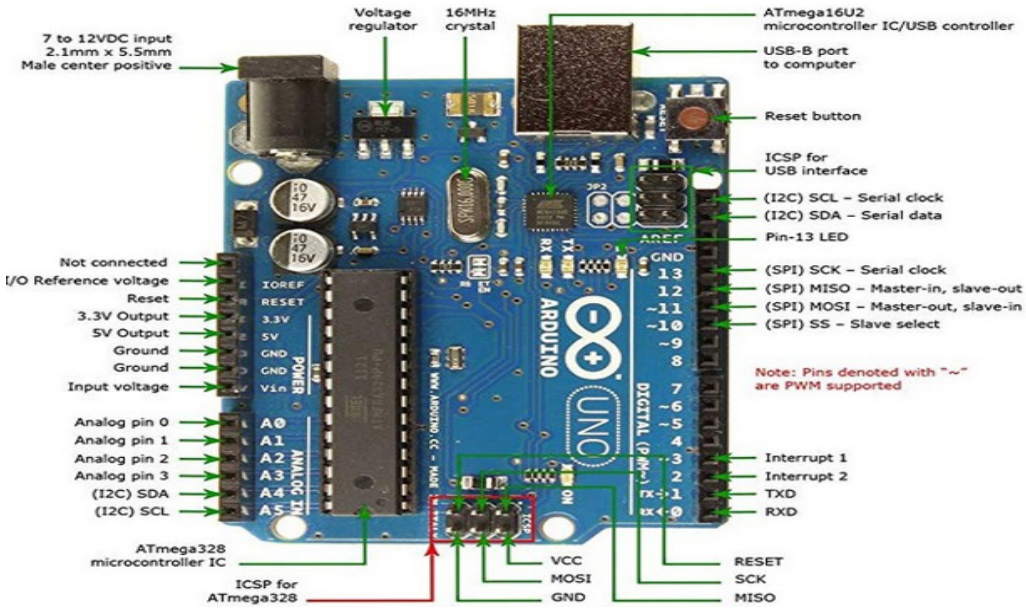

Figure 2. Arduino Uno

L298N Motor Driver

L298N motor driver circuit operates at temperatures between -20 and +135, between 5 and 35 volts and with a maximum of 2 amps (Celik & Gunes,2018). The motor driver board is designed to drive two motors at the same time. It has two channels and can give a maximum of 2 amps per channel.

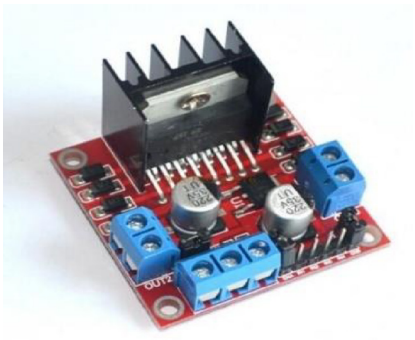

Figure 3. L298N Motor driver

DC Motor

DC motors consist of two parts, the fixed electrical part called the stator, and the rotor, where the rotation takes place (Gurgöze & Turkoglu, 2022). In this study, DC motor can be driven directly with Arduino. However, since high torque is required for the roller that will pull the fabric, DC motor is used with L298N motor driver.

Figure 4. DC motor

Conveyor

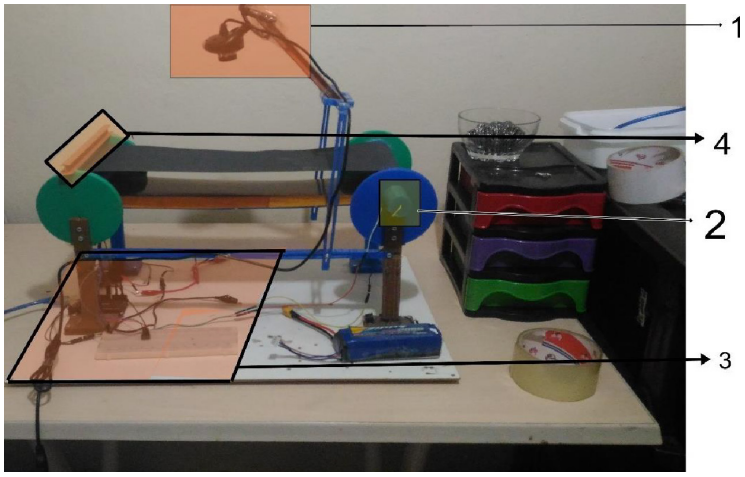

Figure 5. Conveyor

1- The camera is 80 degrees away from the rotating belt and 14 cm from the belt.

2- The DC motor chamber is fixed so that the motor can stand still and rotate the cylinder connected to its shaft with minimum vibration.

3- Arduino is the part where the motor driver and breadboard are fixed.

4- Support Unit (Screw Jack) is a fixed support unit to provide tension on the band and to prevent the motor from vibrating during rotation.

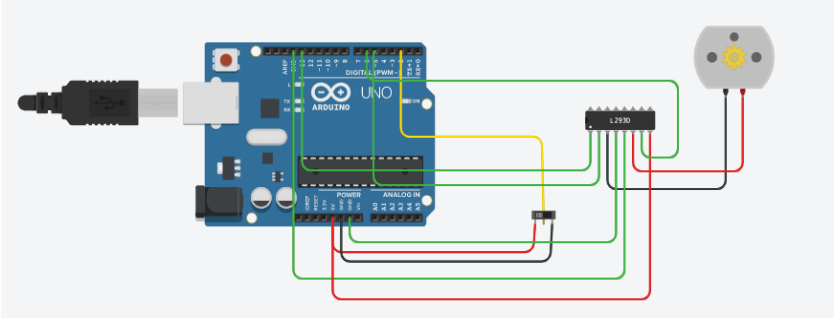

Figure 6. Electrical circuit design

Conveyor 3D Drawings

Conveyor belt design was designed in Solidworks program. In this design, two elbow profiles that can support the weight are used. These profiles are fixed to the ground so that they can lift the weight. In order to ensure the movement, the bearing is fixed to one part of the pulley and the other part of the pulley is fixed to the DC motor. An area is designed to fix the camera at the top of the profile in the middle.

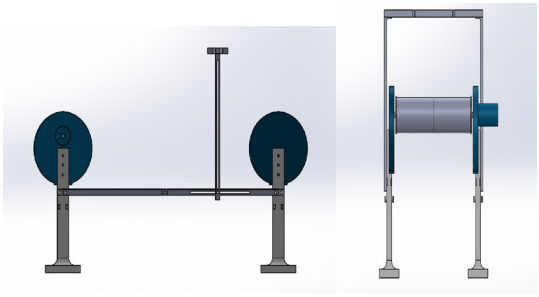

Figure 7. Side view of the conveyor

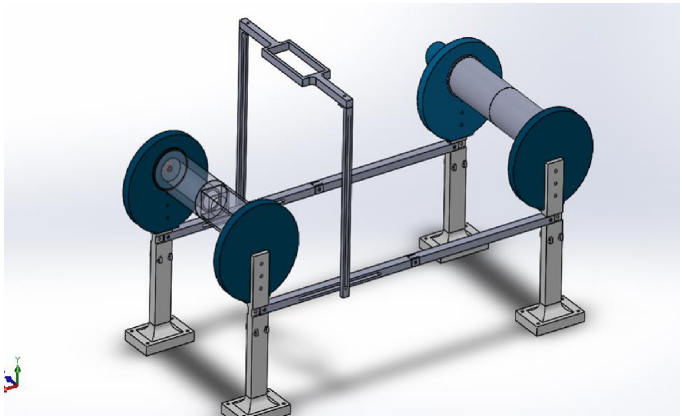

Figure 8. Detailed design of the conveyor

Tools Used in Project Construction

Microsoft Visual Studio

Microsoft Visual Studio is an integrated development environment (IDE) developed by Microsoft. Console and graphical user with native code and Windows Forms applications, websites,

web applications and web services with managed code for all platforms supported by Microsoft Windows, Windows Mobile, Windows CE, .NET Framework, .NET Compact Framework and Microsoft Silverlight interface is used to develop applications (Microsoft Visual Studio, 2022).

C++ is a multi-paradigm, widely used, general-purpose programming language that has been developed by Bjarne Stroustrup of Bell Laboratories since 1979. It was first named C with Classes, and its name was changed to C++ in 1983 (Ege, 2012). In this study, C++ programming language and OPENCV library were used. Visual Studio was installed according to OpenCV's instructions.

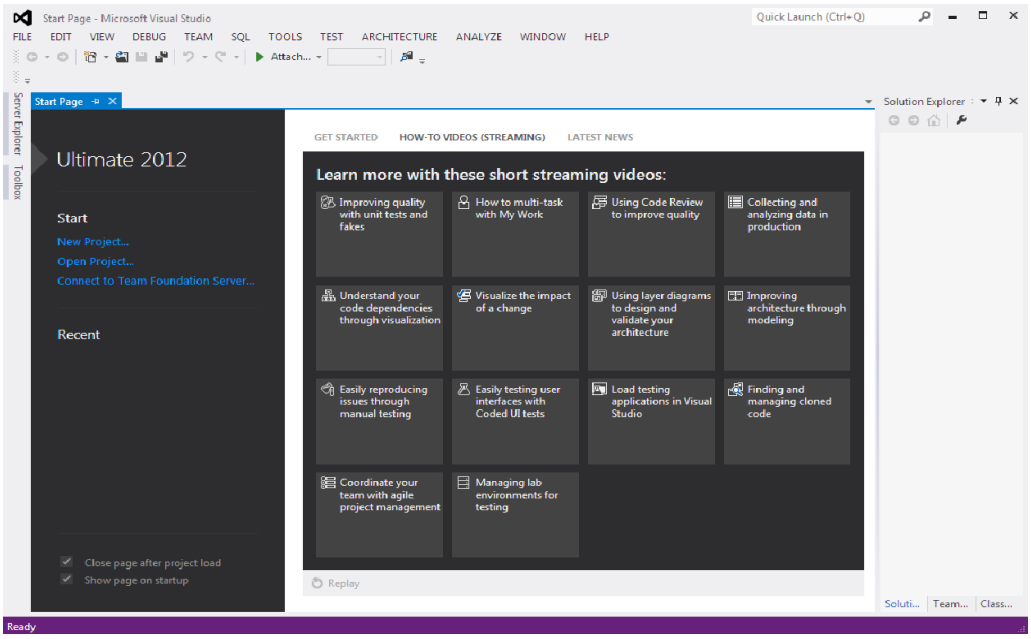

Figure 9. Microsoft Visual Studio

Arduino IDE

Arduino IDE code editor, while working as a compiler, is an application that can upload the compiled program to the card, and can run on any platform.

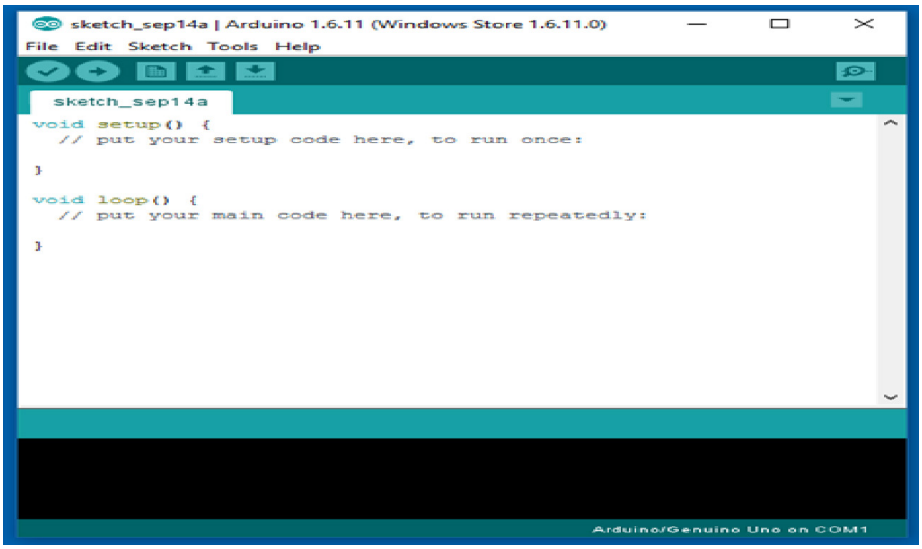

Figure 10. Arduino IDE

The interface required to program Arduino is an open source, free JAVA supported application software developed by Arduino. A screenshot of the program made to program the Arduino microprocessor is shown in Figure 10. It has an advanced debugging system used to detect errors that occur in programming. It also has the possibility to program all Arduino board types (Arduino, 2022).

OPENCV

OpenCV (Open Source Computer Vision) is an open source image processing library (Eristi, 2010). It was started to be developed by Intel in 1999, and then the development process continues with the support of companies and communities such as Itseez, Willow, Nvidia, AMD, Google. The first version, OpenCV Alpha, was released in 2000. It started to be developed with the C programming language in the first place, and then many algorithms were developed with the C++ language (Akkoca & Invention, 2021). The OpenCV library has more than 2500 optimized algorithms.

With the image processing algorithms in the OpenCV library, many applications such as object detection and recognition, motion capture can be realized. With these algorithms, operations such as face recognition, distinguishing objects, detecting human movements, object classification, license plate recognition, processing on three-dimensional images, image comparison, optical character identification OCR (Optical Character Recognition) can be easily performed (Tenekeci, Gümüscü & Aslan, 2014). OpenCV architecture and components are as follows (Akbal, 2019);

Core: It contains the basic functions of OpenCV and data structures such as size, matrix, and point.

HighGui: Contains methods that may be required for displaying images, managing windows, and graphical user interfaces. With this module, we can display an image with a single function, for example.

Imgproc: It is a package that covers almost all functions such as filtering operators, edge detection, object detection, color space management, color management and thresholding. Imgcodecs: It contains methods that perform image and video reading/writing operations over the file system.

Alternative Image Processing Libraries

The library to be used in image processing studies should be chosen in accordance with the purpose of the study. For example, it may not be necessary to integrate OpenCV into the work just to get images from the camera (usb, ip, etc.). For such cases and to understand why OpenCV is good, alternative image processing libraries are discussed below (Can, 2021).

MATLAB: Although Matlab is not an image processing library, it contains basic algorithms for image processing. It is a fourth generation and multi-purpose programming language. It can be preferred for basic image processing in academic research and when performance is not important. It is also possible to develop applications interactively with the OpenCV Library using Matlab.

Halcon: It is a commercial software focused on machine vision, which is preferred for industrial projects, has a library for various programming languages (C, C++, VS C++, C#, VB.NET) as well as its own development environment. It contains many ready-made functions, so that fast applications can be developed.

OpenCV is an open source, free library and focused on computer vision. It differs from Halcon in these aspects.

OpenFrameworks: This open source library developed for the C++ programming language, this project can run on OS X, Linux, Embedded Linux (ARM), iOS, Android platforms. It uses many algorithms of the OpenCV library and its main purpose is to develop applications easily and quickly. For example, with OpenCV, you can complete a job in 2t time, in 1t time, the main reason for this is that it can perform standardized works with a single line through its many functions (Object detection, tracking, color determination, comparison, etc.). CIMG is an open source image manipulation library. It works on Windows, Linux and OS X platform. It has support only for C++ language, but with written wrappers, applications can also be developed with Java and Python. It contains many algorithms, but it does not have as performance and a wide algorithm infrastructure as OpenCV.

Fiji: It is an open source GPL licensed image processing library developed for the Java platform. It runs on Windows, Linux and MAC OSX Intel 32-bit or 64-bit. It was developed for scientific image analysis. It has customized algorithms for fields such as genetics, cell biology, and neuroscience.

Camera, Video Viewing and Interpretation

Camera

Cameras consist of a lens that transforms the object area from the image plane to the image area (Egels, 2001). The cameras used in photogrammetry are metric cameras. Metric cameras are cameras that consist of a large number of lenses with known internal directing elements and these are cameras that can be considered perfect (Yıldız et al., 2005). These are also called measurement cameras. In general, it is possible to distinguish between analog and digital cameras. While analog cameras provide projection with lead bromide solution, digital cameras are cameras that provide projection to CCD and CMOS sensors (Ucar, and Ergun, 2004). The cameras consist of three parts.

First of all, the main task of the lens is to collect the images from the outside world through the lenses inside and deliver them to the camera body. The lens in the front of the lens collects the image, and this image reaches the camera body by reflecting specularly from the lenses further back. CCDs in the camera body convert these images into electronic signals (Ministry of Education, 2011). The camera body is the part where the image is processed and recorded. After the image falling on the CCD is converted into electronic signals, it starts to be processed in the body. This process takes place with electronic circuits inside the body and is triggered by a button located outside the machine. The main task of lenses is to produce a small image in front of the CCD. Video cameras often have variable focal length lenses. The focal length is to determine how narrow or wide an area the produced image will cover. lenses; It differs in wide-angle, narrow-angle, normal and variable focal lengths (Ministry of National Education, 2011).

What is Angle of View?

The viewing angle of a camera basically changes depending on two parameters. The first is the size of the camera's image sensor, and the other is the focal length of the lens, expressed in "mm". The table below shows the "horizontal", "vertical" and "diagonal" viewing angles for different sensor sizes and different lens types.

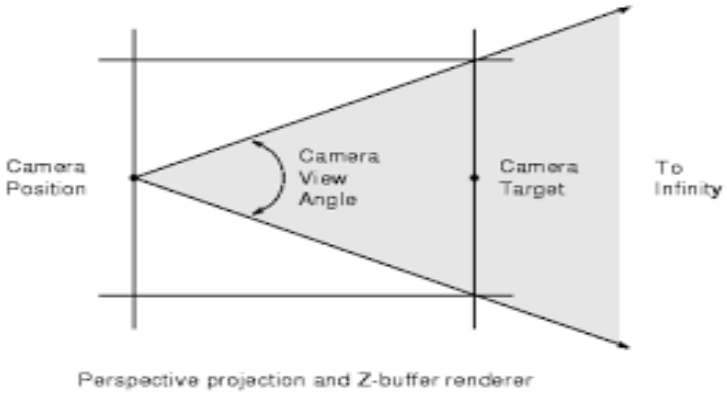

Figure 11. Camera angle of view diagram

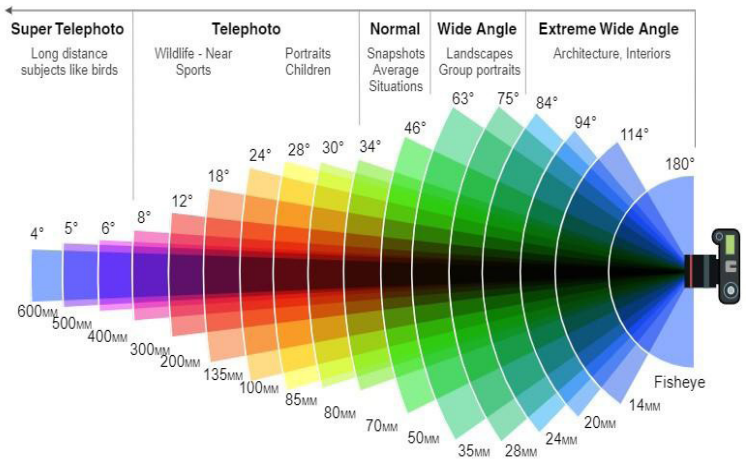

Figure 12. Lens focal lengths by camera sensor size and angle

The light transmittance of each lens is different. Some lenses pass more light, while others pass less. The light transmittance capability of the lenses is expressed as the “F” value. A small “F” value indicates that the lens passes more light and provides a brighter image. Lighter passing through a lens means that it will provide a brighter image in low-temperature environments.

Resolution

It is the number of points that make up the image. It is a unit of measure that shows quality in display technologies. Digital images are created by dots called pixels. 800x600 image resolution, left-to-right 800; It refers to an image created from a total of 480,000 small dots with 600 pixels from top to bottom (General Directorate of Security, 2017). Webcam used in the study has VGA resolution. This means that inferences will be made with the changes in the values of the elements in an 800x600 matrix in unit time.

Video Viewing Process

An image signal is any image converted to electromagnetic energy for sending or storing. This signal is called the other name (VF). In our study, we will focus on the transfer of the video signal on the television and how the digital data is sent to the receivers. The numerical data sent in our country depends on the B/G system. An image is made up of many small image elements combined. The maximum number of details in images is called resolution. The clarity of the image on a television or computer is also related to resolution.

On the screen, there are very small phosphor plates, called pixels, that emit different colors of light when electrons fall on them. Their number affects the clarity of the picture on the screen. These color-emitting plaques can be easily seen with a lens. The power of resolution (resultation) is explained by seeing the details of small objects, with a physical phenomenon opposite to that. Examining microbes under a microscope is also about resolution. It is aimed to ensure that the microbe or bacterium appears in detail enough to be recognized by making the microscope at sufficient magnification. Here, it is essential that the rays coming from different points of the small creature are separated from each other. In other words, it is essential that the piece of painting coming from these points does not overlap and should be seen separately (Isci, 2008).

The B/G system determined the number of details in the vertical and horizontal directions as 625. These numbers are called the number of rows and columns. Up to 320 pairs of contrasting colors (such as black and white) can be transmitted side by side in each line. White is represented by 1 volt and black by 0.3 volts. Since two contrasting colors together can be represented by one period of the sine signal, the most detailed image (625 x 320 =) consists of 200 000 sine signals. Moving image; for a moving image, the

screen should be scanned line by line, starting from the top left. It is assumed that the screen is scanned 25 times per second in analogue broadcasting. In other words, the television broadcast must be able to transmit 25 full-screen images, each consisting of a maximum of 200 000 sine waves, in one second. In other words, the bandwidth of the video signal is (200 000 x 25 =) 5 MHz.

Interlaced Scan

If the entire page were to be written and read in this way in interlaced lines, the same amount of information could be obtained with all successive lines as if written in a special way. Before interlaced scanning, all single lines are scanned from top to bottom of the frame. Even lines are then scanned, skipping odd lines. At the end of the vertical sweep, vertical reversal occurs rapidly and the electron beam returns to the upper part of the frame. Thus, all single lines are scanned from top to bottom, skipping previously scanned lines. Each frame is divided into two areas. The first is the Single line field with odd lines, the second is the Even line field with even lines. Scanning of 30 frames per second is completed. Since each frame consists of two fields, 60 fields will pass per second. In this case, the vertical scanning frequency to increase to 60Hz is due to the scanning of the electron beam by skipping lines one by one (Grob, 1975).

Interpretation of Frames

“VideoCapture video(0);” to create the object for which the frames should be interpreted. After the video images are taken with the Mat new Frame, the object to which the frames taken from the camera will be loaded is determined. This frame in RGB format is converted to HSV. Then the object to which the HSV image will be loaded is determined. After the object is prepared for the frame to be processed, the “HMAX HMIN SMAN SMIN VMAX VMIN” values, which are initially prepared as integers, are compared with these received frames. According to the HSV values, in order to reach the entire image that is desired to be taken as the original, point clarification is performed on the image with a 5x5 matrix. Next, erode(operandFrame, operandFrame, getStructuringElement(MORPH_ELLIPSE, Size(5, 5))); dilate(operandFrame, operandFrame, getStructuringElement(MORPH_ELLIPSE, Size(5, 5))); The images are deleted by scanning with a 5x5 matrix with their codes.

Conclusion

Testing the System

In this study, the factors affecting the system were examined under two headings as mechanical and software factors. For the conveyor belt formation process in mechanical factors, the material moving on the belt was chosen as rubber plastic. After the design of

the pulley and moving parts was made, it was ensured that it was printed in the form of PLA plastic on a 3D printer. A screw jack system is used to ensure the tension of the belt. It is necessary to turn the screw at the end of the band to provide tension on the screw jack. There are also some negative effects of the screw jack system. The pressure in the belt in general becomes difficult to detect when the screw is turned to provide adequate tension. In this case, the life of the rubber plastic band decreases and the screw must be turned to make adjustments. This situation creates a loss in terms of time.

After the conveyor belt is formed, one of the pulleys is fixed to the DC motor so that it can be placed between the two pulleys and given movement. Bearings are fixed on both ends of the other pulley so that it can be movable. Then, it was adjusted how high the camera should be positioned from the tape in order to see the tape at a full angle.

In terms of software factors, first of all, the quality of the camera that transmits the images should be at a high level and the filters selected should be of good quality. The program should be able to interpret the photograph well. The amount of light in the environment must be sufficiently constant. Depending on whether the light intensity falling on the band is low or high, after the first value is introduced manually, the threshold value can be determined with a parameter. The amount of light is fixed over the specified parameter.

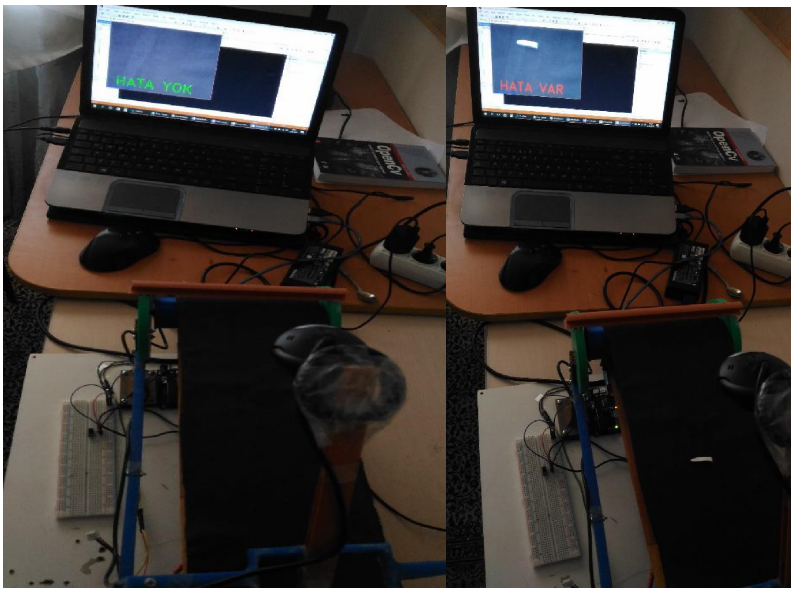

Figure 12. Testing the system

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CHAPTER 4

Augmented Reality in the Field of Rehabilitation

Hasibe Nur KILINC, Yusuf UZUN

Augmented Reality in the Field of Rehabilitation

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Necmettin Erbakan University

Yusuf UZUN

Necmettin Erbakan University

Introduction

Augmented Reality is created by combining virtual content on real images using the object recognition structure of technological devices. In order for us to use this technology, it is necessary to have technological devices (smartphone, smart glasses or tablet) that will identify the operation of augmented reality. In addition, one of the studies that has been identified with Augmented Reality needs to be defined on the device to be used. After these steps have been created, the images designed for Augmented Reality should be identified by the application on technological devices. As a result of these steps, the technological device detects the pictures and new images are obtained in a stationary environment (Pehlivan, 2019).

Augmented Reality is a computer vision technology in which views in a real environment are created by computers into virtual environments. It completely simulates the real world and replaces it with a virtual environment. Augmented reality is designed to improve people's perception of reality (Kalkavan, 2021).

The technologies used in Augmented Reality applications are usually created with video and optical-based technologies. The differences between the technologies created with them are the parts in which the environment created by Decoupling the virtual and real world is located. Scenes combined in video works should be Deconstructed using technological devices, as well as combining studies and the integration of glasses with real environments (Icten & Bal, 2017).

Augmented Reality applications are created in real environments on a pointer-based, marker-free and location-based basis (Akkus & Ozhan, 2017). Pointer-Based Augmented Reality is created by combining an image created in real environments with materials in a virtual environment. They work depending on the visuals. Generality is used in all areas. Artoolkit, Wikitude, Layar, Vuforia, etc. it is used in platforms (Akkus & Ozhan, 2017).

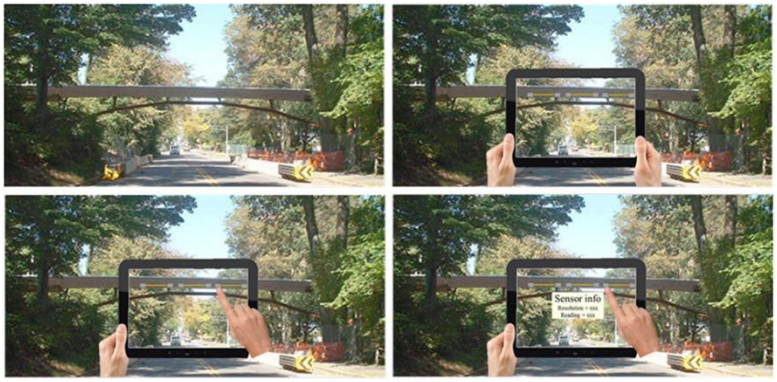

Figure 1. Pointer-based augmented reality

Markerless Augmented Reality has been used in recent years with a new generation of optical-based smart glasses. It involves the user in interaction in real environments. Education, medicine, military, tourism, etc. it is used in many fields, especially. Vuforia, ARKit, ARToolKit 6, Wikitude, ARCore, etc. it is used with platforms (Akkus & Ozhan, 2017).

Figure 2. Markerless augmented reality

Location-Based Augmented Reality is created by pointing the content created in virtual environments at specific locations using location or location information and displaying it in real environments. They use location and map information. It is more widely used in tourism fields. It is used with Wikitude and ARToolKit 6 platforms (Akkus & Ozhan, 2017).

Figure 3. Location-Based augmented reality

Augmented Reality Peripherals

The peripherals used for Augmented Reality are Marker Peripherals, Hardware Peripherals, Software Peripherals, Augmented Reality Glasses (Cakal & Eymirli, 2012). Marker Peripherals constitute the positional Dec between virtual environments and real environments. When markers were first used, they were created in 2-bit shapes, while today any real-life object is shown as a pointer marker (Cakal & Eymirli, 2012).

Figure 4. Marker peripherals

Hardware Peripherals, Augmented Reality all created works are created using computer infrastructure. High-performance computers are usually used in terms of the speed of the application so that three-dimensional models can be displayed in real environments. Augmented Reality technology is often being developed on mobile technological devices. Because of this, Ipad, PC, Notebook, camera, etc. the devices can be given as an example (Cakal & Eymirli, 2012).

Figure 5. Hardware peripherals

An auxiliary interface is needed to Decipher software peripherals, real environments, and virtual environments together. Because of this, it is usually available on the market as licensed software in the software sector. These softwares consist of tools that do not provide a number of conveniences. These tools are usually composed of mobile application, modeling, marker tools and web Dec development tools (Cakal & Eymirli, 2012).

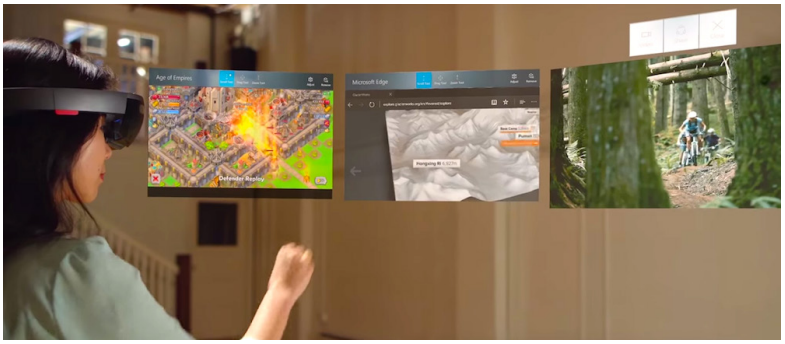

Figure 6. Software Peripherals

Augmented Reality Glasses are glasses that allow data and images to be created between real environments and virtual environments and allow users to Decode the application (Cakal & Eymirli, 2012).

Figure 7. Augmented reality glasses

Augmented Reality in the Field of Rehabilitation

Rehabilitation is the health science responsible for developing, renewing and maintaining the maximum mobility abilities that individuals can use throughout their lives. With the recently developed non-woven sensors, rehabilitation positively improves the recovery processes of individuals throughout their lives. In addition, it is thought that healing and treatment processes are shown to develop faster in individuals differently with augmented reality technologies. In this study, virtual environments are compared with the position of the individual in three dimensions and constitute the physiotherapy system by connecting the individual with real and virtual environments (Ong et al., 2012).

Figure 8. (a) A pointer icon placed on a person's head (marker) and the pointer icon is used to track the camera located on the monitor. (b) The game developed with Leap Motion and the human perspective (Ong et al., 2012).

Elements such as distraction or excitement in the nerve during rehabilitation are one of the problems in the prolongation of the diagnostic and treatment processes in individuals. For example; stress ball, door handle, etc. such objects distribute the minds of patients, allowing them to achieve the necessary measurement values. In addition, these methods are also used today to observe sick individuals through games with game consoles. It has been observed that applications in rehabilitation areas with the help of non-woven sensors have shown successful results in sick individuals. Therefore, encouraging such practices with rewards increases the speed of improvement in exercise practices, especially in children's sick individuals. Augmented reality studies created for the purpose of rehabilitation communicate with real environments by taking movements in the body parts of sick individuals in the form of specific points (Ong et al., 2012)

Figure 9. (a) Wrist flexion movement. (b) Wrist extension movement (Ong et al., 2012).

It is a study that will contribute to the rehabilitation programs of patients with emotional and physical problems.

- Sick individuals in the neurological rehabilitation group,
- Sick individuals in the orthopedic rehabilitation group,
- In the health of athletes,
- Sick individuals in the pediatric rehabilitation group,
- Sick individuals in the geriatric rehabilitation group,
- Vestibular problems

It is used for exercises aimed at control, November strengthening, balances. At the end of the exercise study, the patient's success in each movement is output as a report.

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CHAPTER 5

Virtual and Augmented Reality Concepts

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Virtual and Augmented Reality Concepts

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Introduction

The period we live in is a period in which the internet and computer are at the center of our lives. Digital applications are increasing day by day and accordingly people's communication styles are changing (Arslan & Elibol, 2015). Since its existence, human beings have always tended to research and learn. Requirements arising from wanting and needs have further increased this tendency. This cycle that will continue throughout life will never end. Depending on this cycle, technological developments will continue continuously. Other Technologies that develop over time are "Augmented" and "Virtual" reality Technologies. In the past, the concepts of virtuality and reality were referred to as completely separate from each other. The place where people are directly affected is the "real environment"; the environment, which is made up of computers with the laws of physics such as time, equipment, gravity, and has no borders, is called "virtual environment". Today, the concept of virtuality has left its place to new environments that combine virtuality and reality. The virtual environment, which is a computer output, is called "virtual reality", and the environment that is a combination of reality and virtuality is called "augmented reality" (Azuma, 1997).

Technology has been important to every aspect of their lives for people that have adapted to the virtual world quickly. Technology and its elements change people's lifestyles and even their perspectives on events or the world. For example, shopping is one of the indispensable needs of all people, young and old. Although stores and shops come to mind first when it comes to shopping, it is a fact that shopping can be done online nowadays. Thanks to VR and AR technologies, people will feel like they are shopping from wherever they are and will be able to examine products for 3D. It has been observed that virtual shopping has positive effects of production of consumption (Kose & Yengin, 2018).

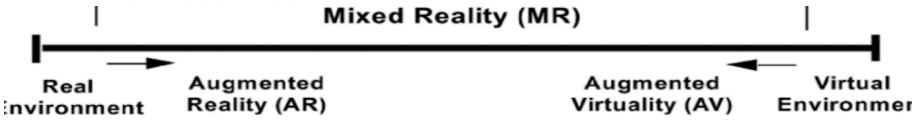

Figure 1. Virtuality-reality continuum

Virtual reality consists of computer-generated animation and 3D models. Through technological tools, people feel themselves in these virtual environments and interact with 3D objects. AR and desktop virtual reality is a technology developed based on VR technology. In Figure 1, the communication between the concepts of virtual, augmented and mixed reality is knitted. On the left is the real world, on the far right is the virtual world. These two media transitions are called "Mixed Reality" (Kucuk Avci, 2018). MR (Mixed Reality) can be defined as the combined form of VR and AR applications. In mixed reality, virtual and real environment objects coexist. Unlike VR and AR, MR technology can be physically supported (Avci & Tasdemir, 2019).

Virtual Reality

Virtual environments realized by using virtual reality technology are formed by the combination of imagination and real world. VR enables people to interact directly with the computer to solve complex problems. Being able to imitate real environments is the main purpose and most prominent feature of VR technology. These technology developers are now able to design very realistic environments thanks to artificial intelligence algorithms. The subject of virtual reality has been used in the past to cover meanings such as 3D simulation, virtual environment, console and computer games. Today, it emerges as systems that can interact with the sphere, which provides 3600 visions of glasses, and where virtual environments can be experienced (Wikipedia, 2020). Another definition of VR is Diemer et al. (2015) gave. According to Diemer et al., virtual reality is environments simulated to reality by computer. In this way, people can communicate not only with the real environment but also in the virtual environment (Diemer & others, 2015). When we look at virtual reality from the framework of the system, we come across the following definition: "A system in which users actively feel and control a real-world situation with the help of equipment and special tools they wear on their bodies on a 3D simulation created in the computer environment." In this plan, virtual reality applications users; It provides the opportunity to enter the virtual world created by the computer, to have various experiences there and to direct it (Deryakulu, 1999).

Virtual Reality Triangle

In order for a computer-generated work to be considered a VR work, it must have the following: These aspects are called "virtual reality triangle" or "virtual reality 3I" or "virtual reality triangle" (Karışma, 2017). Figure 2 shows the virtual reality triangle.

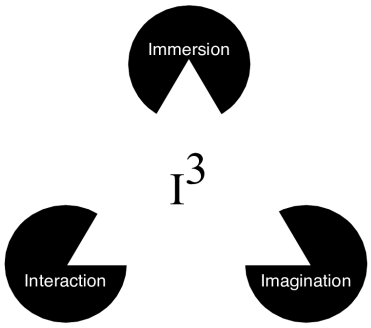

Figure 2. Virtual Reality triangle

Immersion: VR infrastructure takes users with different devices into a virtual environment and cuts off their relations between the real worlds. Wrapping process (Unur, 2001);

- 3D graphics simulations,
- A world with real representation,
- The device allows you to feel as if you are a part of the virtual world.

Wrapping means that users enter the created virtual environment using different devices (tablets, glasses and phone screens, etc.). In addition, immersion is the factor that completes the experiences of individuals. As the variety of senses used by users in the virtual environment increases, the rate of immersion also increases. The fact that there is feedbacks such as images, sounds and smells of the people in the virtual environment increases this rate (Unur, 2001).

Interaction: It appeals to all sense of individuals such as hearing, sight, touch and taste. First of all, a virtual world that is not motionless is required for interaction. A reaction is created in the virtual world to the actions of individuals. Reactions, on the other hand, are verbal, visual, verbal instructions, etc., using various devices (Unur, 2001).

Imagination: Imagination: An individual creates an illusion by imagining non-existent images of the world. Dreaming of individuals depends on the created virtual world, imagination and problem solving efforts in this environment (Ünur, 2001).

Types for Virtual Reality

VR infrastructure is an environment realized by the joint operation of hardware and software components. Virtual reality infrastructure is mainly associated with computer software. There are devices developed to display VR content. The use of these devices affects the Wrapping and interaction characteristics that make up the VR technology. The devices strengthen the wrapping feature of VR technology and increase the wrapping rate. VR types are shown in Figure 3 (Saka, 2019).

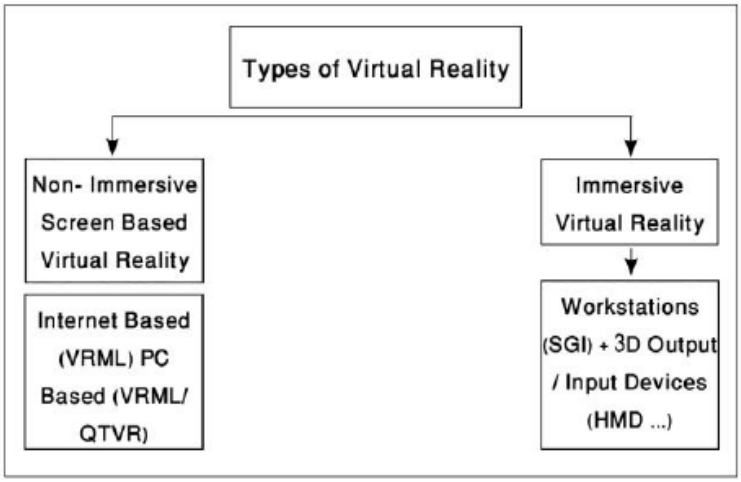

Figure 3. Types for virtual reality

Non-Immersive Virtual Reality: In this virtual reality world, a computer monitor requires a hardware that allows you to enter information in order to control the system, for example, keyboard, mouse, etc.

Compared to immersive VR, it is easy to develop. In addition, they are systems that cost less in terms of hardware. Interaction in the virtual world can be done with modern tools such as mouse and keyboard. As an example of the non-wrapping VR type; computer, internet and image-based virtual reality studies can be given without using an additional device (Kurtulus, 2017).

Immersive Virtual Reality: Immersive VR adds the individual to the system with HMD (Head Mounted Display) or multiple projections in a virtual 3D rendered virtual reality. A sensor in the HMD detects the head movements towards the individual and transmits them to the relevant processor. Thus, it shows the images of the individual according to the head degree (Fig. 4) (Kurtulus, 2017).

Prepared with multiple reflectors, Immersive VR uses its reflectors to create a virtual reality and aims to give the individual a real-life experience.

Figure 4. Head mounted imaging equipment

Examples of Virtual Reality Applications

Virtual reality is a technology that facilitates interaction thanks to the visual system it

provides with objects and events that do not exist in reality (Freina and Ott, 2015). Virtual reality is a 3D simulation model that gives users a sense of reality. The environment designed through a computer provides the opportunity for mutual communication. In this way, the designed systems significantly increase our perception and grasping power. Virtual reality is used in many areas from healthcare to entertainment (Bayraktar & Kaleli, 2007). Virtual reality technology is also used effectively in the field of education. As it gamifies the education given, it increases the students' desire for learning and ensures their more intense participation in the lesson (Freina and Ott, 2015; Bastiaens, 2014). Thus, learning and entertainment processes can be used to support each other through virtual reality. In addition, virtual reality enables students to be in the same virtual environment. In this way, students can interact and work together. Virtual reality technology allows students to explore more different types of learning. With these discoveries, students also increase their tendencies towards different types of learning. In short, virtual reality emerges as a new tool to improve learning, make it fun and more attractive (Simsek & Can, 2019).

With virtual reality, it is possible to visit cities, buildings or a place you have created with your imagination in a virtual environment. For example, with the ancient city tour application with VR technology in Turkey, Zeus, Asklepios, Red Court and Athena temples in Bergama can be visited in 3D. In addition, the Techno Mersin Project has been developed by METAB and Mersin Metropolitan Municipality to promote the province of Mersin. With this project, Mersin can be visited in a virtual environment (Ekici & Guven, 2017).

In the digital age, information flows is experienced very intensely. This situation causes the search for differences in news presentations. The journalism industry has entered into different searches for virtual reality. With VR used in journalism, the audience can think of themselves as in the event and creates empathy towards the event. In other words, the audience will not only watch the news, but will also be able to add their own feelings and thoughts to the news. This journalism is called 'immersive journalism'. Immersive is defined as aiming to draw the audience into the event (Caba, 2018).

Gunes and Dilipak aimed to contribute to the training of people who detect explosive substances with VR in their study. It is known that deactivation of explosive materials is an important issue. It is extremely important to the defense personnel working in this field to detect the substance and destroy it without being damaged. Thanks to the virtual environment created with virtual reality technology, people think of themselves as in the real environment. This increases the realism in training of the personnel and allows them to complete their training carefully (Gunes & Dilipak, 2020).

One of the most important areas where virtual reality is applied is health. Işıklı et al., in their study, aimed to treat people diagnosed with specific phobia with VR technology. In

the study, 11 participants that did not use drugs were exposed to virtual environment scenarios according to their phobias. As a result, the reactions to the participants according to their phobias decreased day by day (Isikli et al., 2019).

Augmented Reality

"Augmented Reality (AR)"; It is defined as a technology that combines real and virtual environments. In this technology, virtual and real objects interact with each other (Azuma, 1997). 3 important features of AR;

- Combination of real and virtual objects
- Provide real-time interaction
- Finding 3D (3D) visuals

In AR technology, a real world image is taken primarily through the camera. On top of the captured image, it is checked whether one of the target impressions introduced to the system exists. If a target impression is found, pre-created virtual objects are placed on this target impression (Azuma, 1997). In applications developed with AR technology, virtual objects such as 3D images, pictures, animations, texts and videos can be used together or separately (Wang and others, 2013). Thus, individuals are provided to communicate naturally with events, objects and information (Woiciechowski & Callery, 2013). In AR technology, glasses and special head-mounted devices were used for the first time. Today, we can use it even only with our mobile devices (Kommera and others, 2016). This technology, which has become increasingly widespread, has become available with different devices such as desktop and laptop computers, smart phones.

Types for Augmented Reality

There are several types of developing applications for AR. Developers need to determine their needs before choosing the type of app they want to use. In this way, the most suitable choice will be made according to the wishes and needs. AR technology is of two types, location-based and image-based. Once the selection is made, the AR system is carried out in 3 steps: recognition (detection of image, image or location), tracking (layout of 3D objects) and merging (Icten & Bal, 2017; Zhou et al., 2008).

Software and SDKs Used in Augmented Reality

While the AR application is being developed, tasks are defined with code to the hardware. Different software is used according to the infrastructure, type and function as the hardware. The use of mobile technologies in AR applications have increased due to convenience and accessibility. Due to this increasing interest, a new sector has emerged. Today, AR applications appear as mobile applications instead of special hardware or

glasses (Craig, 2013). Software development kit (SDK) is used to produce AR applications. Vuforia, ARCore, Wikitude, ARKit are the most used SDKs. SDKs are used a lot when developing mobile games or applications (Craig, 2013). *ARKit*: Apple has acquired Metio, a company that conducts research on augmented reality technology. After working on ARKit for a year, it was released in 2017. ARKit offers very different experiences of Apple devices. It is possible to develop applications with game engines such as Unreal Engine, Unity or SceneKit. (Apple, 2020; Agacayak, 2019). In Figure 5, there is a visual of the interface of the ARKit application.

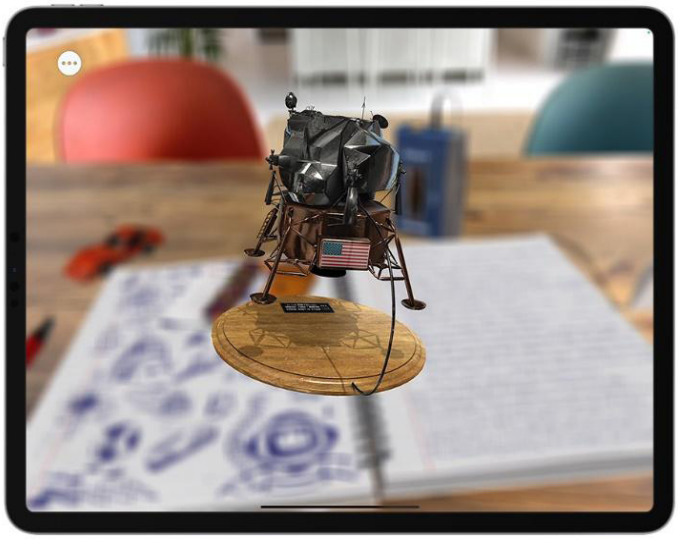

Figure 5. An example for ARKit SDK application

ARCore: It is the SDK developed for the AR application released by Google. With ARCore, applications can be developed for devices with Android and iOS operating systems. The most important features different from the others (Agacayak, 2019; Google, 2020):

- It estimates the application light by reference to the ambient light.
- It can perceive surface maps diagonally, vertically and horizontally. Positioning features is at their best.

Figure 6. ARCore interface

ARCore provides free use to users. Figure 6 shows the image of the ARCore interface. Developers can use platforms such as Unreal Engine, Unity or AndroidStudio (Agacayak, 2019; Google, 2020). *Wikitude*: is a company found in Austria in 2008. It is one of the

augmented reality development SDKs (Figure 7). Its founding purpose is to develop AR application for locations around the world. It has become a general AR application as its popularity has increased from a short time. The most important reason to use Wikitude is that it provides rapid application development. In addition, the technologies it contains are available for Android, Windows and iOS operating systems, allowing developers to choose Wikitude (Agacayak, 2019; Wikitude, 2020).

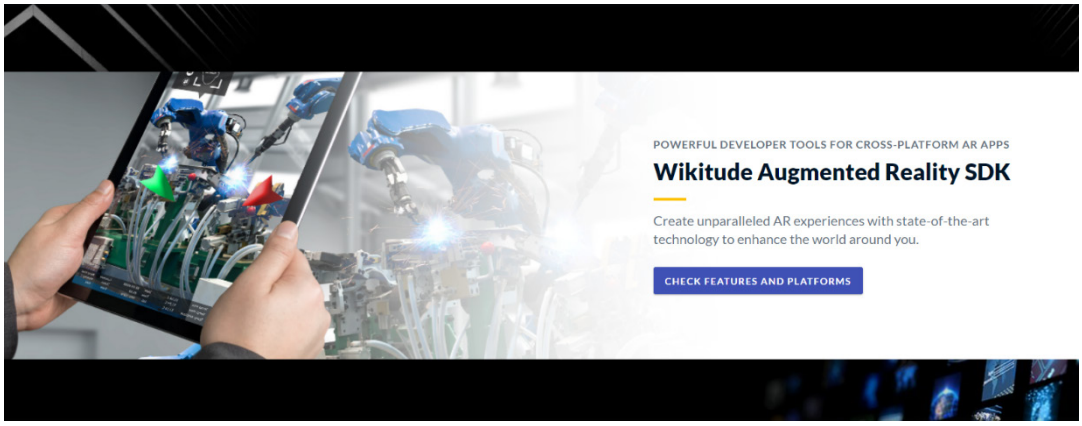

Figure 7. Wikitude interface

Vuforia: Vuforia is an SDK that enables the development of high quality, fast and immersive applications. It can be used in different operating systems. Thanks to the VuMark feature, markings can be made on reference points, thus providing users with the opportunity to develop interactive applications (Figure 8) (Agacayak, 2019; Vuforia, 2020).

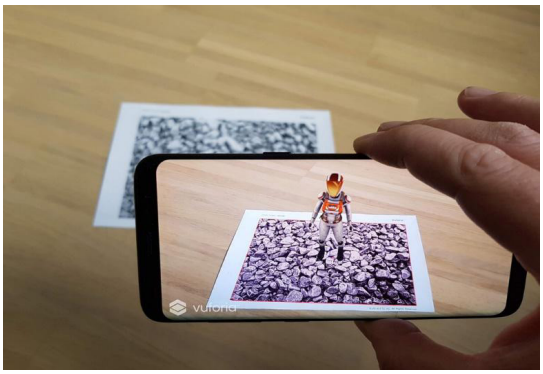

Figure 8. An example for Vuforia SDK application

Examples of Augmented Reality Applications

Augmented reality technology is also used in many areas, just like virtual reality technology. The aim at the developed AR applications is; making life easier, studying, having fun, etc. For this reason, it is widely used today, just like VR. AR applications need to be interesting and impressive in order to be suitable for their purposes (Demirezen, 2019). In this section, a few examples related to augmented reality applications will be explained. Driving a vehicle is an activity that is fun and requires a lot of attention. Accidents occur because of drivers' carelessness or fast driving. And these accidents, un-

fortunately, can result in death. Many applications have been made in order to reduce the accident rates of the automotive sector. Among these applications are Head-Up display analyzers with DLP (Digital Light Processing) imaging system feature. These screens are the most important AR devices in the industry. Head-Up (Figure 9) instantly shows the speed value that the driver must comply with by calculating the distance between the vehicles used and the vehicle in front of it. In this way, drivers will see at what speeds they need to drive the vehicle. distance, speed etc. as a result of calculations, the receipt and processing of information are Emgu CV or Open CV, etc. provided by libraries. An example image of Head-Up is given in Figure 9 (Bradski & Kaehler, 2008; Shi, 2013).

Figure 9. An example head-up application

Traveling and exploring new places is one of the hobbies of people. Travel companies have sought different ways to make this hobby more enjoyable and enjoyable. In this respect; Technological studies based on iOS have been made, such as the ease of introducing important or historical places and finding their addresses. Thanks to AR technology, people can read information about the historical places they have visited and see the old version of a newly built building as a 3D model instead of recreating it in their dreams (Figure 10). It is possible to show applications such as Urban Sleuth (Drupal, 2020), Street Museum (Museum of London, 2020), Metro AR Pro developed for the London museum as examples (Icten & Bal, 2017). In our country, an AR application was made by the Mardin Metropolitan Municipality in order to promote the city and inform the tourists. In this context, the "Mardin AR" application was launched at the Information Culture and Promotion Center (Anadolu Agency, 2020). Figure 11 shows an application example of the archaeological field.

Figure 10. An example of AR for archeology

Another area where AR technology is used is sports applications. It has been used in sports such as cricket, tennis, football. Hawk-eye (Owens and others, 2003) is the most well-known AR application for this field. The purpose of this application is to follow the path of the ball. The purpose of using AR technology in sports applications is to provide more useful training to the athletes by preparing realistic environments, and to improve their performance and abilities (Bozyer, 2015).

Mobile games are indispensable to people, especially young people. There are educational games as well as games that cause us to waste our time. Considering the studies made with AR technology, it is estimated that wearable and Head-Up devices will take the gaming industry to another dimension. The game Pokemon Go (Serino et al., 2016), which almost everyone played a few years ago (Figure 11), is a location-based AR technology game. Although this game allows people to act in the real world, it has created problems in terms of security. In addition, a negative aspect of people's addiction to the game has also emerged.

Figure 11. AR-based Pokemon Go game

With AR technology in marketing, it can be easier to promote and sell customers' products (Bule & Peer, 2013). Because with AR, it is possible to present the customer's product as a picture, text or 3D object. In this way, the customer will have the opportunity to examine the product as if he saw it in the real world. In the studies carried out, customers can remotely control the product with hand movements towards the store or at home. Examples are applications developed by companies such as Kinect (Vimeo, 2020), Smatrix (Vimeo, 2020) and Fitnect (Youtube, 2020). In addition, with IKEA's IKEA AR catalog application, customers can see all kinds of household goods or furniture in their home environment in 3D (IKEA, 2021). Figure 12 shows the image of the IKEA AR application.

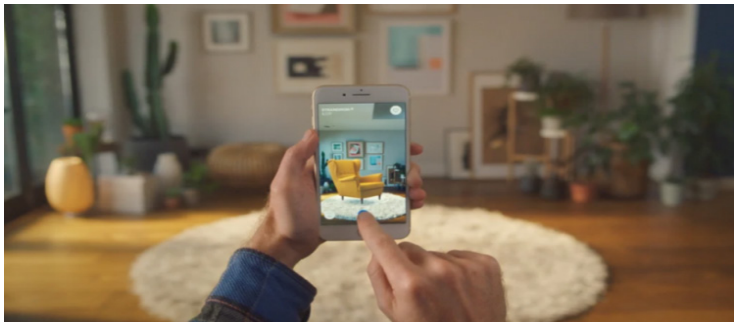

Figure 12. IKEA AR app

One of the most important areas where AR technology is used is education. Signal-based AR technology is generally used in the field of education. The knowledge to be taught with 3D objects, animations and drawings becomes more fun. Quiver (ColAR) application was developed by Quiver Vision Company (Figure 13). With this application, students can view the pictures on the marker papers in 3D according to the colors they paint (Quiver, 2021). Another application for this field is the Brainspace magazine application developed by Blippar Company. Users can view the objects of the magazine pages in 3D or video form with Brainspace (Brainspace, 2021).

Figure 13. Quiver app image

Conclusion

The purpose of augmented and virtual reality is to create virtual environments for users. This technology can be defined as two sides of a coin. With AR, people can interact with 3D objects without breaking away from the real world, while in VR they are completely in the virtual world (Sidiq et al., 2017).

Table 1. Augmented Reality and virtual reality comparison

	Augmented Reality	**Virtual Reality**
Function	AR is the fusion of the real world and the virtual world. Digital content is simulated in the real world.	VR changes reality by immersing the user in a completely imaginary world.
Devices	Presented on Google Glass. HoloLens is the most famous AR device.	VR has been around for a long time. Oculus Rift is the most famous VR device.
Applications	Video games, theme parks, simulation apps, worker training, trading, etc.	Video games, theme parks, entertainment applications, video, collaboration, worker training, simulation applications, etc.
Actors	Epson, Microsoft, Skully, Vuzix	HTC, Oculus VR, Sony, Samsung Gear VR

Key differences between VR and AR (Icten, 2019);

- VR is based on the virtual world, while AR is based on the real world.
- While VR takes the users completely into the virtual environment, AR maintains the connection of the users with the real world.
- While VR transforms the data onto a part of the virtual environment, AR adds this data created with computer software on its real image in the form of layers.
- VR allows to intervene in the virtual environment with data and special tools, while AR also allows to intervene in the real environment manually.
- VR imprisons users in the virtual world. It does not allow seeing depressed objects or events in the virtual environment. AR, on the other hand, allows the user to see the events and objects of them by not detaching them from the real world.
- VR usage tools are airplane, car simulator or glasses. With these tools, the field of view of the users becomes a completely virtual world. AR usage tools are devices such as tablets, smartphones or computers.
- VR receives direction and position information about data onto sensors, AR receives this information through interaction with the real environment.

Figure 14. Comparison of Augmented Reality and Virtual Reality

Figure 14 shows the differences between real, VR and AR environments. When we take the real world as a reference, a three-dimensional computer image can be added to the environment in AR. In the VR environment, the real world has been virtualized and a computer object has been added. As a result, AR can be expressed as virtuality and reality, and VR as virtuality and virtuality (Icten, 2019).

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CHAPTER 6

Use of Artificial Intelligence Technologies in Education

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Use of Artificial Intelligence Technologies in Education

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Introduction

Artificial intelligence is able to perceive the human ability to know, reason, comprehend, make sense of, generalize, make inferences, learn, and successfully perform multiple jobs at the same time (Gondal, 2018, s.1). In a different expression, it is called information technology that can imitate human intelligence. In addition, artificial intelligence technology is a branch of science that continues to develop continuously by studying human intelligence and the working system of the brain. Human intelligence is superior to artificial intelligence. But it is known that artificial intelligence works much faster than the human brain if the environment changes rapidly, tasks are complicated and many tasks are solved simultaneously in a certain order and with an unchanged technique (Teng, 2019). It should be noted that artificial intelligence technologies are widely used in healthcare, industry, military, transport, transport, trade, etc. it is seen that it is widely used in fields. One of them has been the training area where it has been used a lot nowadays. Artificial intelligence has been an evolving technological field that can change every aspect of our social interactions. As an inevitable result of affecting our interactions, the field of education also affects and changes. Artificial intelligence technologies in education have begun to produce new teaching and learning solutions that are currently being tested in different contexts. An important area affected by artificial intelligence technology is education. 21. considering that individuals who grew up in the XIII century were individuals who grew up intertwined with technology and got acquainted with computers and the Internet from the moment they were born, it seems that different methods are needed in education than the traditional teaching method. It is one of the indispensable elements of my education to bring today's students to a level that can solve their current and future problems. Because of this, it is possible to see that the question "what do you want to be when you grow up" for children has been replaced by the question "what problem do you want to find a solution to in the future (Kis, 2019).

With this change, personalized training programs, individual performance monitoring, course content preparation, determining the teaching model, etc. are being implemented today with the use of a large dataset thanks to artificial intelligence technologies. the procedures have significantly improved the quality of training. Considering the artificial intelligence studies in the field of education today, it Dec seen that the most development has been achieved between the educational organization, parents, teachers and students, and the area where work has been done is on students and learning(Tablo 1).

Tablo 1. Advantages and Disadvantages of Artificial Intelligence in the Context of Educational Stakeholders (Osetskyi et al.,2020).

Shareholder	Advantages	Disadvantages
Educational Organization	Identification of students as personalities and individuals, School safety, Objectivity of assessment, Digital learning, Protection of student personal data, The possibility of efficient learning and study, Lifelong learning, Personalized teaching.	Low confidence in the new system, possible problems at the stage of evaluating the creative work of students, concerns about ensuring classroom discipline, the possibility of the System crashing or being hacked.
Student	The ability to objectively monitor the learning process, Improve the quality of distance learning, Integrate into new technologies, Access to it at any time.	Difficulty in being motivated, Lack of communication and interaction between students and teachers
Teacher	Ease of managing students, Automating task and content creation, Continuous improvement, Objective evaluation, Fast and complete feedback, Performance monitoring, Protecting teachers' strengths, Contributing to the development of their weaknesses	It can lead to an increase in the expected professional qualifications of the teacher, replace teachers.
Parent	Real-time feedback, Informing about progress, New learning opportunities for their students, Reducing problems in reaching education for financially disadvantaged families.	Since there is no communication with people, there is a lack of communication and interaction, as well as dehumanization.

Artificial intelligence studies in education are not limited only to the effectiveness of learning, but also work is underway to actively use it in other areas of education. In this context, the areas on which development studies are ongoing and the techniques that are intended to be applied in these areas are given in Table 2.

Tablo 2. Application Areas and Techniques of Artificial Intelligence in Education (Chen et al.,2020).

The Field of Application of Artificial Intelligence	Techniques
Evaluation of students and schools	Adaptive learning method, Personalized learning approaches, Academic analysis
Grading, evaluation of assignments and exams	Image analysis, Computer vision, Forecasting system
Personalized smart teaching	Data mining, Information intervention, Analysis of the individual and learning
Smart school	Face recognition and voice recognition, Intelligent laboratories, AR, VR systems, Hearing Dec technologies
Online and remote mobile training	Precise analysis of the individual, Virtual personalized assistants, Real-time analysis and instant feedback

In this section, studies conducted in education using Artificial Intelligence Technologies are mentioned. The use of artificial intelligence in education has been gaining importance in recent years. The part related to education occupies a small place in the field of artificial intelligence (Arık & Seferoğlu, 2020; Tahiru, 2021). Artificial intelligence plays a supporting role in education by helping teachers and providing meaningful lives for learners (How & Hung, 2019). Baker and Smith (2019), educational artificial intelligence tools are approached from three different perspectives: a) student-facing, b) teacher-facing, and c) system-facing educational artificial intelligence tools. Artificial intelligence tools for pupils, students use to learn a topic, adaptive or personalized learning systems such as learning management systems or intelligent software. Teacher-facing systems are used to support the teacher and reduce his workload by automating tasks such as management, evaluation, feedback and plagiarism detection. Educational artificial intelligence tools also provide insight into the learning process of students so that teachers can offer support and guidance when necessary. System-oriented educational artificial intelligence is a tool that provides information to managers and managers at the enterprise level, for example, to monitor data exchange models at faculties or schools. Although the educational applications of artificial intelligence were based on an information-based approach from the 1980s to the 2000s (Etzioni,A. & Etzioni, O., 2017) today's studies show that there are different applications in which data and logic-based artificial intelligence applications are involved in almost every field (Fritz &Dermody, 2019).

It seems that artificial intelligence will undoubtedly dominate all areas of life in the near future. A survey of 352 artificial intelligence researchers from Oxford and Yale Univer-

sities was conducted on when artificial intelligence can do various jobs that people do in the future. According to this survey, it has been concluded that by 2051, artificial intelligence will be able to automate all human tasks (Oztuna, 2017:99). At this point, both academic education and, in parallel, artificial intelligence will have a great share in shaping organizational educational activities today and in the future. One of them, Intelligent Instructional Systems, instead of providing the same content to all learners, creates a model according to the goals, preferences and information of each learner individually (Esdeira, 2017). Intelligent Training Systems are used by NASA in the training of astronauts. NASA has trained astronauts with Intelligent Instructional Systems on how to use robotic arms on a space shuttle. Astronauts learn to complete their tasks in this way, and feedback is given according to successes or failures in learning tasks. The system records performance data for each astronaut and provides appropriate performance results by making decisions based on the understanding capacity of the trainee (Noe, 2009).

The introduction and adoption of new technologies of artificial intelligence technologies in higher education policies, and especially in education and training, has been developing rapidly in recent years. It is known that many scientists are interested in artificial intelligence technologies and are exploring the areas of use of artificial intelligence in higher education (Bostrom & Yudkowsky, 2014; Khare, Stewart, & Khare, 2018; Muller, 2016; Popenici & Kerr, 2017; Russel & Norvig, 2010; Stefan & Sharon, 2017). Firstly, with the help of artificial intelligence, learning in higher education can be individualized and the special needs of students can be met (Chatterjee & Bhattacharjee, 2020). Students enjoy studying with a completely new and unique educational approach adapted to their individual needs. For example, Artificial intelligence can help with this kind of personalized learning approach. Therefore, different applications of artificial intelligence will also help to personalize the learning experience (Kumar et al., 2019).

Another area of application of artificial intelligence focuses on the student. For example, some artificial intelligence to observe the behavior of students of higher education institutions, student attendance, and homework are used to monitor while (Baker & Inventado, 2014), others, game, or game-based learning is increasingly common to prefer, it is observed that Intelligent Tutoring Systems (Spector & Ma, 2019). Another potential area where artificial intelligence can help on college campuses is the career placement office. Parker points out that artificial intelligence-assisted interviews through career placement offices at a university are more objective (Jackson, 2019).

In the pandemic period, the inclusion of artificial intelligence applications in the educational process has been of vital importance. In education, online training courses based on artificial intelligence systems have been organized using data mining and student analytics based on student information, and attempts have been made to prevent disruption of educational activities. Applications such as Questa, Cognii and Active have been

used to provide data for the establishment of artificial intelligence systems, and artificial intelligence-supported educational platforms such as Knewton, Century Tech, Voleybolu and Querium have been created (Raza, 2020).

Yin and Moore (1987), the use of artificial intelligence systems in the field of special education; Zawacki-Richter, Marin, Bond and Gouvernour (2019) the use of artificial intelligence systems in higher education and Timms (2016) the use of educational robots based on artificial intelligence systems and intelligent classrooms in the educational system; Ucar and Uludağ (2018), Intelligent classroom applications in the Turkish education system; Bahceci and Gurol (2010) conducted studies on the use of intelligent education systems based on artificial intelligence in education. Artificial intelligence in education has begun to produce new teaching and learning solutions that are currently being tested in different contexts. The most common examples of artificial intelligence applications in education are intelligent teaching systems, adaptive learning systems and recommendation systems. Intelligent Learning Systems use artificial intelligence techniques to model a human teacher to improve learning by providing better support for the learner (Hasanov et al.,2019). Recommendation systems are software tools based on machine learning and information retrieval techniques that provide recommendations for potentially useful items that may be of interest to someone (Syed & Zoga, 2018). Adaptive learning environments create a model of various characteristics of learners and provide an individualized learning environment that meets their needs (Somyurek, 2009).

Intelligent teaching systems are pedagogical computer programs that predict to whom, what, and how they should be taught. According to the data obtained by using artificial intelligence techniques and evaluating the student's performance in the learning process, he has the ability to organize the educational program, determine the level of the student, and interact with the student. It is a system that can imitate what a human teacher can do using pedagogical teaching techniques in a way that suits the student's level and abilities (Piramuthu, 2005).

An example of this type of education has been the "Intelligent Tutoring Systems" (ITS (McArthur et al., 2005). The first ITSs appeared in the 1980s. The main purpose of its early research and development work with a student teacher or coach was to simulate interactions between a human and educational experience. An ITS adjusts the content provided to each student based on the student's current state of knowledge in a particular field, such as mathematics, and provides the level of support and feedback needed for the student to learn and progress within the content. Within a personalized learning environment, ITS due to the nature of these systems in many schools, teachers in heterogeneous classrooms, which is a well-known difficulty for many students can be used to help accommodate a wide range of student abilities. Platforms such as Coursera, edX,

Skillshare, and Udemy have radically changed informal learning and career education. Wikipedia and YouTube have made it possible for anyone to learn almost everything. Now more people use Duolingo to learn languages than any other high school student in the United States. These are all prime examples of AI-driven platforms that provide real-time responses and results for continuous learning. In another study, a three-stage project aimed at creating and testing artificial intelligence-based games to improve the clinical reasoning and detection skills of nurses in home care and community settings using advances in information and information technologies was planned by Dariel and his colleagues, and the first stage was completed (Keskinkora,2019). Artificial intelligence is starting to transform classrooms through the use of customizable content and the monitoring of classifications. AI can automate basic routine tasks such as rating and evaluating simple tests. Be able to apply more individualization with adaptive learning programs, games, and software (Romiszowski, 1987). Artificial Intelligence will help create more efficient, personalized, and contextual support for students. Intelligent recommendation systems or machine-assisted systems will demonstrate the student's mastery, repeat the necessary lessons and suggest a personalized learning plan (McArthur et al., 2005).

A simulation game that is thought to reduce the stress and fear experienced by nursing and medical students during their first experience in the operating room has been developed and its effectiveness has been examined in an experimental study. Of these students, who were divided into control and experimental groups, it was observed that the fears of the experimental group students involved in the simulation game decreased and they made fewer mistakes. In addition, it was concluded that these students are more knowledgeable about how they should behave in the operating room and have a more cooperative attitude towards the patient or staff (Keogh et al., 2019).

(Boydak, 2015). Chopra (URL-4) states that artificial intelligence technologies, it is aimed to use each student's educational materials to customize them according to their abilities, preferred way of learning, and experience. In addition, it is expected that 47% of learning tools will be equipped with artificial intelligence capabilities by 2024. The education system in the world is now constantly renewing itself in line with the use of artificial intelligence applications. In our country, it is aimed to use artificial intelligence applications in order to make improvements in the field of education in accordance with the goals of the Ministry of National Education for 2023. Related studies in this direction, the provision of information about the uses and benefits of artificial intelligence in education, trainers keep themselves updated to adapt to new technologies and on the subject of themselves is important. In addition, the study is important in terms of providing up-to-date information and being a resource for those who want to work on artificial intelligence-based training. It will be useful to mention the artificial intelligence studies conducted in the field of education in Turkey. Many workshops and conferences are held

for artificial intelligence applications and training in the field of education in Turkey. In this regard, the institute of education industry and technology (ESTEN) has organized an artificial intelligence workshop in education six times. In the final report of the sixth workshop, it was mentioned that "Intelligent Classroom Behavior Management" can be realized thanks to image processing technologies. Thanks to this system, it is stated that the facial expressions of the students and their emotional state at the time of the lesson can be detected thanks to the cameras placed in the classroom and which can take December at intervals of 30 seconds. It has been emphasized that these feelings of the students can be analyzed and transmitted to the teacher as feedback. As a result, teachers have stated that thanks to these feedback, they can have information about which part of the lessons the students are active in or which part of the lesson the student is not interested in. It can be said that this system can help teachers in terms of determining the best course method. In addition, in the same workshop, it was stated that image processing technologies can be placed at school entrances and exits and polling control can be done (URL-7).

The Ministry of National Education is working to develop artificial intelligence applications in education. In this context, they collaborated with Istanbul Technical University and worked on the creation of personalized educational content to support the individual development of students. In addition, Istanbul Technical University organized training on artificial intelligence for teachers and made progress in providing guidance services to them (URL-12).

In addition, The Ministry of National Education General Directorate of Innovation and Educational Technologies stated that various content will be prepared for schools and teachers in order to use artificial intelligence applications in education starting from primary school students. In this context, the "Artificial Intelligence Education for Children" project has been launched and studies have been planned to provide artificial intelligence training to students with nine partners under the leadership of Manisa Celal Bayar University. It is also stated that within the scope of this project, different applications will be developed through various games and visualizations, and guide books related to artificial intelligence will be prepared. It has been stated that the Cambridge Professional Education Academy from the UK, CCS and Pobalscoil Neasain school from Ireland, and IBM Watson organizations will support the project. (URL-5). MATLAB, one of the techniques used for data analysis, is a software language that is suitable for technical calculations and has high performance. With MATLAB, mathematical calculations can be performed, algorithms can be developed, modeling, simulation, and prototypes can be created, data analysis Dec and visualizations can be performed, scientific engineering graphics can be created, and applications including graphical user interfaces can be developed. In the study where MATLAB was applied, researcher, 3. The effects of reading difficulties experienced by grade students; familial factors, individual factors,

environmental factors, education and training resulting from the results of the survey that is being applied to up to 174 teachers analyzed in a quantitative manner by installing Matlab, detect the degree of difficulty of items and more accurate results. (Celik, 2020).

In order to understand the Fuzzy Analytical Hierarchy Process, another artificial intelligence technique used in data analysis, it will be appropriate to have information about the Analytical Hierarchy process first. The Process of Analytical Hierarchy is a method of organizing and analyzing complex decisions using mathematics and psychology. The Process of Analytical Hierarchy provides a rational framework for a decision that is needed by digitizing its criteria and alternative options and correlating these elements with the overall goal. In a traditional method of the Analytical Hierarchy Process, each binary matrix is evaluated separately, and then the weight vectors are combined with a geometric mean. But in the method of a fuzzy Analytical Hierarchy Process, all binary matrices are first combined using a predetermined set of weights, and then a single vector of weights is calculated at the end. In the study where Fuzzy Analytical Hierarchy is applied, Fuzzy Analytical Hierarchy is used when creating a strategy decision model in open, remote, and flexible learning environments. The data obtained from the focus group interview conducted with 12 experts using the Delphi technique were analyzed using a Fuzzy Analytical Hierarchy and a decision model was created (Karatop & Guler, 2021).

Moodle, e-learning is a learning management system that provides a platform for educators is a free software that various courses, curricula, course structures and significantly simplifies the interaction with the students and thus helps in conceptualization online. In the study using this platform, the researchers followed the homework submissions of the students via Moodle with data mining and interpreted the general situation of the students (Akcapinar & Kokoc, 2020). There are also studies that develop projects from scratch using artificial intelligence techniques. For example, the ArtiBos project has been developed to design, implement and evaluate a game-based adaptive intelligent teaching system that can improve students' problem-solving skills. The project has received a lot of attention, has become a large number of publications and has received awards. The computer-aided educational technology, and artificial intelligence techniques used in this project followed the learning processes of the students in a hierarchical manner; the routing made has been assisted in decision making, has been reviewed and identified their training needs, students ' errors are detected, the solution produced short has helped students in many ways. Another English English language learning project developed from scratch is a machine learning-based mobile English learning application developed to facilitate English learning and increase accessibility for non-native English speakers (Gungor et al., 2021). Like MIT App Inventor, the ArtiBos Project (Erumit, 2019), which originated in Turkey and was developed using artificial intelligence techniques and made available to students, has entered the literature as a proud work on behalf of our country.

ArtiBos, a game-based project developed on problems in mathematics, introduces students to the logic of problem-solving, records students' mistakes, individualized learning, and supports equal opportunity in education because it is accessible to students from all walks of life.

It was designed by Butuner and Calp (2022) to predict the academic achievements of students studying in the distance education process using artificial intelligence methods. The data were obtained from the education management system used in the distance education process belonging to the students studying in elementary, middle, and high schools. Due to the fact that artificial intelligence methods are an effective tool, especially in the classification and forecasting business, the academic achievements of students have been estimated as high, medium, and low. As a result, the results of the study showed that Deep Learning, Random Forest and Support Vector Machine algorithms provide prediction success at higher performance than other used algorithms. Nowadays, when studying artificial intelligence studies in education, one can see different applications in which not only information-based, but also data- and logic-based artificial intelligence and artificial intelligence applications are involved in almost every field. Among these personalized dialogue education or education systems, exploratory Education, Education data mining in the analysis of the articles students, intelligent agents, chatbots, for children with various special needs education, child-robot interaction, artificial intelligence-based assessment systems, automatic test systems, creating is located. If attention is paid, these areas are mostly related to supporting learning. However, artificial intelligence in education also supports schools and universities from an administrative point of view. For example, course programs, personnel programs, exam management, cyber security, facility management, and security are areas where artificial intelligence contributes directly to school management and indirectly to teaching (Holmes et al., 2019).

Intelligent Instructional Systems, which can be considered the second generation of computer-aided Dec, are among the most widely used applications of artificial intelligence in education. In general, Intelligent Instructional Systems provide personalized learning environments that are appropriate for each student through well-structured topics such as medicine, mathematics, or physics and are conducted step-by-step (Alkhatlan & Kalita, 2018). The first example of intelligent instructional systems is SCHOLAR. The basic pedagogical approach of this system is based on the principles of Socratic dialogue. Using artificial intelligence techniques, the SCHOLAR creates a structure from a semantic network (here the semantic network can be seen as a way of representing geography knowledge, in which the semantically related concepts in the subject are interconnected), which gives individual responses to the student's answers (Carbonell, 1970).

In the study conducted by Butuner (2020) for the Guidance Service in schools, facial

recognition and emotion analysis on the human face were performed using the deep learning method (anger, disgust, fear, happiness, sadness, bewilderment, etc.) has detected feelings. According to these identified feelings, students who do not attend school guidance services are recognized and these faces have been published on the internet so that the guidance service can benefit from the system. As a result, it was ensured that students who had problems and did not have problems were followed up with daily emotion analysis.

Conclusion

Considering that computer and Internet technology is perhaps the most important turning point in terms of human history, artificial intelligence technology, which is just beginning to enter our new life, is both encouraging and alarming to humanity. This technology, which we are learning a new field of application every day, opens up new horizons for mankind in the cognitive field, the field that distinguishes man from all other living beings. The potential to affect all areas where there is a person naturally includes education.

In the study, artificial intelligence studies conducted in the field of education were examined. Educational management of artificial intelligence techniques, teaching techniques, material design, etc. can be seen that it appears in many of its operations. In addition, it is seen that these artificial intelligence studies increase the quality of education and provide continuity. With the rapid progress of technology, artificial intelligence studies will increase both in education and in many fields, and with it new teaching techniques, material designs, educational methods, etc. it is expected to develop rapidly in the following areas. With this study, artificial intelligence studies in the field of education have been examined and it is expected to serve as an example for other studies to be carried out.

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CHAPTER 7

Damage Analysis Using Artificial Intelligence Techniques on Composite Materials

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Damage Analysis Using Artificial Intelligence Techniques on Composite Materials

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Introduction

Depending on technological progress, the definition of Artificial Intelligence (AI) varies. AI can be expressed as enabling a computer or robot to do human-specific tasks. This term is used for the development of systems that humans are able to process such as reasoning, meaningful action, situation tracking, or learning from past experiences (Copeland, 2022). By using data, AI facilitates our work by conducting the general tasks that humans generally do. Therefore, artificial intelligence; The voice assistant can offer higher quality, more precise, and faster solutions in translations, consultancy suggestions, location finding, social and cyber security, health services, e-commerce, robot assistant, defense industry, and industrial applications. The means of accessing information are everywhere in our lives. “Data” constitutes the most essential part of the training of artificial intelligence. The efficiency of AI increases as the size, volume, and functionality of data increases. Today, data production has reached incredible dimensions, and the available data and the technological infrastructure required for processing data are also very advanced; Accordingly, AI solutions have reached high efficiency. However, the inadequacy of traditional data processing techniques brings "Big Data" and its solutions. Data volume, speed, and data diversity constitute the main components of "Big Data” which enables us to conclude the processes that would be impossible or inefficient without it, faster and more efficiently. The main areas of use of AI can be listed as follows. Image Processing, Voice Processing, Text Processing, Data Processing, Health Data Analysis, and Treatment Planning, Unmanned – AI Assisted Driving (autonomous) Systems, Insurance and Finance, Big Data Analytics, Smart Applications in Agriculture and Livestock, Cyber Security, Industrial applications, Like Damage Analysis. Like every developed technology, AI applications can be used for different malicious purposes. AI; The use of personal and security data during training may cause different problems if the data is collected illegally. No technological development is scary, provided that ethical, moral, and confidentiality rules are adhered to.

'Data' constitutes a foundation for AI and machine learning (ML). It is the value of qualitative or quantitative variables about persons or objects. Algorithm; It is the process of problem-solving or reaching a result more quickly and effectively by applying well-defined rules and procedures step by step. ML is a branch of data analysis methods that automatically creates an analytical model. It is a sub-field of AI and the idea that systems can be trained by data and take decisions while requiring minimum human intervention constitutes its base. Deep learning is classified among machine learning methods that are developed for computers to perform higher cognitive actions. It is the use of neural networks consisting of many artificial neural layers. Deep learning is the most important element behind image-based AI applications, especially autonomous vehicles (Ballard & Brown, 1982; Sonka et al., 2008; Vandoni, 1996). In Cognitive Science, the processes of the human brain such as information processing and decision making are being studied. Inventions in Cognitive Science are very essential for the computer to think like a human as the main focuses in this field are decision making, processing of information, etc. AI application is generally maintained in the open source ecosystem. Therefore, there are many programming languages, libraries, and application environments. These languages are; Python, C++, Java, C sharp, etc. Libraries are TensorFlow, PyTorch, Knet, Apache Spark, OpenCV, H2O, etc. The types of equipment used are; CPU, GPU, FPGA, ASIC, and TPU. No matter how AI applications evolve, the majority of professions will need human participation. Consequently, the expectation of different new business areas created with AI will emerge is very logical. In addition, AI provides reliable solutions at critical points such as malware analysis or detection in cyber security. AI applications are created especially for the field. These applications are used as decision-making aids, not decision-makers.

AI Techniques

Today, the drawbacks of the rapidly developing technology on people resulting from industry breakthroughs and its negative effects on humanity have been reduced. The developments that are aimed for the protection of the comfort and health of humanity together with inventions and discoveries resulting from industrial breakthroughs should not be ignored. Researchers have tried to design an automatic human model that works with the least error to achieve maximum efficiency at every stage of production. AI has sub-branches such as problem-solving, fuzzy logic, robotics, expert systems, and artificial neural networks (ANNs), and each sub-branch studies one of the human behavior and thinking methods as a principle (Di Scalea et al., 1999).

Machine Learning

Machine learning (ML) algorithms are advantageous tools for structural state monitoring because they can automatically weed out patterns in datasets after they are properly trained. Especially, ANNs are used to handle damage identification problems that can be

differentiated into "healthy" or "damaged", which are typical examples of binary learning. A neural network capable of applying dual learning can be modeled by following two approaches: Discrimination-based learning and Recognition-based learning. The first method is about training the network using both 'positive' and 'negative' samples and enabling it to differentiate between the two; meantime in the later, training is done using only 'positive' samples and can only recognize them (Japkowicz, 1999).

Deep Learning

After its success in ImageNet, a large-scale visual recognition competition held for object classification, in 2012, Deep Learning (DL) became widely noticeable. The primary reason why DL is prominent is that there is an adequate level of data for training, and secondly, there is a hardware infrastructure to process this data. The algorithms that train DL models used in the complicated tasks today are similar to the learning algorithms used to solve toy problems in the 1980s but have made changes to the models prepared with these algorithms that simplify the training of very deep architectures. In addition, another important development today is to provide these algorithms with the necessary resources required to be efficient. Data, which is the first of these resources, is provided by the increasing digitalization of society. With the increase in activities performed on computers, more transactions are recorded. As computers become more networked, it has become easier to centralize these records and turn them into a dataset suitable for machine learning applications. Deep learning, image and sound analysis, robotics, autonomous vehicles, gene analysis, disease diagnostics, virtual reality, etc. have been used in various fields. The biggest reason for this degree of prevalence is the high accuracy achieved in solving problems. Indeed, some problems such as sound and image processing have exceeded the human level. Deep learning was used to colorize images and pictures taken without color. In a silent video, based on the prediction of speech by imitating the lip movement of people, the silent video was voiced with deep learning. While the success of people who guessed by reading the lip movement was 52%, the success rate in this study conducted with deep learning was 93%. Obtaining a picture in a sketch, the shape of an object from a drawing, or a real map from a map sketch has become possible with deep learning. Recording of images used by large corporations such as Facebook and Google, object identification, and classification of images were carried out with deep learning models. In the study, the movements in the human skeletal structure were modeled in two dimensions and the conversion of normal writing to handwriting was carried out with deep learning. It has been used with a deep learning structure to voice a text that people have never spoken by synthesizing their old speeches in a way to read it live. These studies have also been extensively used in voice identification, natural language processing, and robotic applications (Inik & Ulker, 2017).

Fuzzy Logic

Experimental studies are very important for designers in solving engineering problems in industrial applications. These studies involve many disadvantages such as time and cost requirement and non-standard environmental conditions. Thus, with the developments in computer technology, various analysis programs that have become widespread and accepted industrially or computer software developed for very specific problems to be examined are used. Fuzzy expert systems, one of them, make reasoning by using numerical operations instead of symbolic reasoning, unlike traditional expert systems (Zadeh, 1983). With its use in expert systems, efficiency increases and turnaround time decreases (Zimmermann, 1996). Statistical methods in damage analysis is also another field where it can be applied. However, studies have shown that the fuzzy expert system delivers better results. It is concluded that computer-aided analysis studies save time and waste no material. (Balli & Sen, 2014).

Fuzzy expert systems are used in linear and non-linear control, sample recognition, financial systems, business research and data analysis, etc. Many systems can be modeled and copied with the help of fuzzy systems. Today, it is seen that fuzzy logic has become quite widespread with projects and research around the world. Some of these are fuzzy logic control systems for mining in deep seas, sample identification using fuzzy logic and genetic algorithm, zooming criteria for fuzzy modeling, sample identification in medical imaging, event detection based on fuzzy logic for intelligent path control. Fuzzy logic is emerging as a useful tool for home management-specific entertainment electronics, diagnostic systems, and other expert systems, as well as for the control of dark zone systems and complex industrial processes. Fuzzy has become a keyword for marketing. Electronically created articles that do not have a fuzzy component are gradually excluded. Fuzzy logic research in Japan is supported by a huge budget. In Europe and the USA, many efforts are being made to capture the extraordinary achievements of the Japanese. For example, NASA space agency is trying to apply fuzzy logic for complex docking maneuvers (Forsyth & Ponce, 2003). Your fuzzy logic;

- Being close to one’s way of thinking,
- His practice does not need a mathematical model,
- Its algorithm is simple, so it costs cheap, its advantages,
- Dependence of the expert on the creation of the rules in practice,
- It may take a longer time because the membership functions are found by trial and error method,
- The difficulty of performing the stability analysis is; are the disadvantages

Artificial Neural Networks

They are information processing systems inspired by the way how human brain works and the Artificial Neural Network (ANN) established by the combination of artificial nerves. ANN consists of artificial nerve cells interconnected in various ways and is usually arranged in layers. It can be produced with electronic circuits as hardware or as software on computers. Each neuron in this network has main parameters, namely input (dendrite), output (axon), connections (snaps), and cell nucleus.

We can list some applications of ANN in the industry:

- Production: Automation of robot and control systems, production and quality control, part selection in assembly.
- Medicine: Voice analysis for the hearing impaired, diagnosis and treatment of symptom diseases, surgical imaging, analysis of side effects of drugs, reading x-rays
- Military: Processing radar signals, developing new and advanced weapons, reconnaissance, optimizing resource use, target identification, and tracking.

Extraction of ANN Models:

- The network structure
- To feed forward and backward
- Whether the weight matrices are symmetrical or asymmetric and their values are constant or variable,
- The node characteristics in the network,
- Whether the threshold function used is analytic or stochastic,
- To the node, only analog / secondary or continuous values can be applied,
- Education or learning rules; it depends.

Artificial neural networks have many uses. Some of these are classification, clustering, prediction, pattern recognition, function approach, and optimization. Artificial neural networks are a powerful technique because of their non-linearity, ability to learn and generalize, adaptability, low error tolerance, and speed. In particular, the low tolerance for errors and the rapid resolution of problems. makes artificial neural networks one step ahead of other algorithms.

AI solutions are a set of algorithms applicable to perception and cognition that involve training by the data and experiences that mimic human intelligence and abilities. Convo-

lutional neural networks (CNNs) are deep ANNs mainly used to classify and cluster images and perform object recognition. These algorithms can detect human faces, people, street signs, tumors, platypuses, and process many other aspects of visual data. Keeping that in mind, as a reference to detect damage areas of a car and classify the damage level, CNNs can be used. It uses object detection and classification models such as no damage, light damage and heavy damage together to measure the damaged area and level by processing images. Hence, it can be used successfully in vehicle damage analysis for the insurance market. (Di Scalea et al., 1999).

Genetic Algorithm

A Genetic Algorithm (GA) is a search model modeled on the mechanism of change in nature. The method is used to separate specific data from the general data set. In the early 1970s, Holland introduced GA. Genetic algorithms are a probabilistic search method.

- Optimization: It is used in genetic algorithms, circuit design with numerical optimization problems, solution of nonlinear equation systems, and factory/production planning.
- In machine learning: Genetic algorithm is used in robot sensors, neural networks, chip design, and protein structural analysis.
- It is used in elevator control systems.

Expert Systems

It has contributed to the science of management and expanded its boundaries by enabling the analysis of unstructured problems. Expert systems can only be used by an expert.

A solution can be reached that can not be solved by a human. They are computer programs that are equipped with a piece of particular knowledge and that can provide solutions to field problems as any expert can find. The reason why the term expert system is used here is that the system tends to take the place of one or more experts by knowing. The aim here is to develop an expert system like or better than an expert person. Although obtaining such a system does not necessarily mean one becomes an expert, but enables them to complete a part of or all of the work of an expert through the system. In general, such as product design, process planning, medical treatment, quality control, sound detection, image recognition, robotic applications, design probability, signal analysis, configuration training, aerospace engineering, medicine, agriculture and other engineering designs, computer-aided design systems. It provides the data flow for routine work, keeps it under record, and allows it to be controlled.

Advantages and disadvantages:

- Explaining how and why a conclusion is drawn

- Third parties can easily change expert systems by producing new rules.
- Finding an expert who can give the information to the expert system may not be easy.
- Experts may not state their knowledge in rules.

Usage areas:

It is used extensively in areas such as product design, production planning, medical, treatment, quality control records, sound processing, image recognition, robotic applications, error correction, and educational software (Zimmermann, 1996).

Ant Algorithms

The ant colony optimization algorithm is created to obtain the closest optimal solution for optimization problems involving combination calculations. The areas where these algorithms are applied:

- Robotic applications
- Sales-marketing Problems
- Traffic management
- Telecommunications

Image Processing

Today, the applications of AI methods in engineering disciplines are becoming highly popular, bringing solutions to engineering limitations and creating alternative methods and techniques to the ones that are used today. The image processing technology is one of the AI methods. Image processing includes many processes such as obtaining, digitizing, and improving the image. Civil engineering is also one of the fields in that Image Processing technology is utilized widely. There exist various studies, especially on concrete technology and material science. An analytical model is created on the digitized image by combining image processing and ANN. Using image processing and ANN together gave more meaningful results in measuring the compressive strength of concrete compared to other non-destructive methods. Therefore, the image processing mechanism can be regarded as an alternative analysis method (Cankaya et al., 2013).

The ability of a computer to extract meaning from images is referred to as Computer Vision. Security, defense, health, and industrial production are some of the areas in which this method has been applied. This is an interdisciplinary field dealing with making sense of digital images or videos. With engineering methods, serves to process and continuously run the tasks that the human action system can do. Computer vision tasks

involve taking, processing, and analyzing digital images to produce digital information. (Klette, 2014; Morris, 2004; Shapiro & Stockman, 2001).

The scientific discipline of computer vision is concerned with the scientific knowledge behind artificial systems that extract meaningful information from images. Image data; videos can be in many forms, such as images from multiple cameras, multidimensional data from a 3D scanner, or images from an industrial image scanning device. It is necessary to integrate the technological disciplines, theories, and models of computer vision into computer vision systems. The fields of object detection, event detection, video surveillance, object recognition, learning, motion prediction, automatic image creation, and image repair can be listed under the Computer Vision field.

AI Applications in the Industry

- Electronic control systems, decision making, process planning (Fuzzy logic)
- Composite cable laying, circuit design: (Genetic algorithm)
- Optimization: It is used in genetic algorithms, circuit design with numerical optimization problems, solution of nonlinear equation systems, and factory/production planning.
- Transportation automation: For example, precise logic and expert systems can be used in autonomous vehicle driving techniques and signaling.
- In the repair and design of complex electronic and electromechanical systems.
- Design and fault finding of computer and communication systems.
- Many applications related to space (expert systems)
- Search Engines (Yahoo, Google…) (expert systems)
- Routine day trading robots (expert systems)
- Applications in the fields of telecommunications, image and information comparison, automatic information services, multiple translations, consumer payment systems
- Electronics: Code sequence prediction, assembly and repair of chip circuits, voice synthesis, non-linear modeling
- Industry: Process control in industry, product design, and analysis, method and machine learning, part identification, surface quality inspection systems, quality control in welding production, paper quality control, computer chip quality control, grinding methods analysis control, chemical product design analysis, machine maintenance analysis, cost planning and management

- Estimation of gas volume produced by furnaces in an industrial process
- Ability to work with the voice on mobile phones
- It is applied greatly in the areas such as online carbon flow measurement and waste gas management for coal power stations.

Sensors Used in Industry Applications of AI Technology

Sensors give automatic devices the ability to investigate and analyze events around them through sight, touch, and other senses, and as a result act more intelligently. Image sensors (Vision Sensors) are used for part recognition and part measurement. Some sensors measure temperature, power, and shape.

Sensors serve for controlling, protecting, and inspecting industrial processes. They are tools that convert measured physical properties, quantities, and conditions into usable electrical data. There are mechanical, thermal, electrical, magnetic, radiation, and chemical sensor versions (Bozuyuk et al., 2005).

Damage Assessment Applications in Composite Materials

Damage is a term to define a phenomenon that harms normal functioning and changes material performance. Machine learning-based structural condition investigation in composite materials requires the identification of different damage-related indicators based on the data and its unique properties. Damage diagnosis is a well-known engineering problem. Eliminating critical aspects of damage is essential for the efficiency of the ML method. However, machine learning tools are critical for such damage to any structural system (e.g. aerospace, petrochemical, etc.). As composite materials became very popular in certain sectors, the need for early error assessment has arisen by using artificial neural networks. Composite materials have various types of complex damage due to their heterogeneous nature such as interlayer porosity, delamination, fiber disorientation, matrix cracking, and crushing and voids (Smith, 2009). The visual methods can neither detect the onset nor the development process of damage in composite structures due to the complexity issues. Early detection of faults is what most studies aim for. Considering this, the expectation that the usage of AI techniques will be a very important method for damage assessment is very rational (Patro et al., 2021).

In damage detection mechanisms, the method requires measuring every change in structure that is intended to be used to build, train, and test ANNs. After the training phase, the interrelationships between the changes that represent the ‘fingerprint’ of the studied structure are analyzed by networks. The differences in the distribution of these changes are captured by evaluating the differences in the variance correlations previously defined. Any damage situation that changes this distribution is considered an important reason for this further investigation (Califano et al., 2020). Convolutional neural networks are

also successful in civil engineering applications and fatigue analysis of aircraft structures (Oh et al., 2019).

Fiber Reinforced Composites

Today, the usage of polymer composites as engineering materials became a general trend. Designing the properties of polymer composites is its most important advantage. It can be designed by choosing the right compound and the correct manufacturing process to meet a specific goal of engineering practice. Some basic parameters in the production process, eg. The curing temperatures and production rate that govern the final quality of the composites must also be analyzed. Modeling the relationships between fatigue, wear, combined loading, and creep) often involves the creation of a mathematical tool from experimental data; once established, it can substantially lower the experimental burden in the designing process of new polymer composites (El Kadi, 2006).

Composite materials have enormous applications in various fields. Thus, obtaining an efficient damage detection method to prevent permanent damage is highly crucial. It is critical to consider all damage types as there exist multiple damage modes and the data is available in different formats. Deep neural networks are capable of solving similarly complex problems. The specific objectives developed for this are 1) to assess the performance of image coding algorithms, 2) to classify damage using data from individual samples, and 3) to classify damage using mixed data from multiple samples. Efficient structural health monitoring (SHM) strategies must be employed to reduce maintenance costs and prevent the permanent failure of composite structures. This method is a heated topic that has been greatly researched in recent years. Structural health imaging methods use data transmitted by a network of sensors attached to the structure to determine the damage status (H. Liu et al., 2017; Molchanov et al., 2016). Fekrimandi et al. (2016), proposed a methodology based on multilayer perceptron and radial-based functional neural network parsers to detect ultrasonic waves in plates as the charge on composite plates. Unlike traditional methods, deep learning algorithms such as Convolutional Neural Networks (CNN) do not require manual material feature extraction and are widely used in classification problems involving signals that are difficult to detect (Zhao et al., 2016). In composites, the damaged area consists of matrix cracks and interlayer delaminations. Considering the overall damage area for analysis, delamination plays the most important role in damaging composites. Because composite materials have different failure modes, such as fiber cracking and delamination, it is important to consider multiple damage detection or measurement techniques. Thus, more efficient damage detection performance can be achieved by combining these measurements using data fusion and a convolutional neural network. Therefore, data aggregation techniques, when combined with a deep neural network, can resolve the complexity of damage classification in composite materials with multiple damage modes. (Dabetwar et al., 2020).

The artificial neural network has recently been used in the fabrication processes of fiber-reinforced composites and in observing and modeling their mechanical behavior. A recent study by Zhang and Friedrich (2003) observed the applicability of neural networks to polymeric composites, polymers, metals, and other materials. Hajela (Hajela, 2002); In his study, he discussed the applications of ANNs towards the mechanical properties of fiber-reinforced polymeric composite materials in the multidisciplinary field of aviation. In experiments on pultruded glass-epoxy composites, material temperature is the input of the neural network. The results were similar for the load-longitudinal strain and load-transverse strain curves for the glass-fiber composite. The temperature compensation is independent of the structure material under test and depends only on the thermal properties of the strain gauge. Lee et al. (1999), performed biaxial tests on cross-ply composite tubes made of T300 carbon/epoxy. Damages were estimated using Tsai-Wu and optimized tensor polynomial theories. Comparing the results with the findings of Artificial Neural Network, it became clear that ANN had the smallest error rate of the three methods used., Stone and Krishnamurthy (1996) presented a neural network thrust controller to minimize this problem. Delamination monitoring of composite laminates with the help of ANNs was also investigated by Todoroki (Todoroki, 2001). The detection of cracks or defects in composite materials is extremely important considering the recent growth in the applications of composites in various engineering operations. Although conventional ultrasonic techniques are used for this, damage detection has been challenging as the measured signals, the inhomogeneity of the material, or the reflection of many waves from different laminate interfaces in the composite plate. Some studies analyze this issue. For example, Al-Assaf and Al-Kadi (Al-Assaf & Al-Kadi, 2001; Al-Kadi & Al-Assaf, 2002) investigated fatigue life prediction of fiberglass/epoxy laminate using neural networks. In the first study (Al-Assaf & El Kadi, 2001), the usefulness of using neural networks to predict fatigue damage was investigated and they concluded that its use is appropriate. The damage analysis for carbon/epoxy nano-reinforced composites was done using the artificial neural networks method. It is concluded that ANNs are a high assumption method. From these examples, it is understood that various methods are used in the damage estimation of composite materials (Lee et al., 1999).

Applications in Medicine

In the systems of medical diagnosis, satellite image analysis, license plate, and face recognition, the detail is very crucial. The spread of deep learning and the introduction of convolutional neural networks necessitated super-resolution. Thus, super-resolution methods with deep learning based became very popular in the literature. (Shapiro & Stockman, 2001).

Buckling Load Analysis

Numerical analysis methods such as boundary elements and finite differences are used effectively today. With the achievements in computer technology, different analysis techniques had emerged. For example, AI application is utilized in industry, medicine computer, economy and military fields, and structural engineering. Axially loaded columns are designed considering the buckling loads they can carry. A multi-layered mesh structure is constructed that gives the buckling load of the axially loaded columns for various support conditions. A back propagation training algorithm was used and the results are of high sensitivity (Zhang & Friedrich, 2003).

AI in Creep-Fatigue Loads

ML framework can be utilized to examine the probabilistic damage distribution under the creep-fatigue interaction. This type of probabilistic damage assessment has significant potential in creep-fatigue life design for material safety (El Kadi & Al-Assaf, 2002). The main factors that alter the mechanical properties of materials and structures are Long-term complex load and extremely high temperature (Dasgupta et al., 1992). In such a case, creep and fatigue damage accumulates gradually, and the material is damaged when the allowable damage exceeds its critical value. (Robinson, 1952). As a result, the accumulated creep and fatigue damage to fracture for the material also indicates scattering. (D. Liu et al., 2016).

Acoustic Emission Technique

The acoustic emission (AE) technique has become a well-known method for monitoring structural health. The detection and analysis of elastic Acoustic emission waves, including piezoelectric plate active sensors (PWAS) and time and frequency analysis, are effective in obtaining information about fatigue cracking. However, (i) the relationship between fatigue crack length and Acoustic emission signal traces and (ii) AI (AI) methodologies detecting Acoustic emission wave analysis are remains topics that require mentioning. To figure out the effects of acoustic emission waveforms on fatigue crack length, a finite element model (FEM) and convolutional neural network and acoustic emission signals are used together in the same crack. Hence, it was possible to predict the acoustic emission signals match the finite element simulations with a high accuracy level is a possibility. AI is a highly efficient way to predict fatigue crack length considering the accuracy level.

Safety and reliability are extremely important for engineering structures still in service. There are possible failure mechanisms in all environmental and mechanical conditions that engineering structures are exposed to. Metal fatigue includes fatigue, static failure, and friction damage based on mechanical loading and environmental conditions. As structures subject to fatigue continue to increase in current and future engineering

applications, a robust and efficient method to monitor their structural integrity of any kind during use is needed (Garrett et al., 2022). The field of structural health monitoring (SHM) is a rising methodology for detecting modes of damage, such as fatigue damage, in these structures (Catbas et al., 2008; Su et al., 2006). The general concept is that when energy is released from a fatigue crack, it resonates with the crack, forming a standing wave pattern. The wave model contains frequency information about the resonant frequencies of the crack. Using this understanding, and AI signal analysis system is proposed that can distinguish the acoustic emission wave information and predict the length of the crack from which it originates. This system will provide significant advantages in terms of periodic maintenance in various industries and engineering structures. AI competencies have been similarly researched and used in recent years. Tang et al. (Kabaldin et al., 2020) and Xu et al. (Xu et al., 2020) used machine learning clustering techniques to detect fracture modes in fatigue-loaded wind turbine blades, respectively. In the active control of structural systems, there are studies on the application of neural networks for the acoustic emission properties of composite smart structures Lee (Lee et al., 1999).

In polymer composites, enabling the network to solve material problems requires experimental data in large amounts. However, when this process is finalized, when the network is able to solve material problems, the need for more experiments for the network disappears, a new and smaller data with similar effects can be predicted.

AI in Impact Loads

The impact has one of the most dangerous effects on fiber-reinforced composites. Chandrashekhara et al. 1998, by training ANN with the findings of the finite element analysis, analyzed the impact reaction of the composite plate. In the study, finite element analysis and a neural network is used to calculate the strain state and contact force for the low-velocity impact (El Kadi, 2006). Recently, ANNs became a mainstream method to model the mechanical behavior of fiber-reinforced composite materials. Designing structures and components using recently developed composite materials often requires extensive (and expensive) test programs.. Ideally, using a small dataset of the test results, the designer can accurately measure the performance of the new, or existing material under untested conditions. (El Kadi, 2006).

Situations, where material compositions and test conditions are used as neural network inputs, are ideal for polymer composite design. It is expected from a well-trained ANN to be helpful in estimating material properties before designing/testing real composites before producing them. ANNs can be helpful in simulating relationships between material performance and production parameters, which can be used to create a ground for computer-based production optimization. Analysis of the relationships between some simple properties and complex properties will be very helpful when designing new composite materials. Ordinary features are normally easier to obtain than complex ones, and

therefore a successful prediction can be useful to mitigate the amount of complex experiments. The required number of training data can be reduced by optimizing the neural network architecture and choosing the appropriate input parameters. (Lefik et al., 2009).

Modern information approaches are used to check the level of damage detection based on fractographic images of materials. It is possible to construct frequency wave transform and convolutional neural networks and use the fractal dimension to assess the share of viscous and fragile results on damages. Fractal dimension, a value that identifies fractal structures or clusters based on assessing the level of the complexity, is one of the tangible indicators of metal structure and fractures. Today, the fractal dimension in image structures are explored by many programming languages. Detecting changes in refractive images or material structures is essential for accurately detecting fractal dimensions. Likewise, the crucial part in the assessment of microimages of material structures is the determination of the grain separation boundary. Today, ANNs are increasingly used for image description and classification. It is highly popular to use ANN and wavelet analysis in the examination and evaluation of the viscous and brittle fracture ratio of the specimen fracture surfaces after the bending test. This will increase the degree of use of fractography in the analysis of fractures and determine the direction of its destruction, and most importantly, it will eliminate the human involvement in computing the ratio of viscous and brittle components in the fracture. Also, it is essential to train ANNs on a wide range of fracture surface statistics. To detect the fractal size, operations can be performed by covering the digital image with a square cell mesh. Impact and bending tests can be performed for numerical analysis of metal fractures. Fractal dimensions can also be measured from the fractures of the samples. It is usual for the fractal dimensions of sample fracture to decrease relatively with increasing toughness. Studies using artificial neural networks where the fracture surface recognition error does not exceed 8%. This gives hope for the applicability of this method.

AI in Dynamic Mechanical Loads

The dynamic/mechanical features of short fiber reinforced composites were examined by Zhang et al. (Zhang & Friedrich, 2003). The storage modulus corresponds to the stiffness of the material under dynamic loading. High stresses induce microcracks that contribute to frictional damping. In fiber composites, different material components contribute to storage and damping properties in different ways. Although the increaed level of carbon fiber in composite material gives higher storage modulus, it also decreases the damping factor. The damping of polymer matrices varies with temperature, and a poor interface between the filler and the matrix will certainly increase the damping without a strong temperature dependence. Tensile, creep and relaxation tests were carried out using a PR2032 epoxy reinforced with fiberglass, carbon, and aramid, produced by the composite, laminate hand lay-up method, using a thermal chamber at different tempera-

tures. Hence, satisfactory results can be obtained by evaluating all data with an artificial neural network. (Al Qadi, 2006).

Tribological Properties

Machine elements work under the effect of friction and wear. This necessitates lubrication and maintenance. The subject falls within the field of tribology. Two models are used in the tribological data analysis: empirical and phenomenological models. In the first, numerical relationships between tribological variables are assumed as predictions. In phenomenological models, numerical relations between tribological variables are used in continuum mechanics, fracture mechanics, thermodynamics, etc. It is developed from basic equations. The analysis of practical tribological experiments has been dominated by empirical models.

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CHAPTER 8

Applications of Artificial Intelligence in Microstructural Characterization and Optimization of Metallic Materials

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Applications of Artificial Intelligence in Microstructural Characterization and Optimization of Metallic Materials

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Introduction

Almost every field of research and engineering-including materials science-is being deluged with enormous volumes of data from a wide range of sources (experiments and simulations) at a startling rate. Due to this, the fourth paradigm of research-data-driven science-has emerged. It builds on the enormous data that the first three paradigms of science produced (experiment, theory, and simulation). To examine these data in a way that can contribute to expediting the discovery of new materials and achieving the goals of the Materials Genome Initiative (MGI), advanced approaches for data-driven analytics are required. The fourth paradigm of science makes use of scalable machine learning (ML) and data mining tools to draw conclusions that can be put into practice from such large amounts of data and guide materials design initiatives at various levels (Agrawal & Choudhary, 2019).

Because it enables the simultaneous establishment of a relationship between the structure, method, and qualities, predictive materials modeling has grown in importance as a research area (Agrawal & Choudhary, 2016). Realizing the best material quality is crucial for aerospace applications since the need to use the material for lower fuel consumption, lower process costs, and increased mobility is constant. Crystallographic slip and lattice rotation are two mechanisms that cause the generation of texture and variability in property distributions in such materials during forming processes. Controlling the deformation processes that result in the production of textures with appropriate property distributions is a valuable technique for developing materials (Acar, 2019).

The following sections explain the use of artificial intelligence in materials science with an emphasis on the current studies. The sections have different titles grouped as microstructure recognition, microstructure optimization, and prediction of mechanical properties of metallic materials.

Microstructure Recognition

Elemental composition

ElemNet, a brand-new deep learning network created by Jha et al. (2018), predicts the formation enthalpy of crystalline compounds using just their elemental composition as input. To create the deep learning model, they employed a sizable simulation dataset of DFT computations from the Open Quantum Materials Database (OQMD). The set of 275,759 chemicals and their accompanying formation enthalpies formed the dataset. To test how well a model can function in such a scenario, the authors purposefully did not give the model any domain knowledge. Up to 24 layers, they investigated the fully linked neural network at various depths. Up until layer 17, when the deep learning model

reached a plateau, accuracy increased quickly. Both with and without physical features, ElemNet, the top-performing 17-layer neural network, outperformed conventional machine learning techniques. When utilizing solely elemental compositions as features, the top performing classical ML approach, Random Forest, produced a mean absolute error (MAE) of 0.157 eV/atom and 0.071 eV/atom when using composition-derived physical characteristics as input. ElemNet, which only accepts elemental compositions as input, was found to provide an MAE of 0.055 eV/atom, which is a substantially lower value. ElemNet outperforms Random Forest model (even with physical attributes) for all training set sizes more than 4000, according to modeling studies, which is another example of the superior performance of deep learning models on huge datasets. ElemNet was much faster for prediction time, but it took significantly longer for training.

Crystal structure

A CNN framework for crystal graphics was developed by Xie and Grossman (2017) to learn the properties of materials directly from the bonds between atoms in crystals. In their method, the crystal structure is first displayed as a crystal graph, with nodes representing atoms in a unit cell and edges representing bonds that bind atoms. CNN is then built graphically using convoluted layers, fully connected layers, and grouping layers to automatically extract the best views for modeling the desired properties. Their database contains 46,744 materials with 87 elements, 7 grid systems and 216 spatial groups from the Materials Project (Jain et al., 2013). To predict the formation energy, a simple convolution function with a common weight matrix for each neighboring atom produced an MAE of 0.108 eV / atom. Because they did not consider changes in the strength of interactions between neighbors, they created a new convolution function that does this in the form of a weight training matrix. This led to a significant improvement of the MAE of 0.039 eV/atom. Other DFT calculation parameters in the Materials project received the same structure.

Microstructure characterization

One of the primary procedures to increase our understanding of material is materials characterization, which broadly refers to discovering structural information about a particular material. A proliferation of material image data as a result of advancements in material characterization technologies at various time and length scales, including various types of microscopy, spectroscopy, and macroscopic testing, has inspired the use of deep learning to address this inverse characterization problem (Agrawal & Choudhary, 2019).

Although microstructural characterization is crucial and well acknowledged, classifying it is difficult to undertake. Despite the rapid advancement of digital photography and computer systems, specialists still “manually” assess a given image of a structure to classify its microstructure. In situations where there is a mix of different phases with different substructures, classification can seem incredibly challenging. Any effort in that approach can be beneficial because there is no proof of computer systems that allow the automatic classification of microstructure (Mulewicz et al., 2019).

Microstructure image data can offer a unique perspective on the processes creating microstructures and the mechanisms behind material behavior and performance since they are rich in information about the morphology and suggested a composition of constituent phases. Thus, the study of micrographs (i.e., microstructure image data) is crucial for establishing processing-structure-property correlations and for developing new material systems in numerous materials science investigations. Despite the widespread use of micrographs in material science research, there are still substantial difficulties with reliable and consistent picture data interpretation. These difficulties result from the specialized knowledge and abilities needed to obtain micrographs, the various types of image data

that can be obtained (such as from optical and electron microscopy), the difficulties associated with particular domains for image analysis methods, and more. The use of known AI approaches to microstructure recognition and analysis brings up a possibility for computationally guided experiments and objective, reproducible analysis of picture data as AI (i.e., machine learning) advances in a wide range of domains (Ma et al., 2020).

Development of the model for two microstructural segmentation tasks: i Semantic segmentation of steel micrographs into four regions: intergranular carbides, spherical granule matrix, open grain regions and Widmanstaten cementite. and (ii) segmentation of cementite particles into a spherical particle matrix), DeCost et al. (2019) presents a deep learning solution for the quantitative microstructural analysis of high carbon steels. Because segmentation is a pixel-level operation, as opposed to image classification, a CNN must generate a latent representation of each pixel rather than the entire image. To achieve this, the authors used the PixelNet architecture, in which each pixel is represented by concatenating the representation of each convolutional layer by applying bilinear interpolation to the characteristic inter-pixel map and obtaining a characteristic hypercolumn vector for each pixel. The properties of the hypercolumn pixel are then mapped to the corresponding target or segmentation class using MLP. For the PixelNet convolutional layer, they used a pre-trained VGG16 network and trained the MLP layer from scratch using batch regularization, training, weight loss adjustment and data growth. The basic function of the cross-entropy classification loss and the extension of the focal loss of the cross-classification loss function were investigated using modulation factors and scale parameters to take into account the model reliability and class imbalance, respectively. The data set consisted of 24 micrographs of high carbon steel with a resolution of 645 x 484. Cross-validation was used six times to assess the segmentation accuracy of the model and to compare the actual and predicted particle size distributions and the width of the unclosed region. The segmentation model with concentrated loss functions proved to be the most accurate for spheroid and particle segmentation. Because the model could not recognize particles smaller than 5 pixels in radius, most of the predicted particle size distributions proved to be different from the annotated human micrographs, indicating the need for a high quality input for training. However, their study showed that deep learning is effective for microstructure segmentation and quantitative analysis of complex microstructures with a high level of abstraction. Fig. 1 presents the combined prediction of the microstructure of the particle model and the abstract microstructure model.

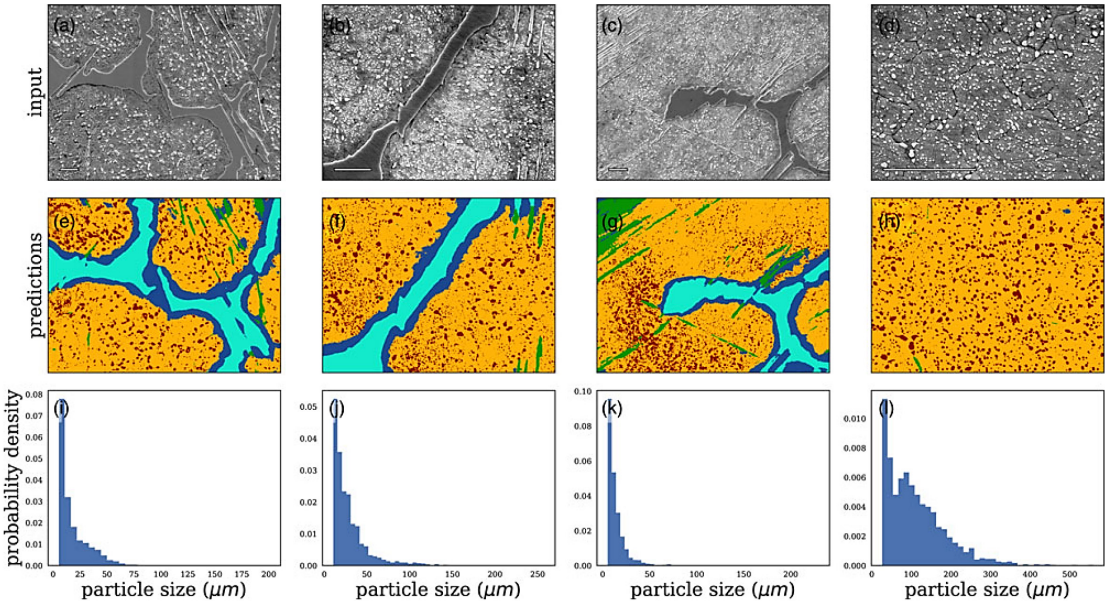

Figure 1. a - d: Micrographs with (e - h) validation set microconstituent predictions and (i - l) derived PSDs obtained by applying the particle segmentation CNN to the semantic microstructure segmentation dataset. Scale bars indicate 10 μm (DeCost et al., 2019)

To categorize steel microstructures, Mulewicz et al. (2019) applied methods from the rapidly evolving field of image analysis based on artificial intelligence, specifically deep learning. The development and application of Deep Convolutional Neural Networks (DCNN) for the categorization of various steel microstructure pictures obtained by light microscopy was the main focus of their research. The neural network was trained using the back-propagation method and the gradient descent optimization technique. Their findings demonstrate that the sophisticated Deep Convolution Neural Network-based system may be used to classify various low alloy steel microstructures.

For automatic microstructure recognition, Chowdhury et al. (2016) used computer vision (CV) and machine learning (ML) techniques. The techniques involved recognizing an important microstructural feature (dendrites) from micrographs that don't have it (just as a human expert would identify that a micro-graph contains dendrites). This challenge of recognition is known as Task 1. Dendrites are a sort of microstructural feature that is not unique to a material system, making Task 1 a high-level microstructure recognition task. It was also accomplished to discriminate between the longitudinal and transverse cross-sectional images of dendritic microstructures (known as Task 2). If Task 1's micrograph was determined to be a dendritic, a second binary classification task was carried out with the intention of differentiating between two distinct cross-sectional views. There were a total of 528 and 188 photos in the data sets for Tasks 1 and 2, respectively. To represent micrographs as feature vectors, approaches for feature extraction and dimensionality reduction were used. Support vector machines (linear and non-linear), voting, nearest neighbor, and random forest models were then used for classification. The classification accuracy for complete and reduced feature vectors, as well as for each feature extraction and selection technique examined, was calculated for each model. Their findings showed that pre-trained neural networks accurately depict micrographs without the need to know the characteristics of the objects or shapes in the images. Additionally, most classifier and feature selection approaches studied showed the highest classification accuracy when pre-trained neural networks were utilized in the feature extraction. Pre-trained neural networks are hence broadly applicable. For Tasks 1 and 2, the highest classification accuracy results were 91.85% + 4.25% and 97.37% + 3.33%, respectively. In a related study, Holm et al. (2020) used convolutional neural network (CNN) layers or feature-based representations to numerically encode the visual information present in a microstructural image, which serves as input to supervised or unsupervised ML algorithms that discover associations and trends in the high-dimensional image representation.

Ma et al. (2020) investigated the representational techniques for microstructures with the goal of using microstructure images to forecast processing conditions. To develop a better machine learning method for picture recognition, characterization, and creating predictive skills tying microstructure to processing conditions, a binary alloy (uranium-molybdenum) developed as a nuclear fuel was researched. They experiment with various microstructure representations and gauge the effectiveness of the models using the F1 score. For differentiating between micrographs corresponding to 10 different thermo-mechanical material processing conditions, an F1 score of 95.1% was attained. The traditional method of using area fractions of different phases was found to be insufficient for differentiating between multiple classes using a relatively small, imbalanced original dataset of 272 images. Instead, they discovered that the newly developed microstructure representation described image data well. Generative adversarial networks were trained to produce artifactual microstructure images to investigate the applicability of generative techniques for enhancing such constrained datasets.

Software for automating metallographic quality control of metals was created by Zhilenkov et al. (2021). It was based on an established approach for identifying the metal grade and on the use of neural networks to recognize photographs of metal microstructures. To ascertain the numerical properties of metals, a neural network's structure has been

devised. They carried out the binarization of the metal microstructure image. Otsu's method was employed for binarization since it is the most successful approach for global binarization. Then, rather than employing the brightness values of objects, the informative elements of the image of the microstructure were created using the properties of the borders, i.e., contours. The Prewitt filter was used to create a precise image of object borders and homogenous region outlines for selecting contours, as shown in Fig. 2.

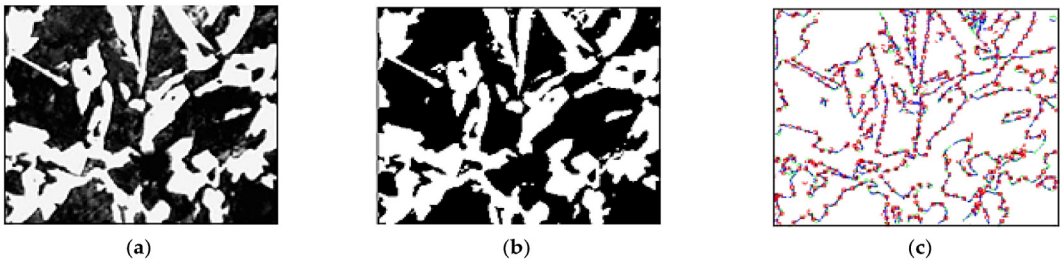

Figure 2. The result of the preliminary processing of the image of the metal microstructure: (a) gray-scale microstructure image; (b) binarization of the metal microstructure image; (c) image thinning operation and boundary detection with Prewitt's filter (Zhilenkov et al., 2021)

The values describing the picture segments of the metal microstructure were established after the base points on the image were fixed and it was vectorized. Triangle hypotenuses, which were created by perpendicular dropped from two neighboring base points, shaped segment elements. The segment elements' sine and cosine values (sin (A), cos (A)) were given into the neural network's input for learning. The Prewitt gradient (Gp), which establishes the contrast value, was also a factor employed as an input parameter. Fig. 3 depicts the design of the neural network used in metallographic analysis to identify the grain point in the metal structure.

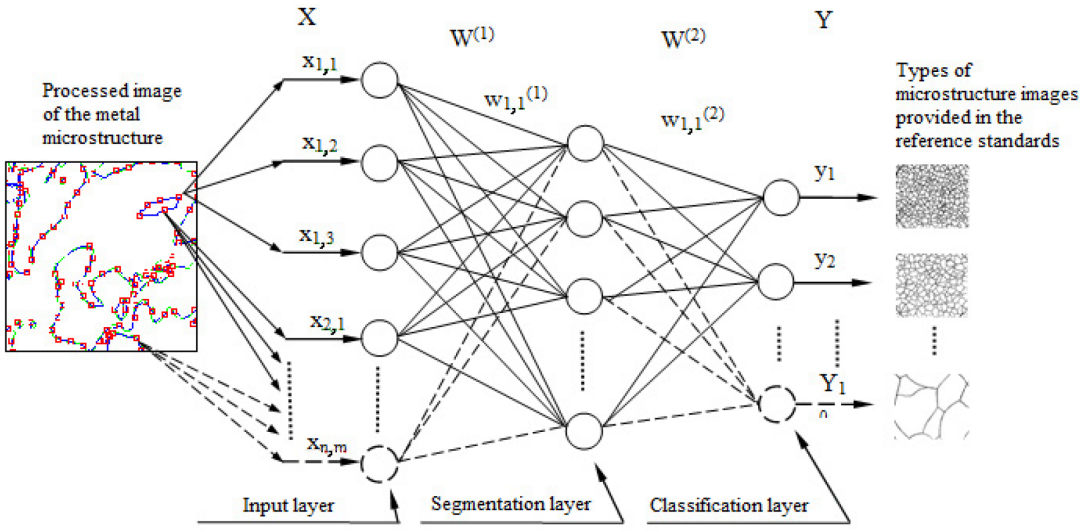

Figure 3. The structure of the neural network for determining the quantitative characteristics of the metal (Zhilenkov et al., 2021)

Microstructure Optimization

The material design groups have recently begun showing a lot of interest in the ML paradigm (Green et al., 2017; Hattrick-Simpers et al., 2016; Mueller et al., 2016; Ramprasad et al., 2017; Ward and Wolverton, 2017). Traditional experiments and computer modeling techniques frequently require a lot of time and resources and are constrained by the experimental settings or theoretical underpinnings, which is the major justification for integrating ML algorithms into material design challenges. As a result, ML has gained

recognition as an effective option for speeding up the process of material discovery and design. To comprehend the nature of the thermomechanical processes and their relationship to the material properties, the process design problem has been investigated in the literature using ML techniques (Abbod et al., 2002; Fang et al., 2009; Han et al., 2011; Zhu et al., 2003).

Acar (2019) used ML techniques to determine the best way to process a texture design. The problem of process design was investigated for this reason by using the transductive learning (TL) algorithm. There are two key data notions in this algorithm. The first one contained "labeled" data, or data that could be matched with a predetermined state (label) from a database of various labels. The second one had "unlabeled" data that could not be directly matched with the labels that were provided, necessitating the use of ML techniques. A database for microstructural textures and deformation processes including tension, compression, xy shear, xz shear, and yz shear was created for this reason. The orientation distribution function (ODF) samples, which represented the starting textures for the various deformation processes, were first created using Latin hypercube sampling (LHS). The final texture information was then stored after simulating the deformation operations. The labeled dataset thus consisted of the known input ODF samples and the related output data. Here, utilizing the coordinate optimization strategy given by the TL method, the goal was to find the labels of the unlabeled designs. The galfenol alloy example problems were addressed using two solutions. In the first application, a previously researched vibration tuning problem's process design challenge (Acar & Sundararaghavan, 2016) was handled for the best numerous ODF solutions.

The findings were verified with the findings of the prior investigation. The TL technique was utilized in the following example to find the ideal deformation process, which could lead to a particularly ideal galfenol microstructure design for a multiphysics problem. Because it provided information on both the ideal and nearly optimal processes, it was discovered that the TL technique was effective to the problem of process design. The best deformation method was then identified using a multiphysics problem's unique optimal galfenol microstructure design developed using the TL methodology. The TL technique was proven to be efficient for the difficulties of process design because it gave information on both the perfect and nearly ideal processes. Any unlabeled ODF information could be used to determine the label (process) using the TL algorithm. For this, LHS was used to create 100 evenly distributed ODF samples for each process (tension, plane strain compression, xy, xz, and yz shear). All processes were predicated on the same process parameters, such as strain rate and total time. Fig. 4 provides a thorough explanation of the TL solution to the process design problem using the TL algorithm, as well as the best ODF solution to the issue. Basic ODF samples were created using LHS in this task, and initial textures were used to simulate various deformation processes. The related deformation processes were recorded and identified on the output textures (ODFs). Using the label data that was previously stored, the label of an unlabeled ODF design was to be found. The coordinate parameter for each label was discovered using the coordinate optimization method. The labels of the unlabeled designs were then assigned in accordance with the criteria for the minimal distance. The optimal deformation process, which was the one most likely to result in the ideal galfenol microstructure design of the optimization problem, was found by solving the process design problem. The best design is the one that minimizes magnetostrictive strain while also meeting the yield stress design limitation (yield stress>555 MPa). Allenol is a magnetostrictive alloy that, in some orientations, exhibits higher magnetostrictive strain values as well as favorable structural characteristics (such stiffness and yield stress). As a result, it is a useful material for applications involving many physics, particularly to enhance the magnetic and structural features that were examined in their study.

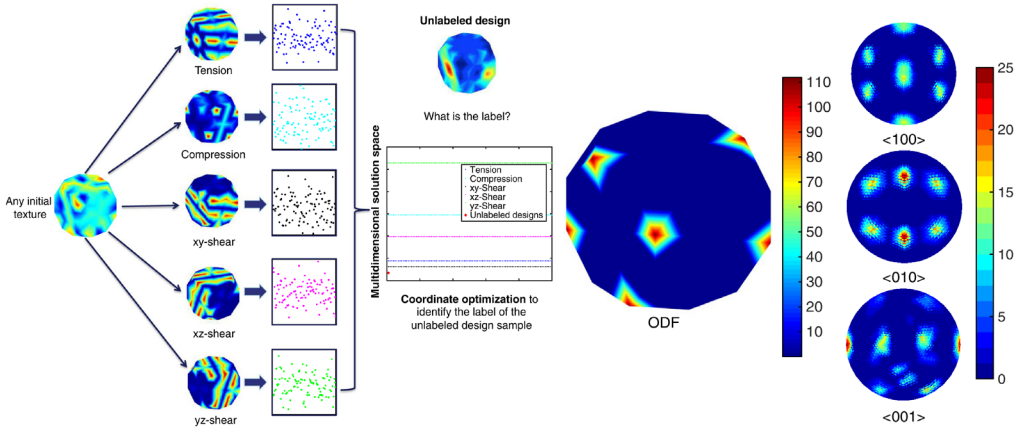

Figure 4. Process design problem of the transductive learning algorithm (left), optimum ODF solution in the problem (right) (Acar, 2019)

Prediction of Mechanical Properties

For the fourth Industrial Revolution's growth of materials science, artificial intelligence has received a lot of attention. Artificial Neural Networks (ANNs), a mathematical technique that matches intricate correlations between input and output layers, can produce superior mechanical qualities with optimal process parameters (Jung et al., 2020). Jung et al. (2020) predicted tensile strength, yield strength and flow ratio using microstructural data of volume fractions using ANNs. They used linear regression and neural network-based algorithms to study combinations of polygonal ferrite (PF), needle ferrite (AF), granular bainite (GB), bainite ferrite (BF) and martensite M (martensite). They calculated the theoretical resistance by calculating the flow limit based on the microstructure. They hypothesized that the yield strength of an alloy could be calculated by simply adding each hardening parameter by work, based on a model governed by a displacement sliding system. The linear regression of the inverse distribution was used to accurately predict the effect of each microstructure on three mechanical parameters. The trend of yield strength deviation with each volume percentage of the microstructure is shown in Fig. 5. (PF, AF, GB, BF and M). The mean absolute percentage errors of the validation and testing set of the deep learning algorithm using hyperparameter matching and cross-validation were 6.59% and 10.78%, respectively. Their algorithm demonstrated good accuracy in predicting experimental data.

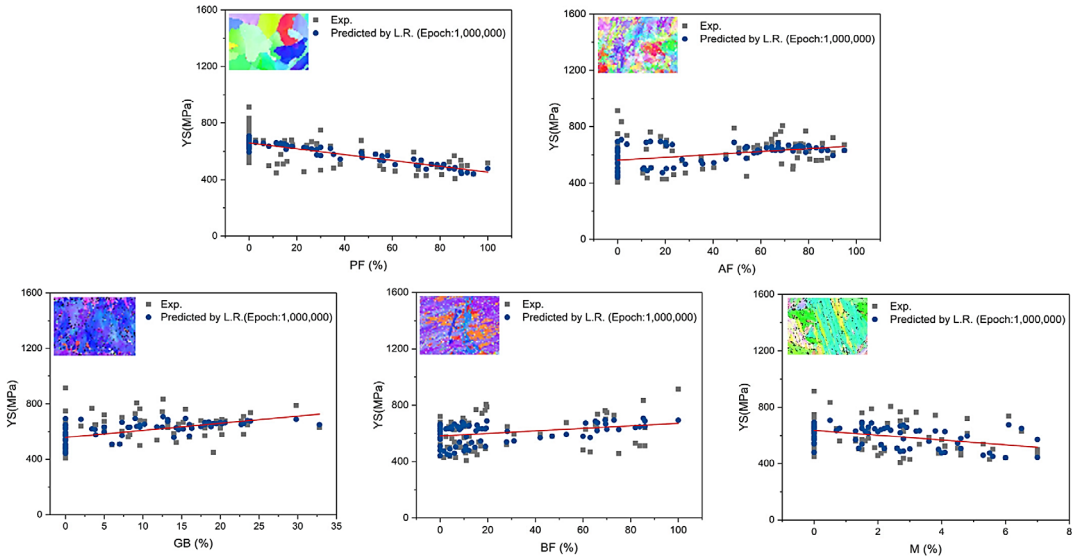

Figure 5. Yield strength tendency prediction with PF, AF, GB, BF, and M via back propagated linear regression (Jung et al., 2020)

In modeling the relationship between the chemical composition and properties of DP steels, Krajewski and Nowacki (2014) suggested a method for determining the tensile strength and yield strength of dual phase (DP) steels using ANNs. Based on the literature sources, they gathered a material database outlining the characteristics of the DP steels. To calculate the impact of alloying components, heat treatment settings, transition temperature, and microstructural characteristics on the mechanical properties of steels, an ANN model was developed. The BFGS (Broyden-Fletcher-Goldfarb-Shanno) training algorithm was used to create the chemical makeup of DP steels that would have the necessary tensile strength. The logistic activation function was utilized to forecast using the MLP 14-7-2 multilayer feed forward neural network (14 inputs, 7 neurons in the hidden layer, and 2 outputs: yield strength and tensile strength). Using a neural network simulation, Fig. 6 depicts the effects of two sample alloying components, including carbon, silicon, and manganese, on the tensile strength of steel under set heat treatment conditions and constant concentrations of the other alloying elements.

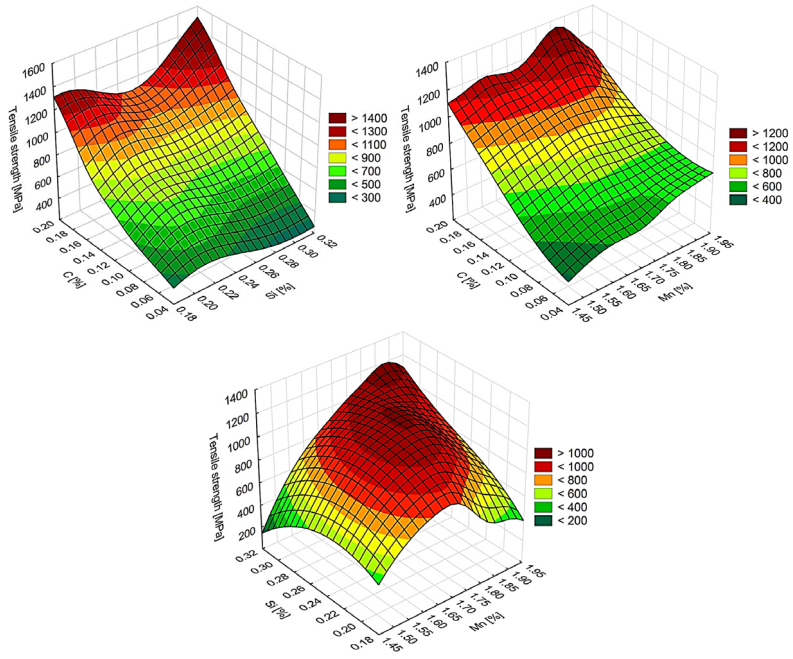

Figure 6. Effect of the concentration of alloying elements on the tensile strength of DP steels; carbon and silicon (left), manganese and carbon (middle), manganese and silicon (right) (Krajewski & Nowacki, 2014)

Li et al. (2021) used machine learning to predict the hole expansion capacity of high strength steels using an experimental dataset made up of the phase constituents of 55 microstructures and corresponding properties, such as yield strength and hole expansion capacity, that were gathered from the literature. These data were statistically analyzed with an emphasis on the hole growth capacity with respect to individual phases, phase combinations, and the total number of phases. The prediction of hole expansion capacity based on phase fractions and chemical composition used various ML techniques. Based on phase fractions and chemical composition, deep learning produced the hole expansion capacity predictions with the highest degree of accuracy.

The Materials Genome Integration System Phase and Property Analysis (MIPHA), an ML tool, was created by Wang et al. (2019) for inverse analysis of steels, where a genetic algorithm was used to explore the potential best-balanced property of tensile strength and total elongation and its corresponding microstructure and processing conditions. The analytical model was fitted using a standard ANN with one hidden layer and the sigmoid function as the activation function. According to their findings, the properties-to-micro-

structure/processing analysis approach was successful in identifying the model that produced the greatest outcomes, had the best property balance, and had the most plausible correlations between processing, microstructure, and properties. It has been discovered that a microstructure-comprising Widmanstatten ferrite, bainite, and martensite is advantageous for a good balanced property.

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CHAPTER 9

On The Hill Cipher Algorithm from Encryption Algorithms

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On The Hill Cipher Algorithm from Encryption Algorithms

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Introduction

From the past to the present, security problems have been addressed in the communication exchange between people or units with the developing technology. As various communication systems have developed in different fields, this problem has brought different problems and difficulties. Encryption and decryption methods applied by the sender and receiver have gained importance to securely transmit the information sent over these communication systems from the sender to the receiver. One of these methods of providing secure communication is encryption with matrices.

Overview of Encryption Algorithms

One of the greatest needs today is that "information is stored accurately and securely and used by relevant people when and where necessary". In this context, we come across "Crypto", that is, "Encryption". Cryptography is the science of sending a secret message to another person, group, or device in such a way that only the recipient can read the message. An undesired person on any communication channel can interrupt the message transmission and receive the message, so it is always assumed that the communication channels are insecure. Encryption is a system that has been used since ancient times. Caesar is the first known source to use encryption in history (Konheim, 1981; Stinson, 2002; Trappe, 2005; Sinkov, 2009).

Now let's give a few definitions that we will use in the chapter.

Plaintext: In cryptography, messages are unencrypted. Understandable original text.

Ciphertext: It is the text converted from plaintext with any encryption.

Key: It is the critical information used by the cipher that only the sender and receiver know.

Encryption: It is the process of rendering plain text incomprehensible, transforming it into ciphertext.

Decryption: It is the process of making the cipher text understandable again.

Public key: In a public key encryption system, it is the key that is used only for encrypting the message and not for decryption.

Cryptanalysis: It is the illegal analysis that aims to reach the original data without information and key by examining the inputs or outputs of a cryptographic system. It is also called a code-breaking.

Cryptanalyst: Practitioners of cryptanalysis are called.

Cryptographic Algorithm: It is a set of mathematical operations used in encryption and decryption operations.

Symmetric Algorithms: These are algorithms in which a (same) key is used in encryption and decryption operations. Also called secret key algorithms.

Asymmetric Algorithms: These are the algorithms in which separate keys are used in encryption and decryption processes, and the decryption key cannot be obtained from the encryption key. Also called public key algorithms.

Entity: A person or tool that uses, accepts, or sends information.

Sender: A person who legitimately sends information in any communication.

Receiver: It is the person who receives the information in communication.

Adversary: It is a harmful person who tries to break the security in the communication between the parties, not the receiver or the sender.

Attack: A successful or unsuccessful attempt to crack part or all of a cryptosystem.

Channel: Person or tool that helps move information from one person to another.

For the adversary not to learn the contents of the secret message, symbolically, the sender named A encrypts the message called plain text and sends the encrypted message called ciphertext to the other party, symbolically named B.

Encryption: It is used for the safe transmission of data and information to the desired persons under all circumstances. The basic algorithms that we use while performing the encryption process constitute the cryptosystem, which are the basic building blocks of the cryptosystem.

In cryptography, encryption algorithms generate keys in the form of a series of bits that are used to encrypt or decrypt a piece of information. How these keys are used makes the difference between symmetric and asymmetric encryption.

Encryption algorithms are generally divided into two categories: symmetric and asymmetric encryption. The main difference between these two encryption methods is that while a single key is used in the symmetric encryption algorithm, two different but re-

lated keys are used in asymmetric encryption. Such a difference, although seemingly simple, determines the functional differences between the two encryption techniques and the way they are used.

Features of Encryption Systems

Encryption systems used to transmit and store information securely should have the following features. (Stinson, 2002; Trappe, 2005; Sinkov, 2009).

Security degree: It is defined as the number of transaction attacks against the system to obtain information until full results are obtained with the best method. The security rating of a typical system, also called the transaction element, requires more transactions than the highest number of transaction attacks.

Functionality: Encryption systems should be able to process different types of information securely within the system. The functions of this encryption system, which is based on providing security, should be integrated with each other.

Transaction methods: During the implementation of the encryption system, the basic transaction processes may occur in different ways with different inputs. This shows the typical characteristic difference in processing methods.

Performance: It is expressed in the number of bits that the encryption algorithm used in the encryption system can encrypt in one second.

Ease of implementation: A software or hardware environment of different complexity may be required for the implementation of processes within encryption systems. The degree of complexity in these environments is a factor that affects processing power. The applicability of an encryption system in constrained and difficult situations is important.

Information Security and Encryption

In order to talk about information security in general; basic elements, such as confidentiality, integrity, identity identification and verification, non-repudiation and continuity, must be found or created by cryptosystems.

Confidentiality can be expressed as ensuring that information is accessible only to those who have been authorized to access it. Confidentiality, which is the most basic step of security, is provided by encryption algorithms or approaches. It is known that it is difficult to have detailed information about any attack carried out with a passive attack. Therefore, since incoming and outgoing messages between two people may fall into the hands of attackers without being aware of it, the element of confidentiality is a must.

Messages sent or received are converted to a different format using an encryption algorithm. A secure environment is provided as the attackers cannot decrypt the hidden

messages that have been converted to different formats.

Integrity can be expressed as ensuring or recruitment that the content of a document or message is not changed. Integrity is one of the indispensable elements for any secure communication, and summarization algorithms are used to ensure this.

To ensure the integrity of a message, a summary of the sent message is taken and this digest is sent to the other party along with the message. The other party, on the other hand, extracts the summary of the received message and compares this summary with the summary sent to it.

Symmetric Encryption

On the basis of symmetric encryption algorithms, data is encrypted with a single secret key, and data is decrypted with the same key. That is, if the encryption is done with a secret key that is securely agreed upon by the communicating A and B in advance, this system is called symmetric encryption. Since the encryption and decryption keys are kept secret by A and B, only persons A and B with the secret key can encrypt or decrypt the message. As long as the keys remain secret, no one can understand or easily decipher the message, so A and B can communicate freely between them. These encryption methods work in mathematically uncomplicated transactions and work very fast, but the text must be delivered to the other user securely in the key as well as sending it to the user. Although often used concurrently with asymmetric encryption to solve the problem of securely transferring keys, symmetric encryption schemes remain an essential element of modern computer security (Konheim, 1981; Stinson, 2002; Trappe, 2005; Sinkov, 2009). Thanks to its speed, simplicity and security, symmetric encryption is frequently used in a wide range of applications, from securing internet traffic to protecting data stored on cloud servers.

Figure 1. Symmetric Encryption

After defining the symmetric encryption algorithms, we can specify the general features, advantages and disadvantages of these algorithms in the following:

Advantages of Symmetric Encryption Algorithms:

- Symmetric encryption is quite fast.
- They can work with hardware.

- They offer a high level of security while being fast and simple.
- Its keys are quite short and consist of simple mathematical operations.
- They can be used as intermediaries in the creation of stronger passwords.

Disadvantages of Symmetric Encryption Algorithms:

- Keys are difficult to store and deliver to parties and involve security risks.
- Large networks need too many switches, not scalable. A system with x users has $\lceil x(x-1)/2 \rceil$ keys.
- It does not provide integrity. The person who got the key may have changed the data.
- It does not provide authentication. Data can be encrypted by anyone with the same key.

Asymmetric Encryption

Asymmetric Encryption Algorithms are called public key cryptography. Unlike the symmetric encryption algorithm, there are two different keys in the asymmetric encryption algorithm, the public and private keys. The encryption key is called the public key, and the decryption key is called the private key. The key used for decryption is different from the keys used for encryption. For this reason, a text encrypted with a user's public key can only be decrypted with the private key of that user. In addition, in asymmetric encryptions, the person can send the text by first encrypting it with his private key and then with the public key of the other person. In this case, the user who receives the text opens the text with his private key and the sender's public key, both securely reaching the text and authenticating the sender of the text.

In the following example, person A encrypts the text with B's public key to send any text that only person B can see. Only person B can decrypt this text with his private key.

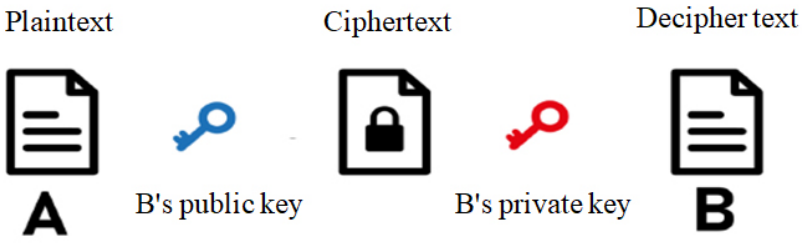

Figure 2. The first example of asymmetric encryption

In the following, we see the use of asymmetric encryption for authentication purposes.

Since person A can decrypt the ciphertext with B's public key, he understands that the text came from person B.

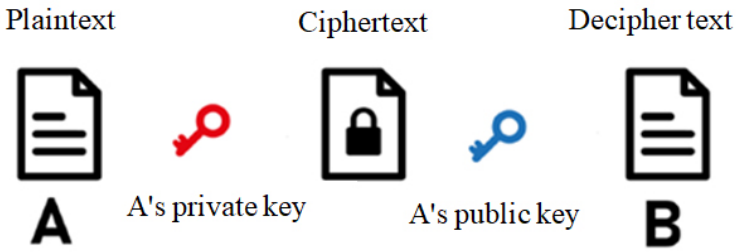

Figure 3. The second example of asymmetric encryption

In the below third example, person B could not decrypt the ciphertext of person C because he used A's public key. Because only C's public key can decrypt the text encrypted with C's private key.

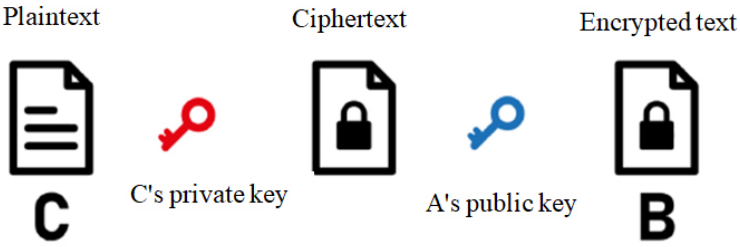

Figure 4. The third example of asymmetric encryption

After defining the asymmetric encryption algorithms, we can specify the general features, advantages and disadvantages of these algorithms in the following.

Advantages of Asymmetric Encryption Algorithms:

1. Passwords are relatively harder to crack.

2. Authentication is a secure way to enforce integrity and confidentiality principles.

3. Since two keys are used in encryption, it cannot be denied with a digital signature.

Disadvantages of Asymmetric Encryption Algorithms:

1. It is much slower than symmetric encryption.

2. It causes more CPU consumption in the system.

In the rest of the report, we will talk about the Hill Encryption algorithm, which is a symmetric encryption method.

Encryption of Hill Cryptography Algorithm

In this part, we present a method of encoding and decoding messages.

Before we start the encryption process, we need to define a square matrix that we will use as the key. Let's call the size of our matrix . We can adjust the size of the square matrix to whatever size we want $K=\left[k_{ij}\right]_n$.

In the second step, we will split the text we want to encrypt into n-length pieces $T=\left[t_{1j}\right]_n$. At this stage, we run into a problem: not every text can be divided into equal parts. Let's calculate the complexity by denoting the text length as M and the key matrix width as n. First, we're going to split our text into n chunks of length, so we'll have M/n chunks. M may not be exactly divisible by n, so we will add values to M as a multiple of n. Then, we can represent our piece count as $\lceil M/n \rceil$. In order to eliminate this problem, we can fill in the remaining gaps with a value that we have determined (Anton,2019).

Then we have to convert the parts of the text we want to encrypt into numbers. We can do this with the values $k, p \in Z$, we set ourselves, or with values in the ASCII Table (Stinson, 2002; Trappe, 2005; Sinkov, 2009).

Table 1. Alphabetic characters and ASCII values

A	B	C	D	E	F	G	H	I	J	K	L
k	k+1	k+2	k+3	k+4	k+5	k+6	k+7	k+8	k+9	k+10	k+11
65	66	67	68	69	70	71	72	73	74	75	76

M	N	O	P	Q	R	S	T	U	V	W
k+12	k+13	k+14	k+15	k+16	k+17	k+18	k+19	k+20	k+21	k+22
77	78	79	80	81	82	83	84	85	86	87

X	Y	Z	.	,	!	…	;	?
k+23	k+24	k+25	k+26	k+27	k+28	…	k+p-1	k+p
88	89	90	46	44	33	…	59	63

Then we will multiply each of these parts $T^{(m)}=\left[t_{1j}\right]_n$, $m=1,2,...,\lceil M/n \rceil$ with our key matrix $K=\left[k_{ij}\right]_n$, that is, we will do matrix multiplication $D^{(m)}=\left[d_{1j}\right]_n$;

$$D^{(m)}=T^{(m)}K, \qquad m=1,2,...,\lceil M/n \rceil$$

$$\left[d_{1j}\right]_n=\sum_{l=1}^{n} t_{1l}\,k_{lj}\,.$$

For each piece, we're going to do matrix multiplication, so we're going to multiply a n x 1 wide array by an n x n wide matrix. We can represent the number of operations here with 1 x n x n, that is, with n^2. If we were to repeat the matrix multiplication for each piece, we would have to perform $\lceil M/n \rceil n^2$ times. We can also denote the complexity as $M\,n$ if we accept M as a multiple of n (Anton,2019).

However, the multiplication results may not be within the range that we have determined for the number equivalents of the letters, so much larger numbers may come out. In order to eliminate this problem, we must take the mode of all the products we have obtained. Since we are using the English alphabet and some characters in Table 1, we have p characters, so we will take the mod of p;

$$D^{(m)} \equiv D^{(m')} \left(\text{mod } p\right),$$

$$d_{Ij} \equiv \left[d'_{Ij} \right]_n \left(mod\ p\right) .$$

Finally, we will add all the values we have obtained side by side in order and find out which letters the number values correspond to

$$D^{(1)} D^{(2)} \ldots D^{(\lceil M/n \rceil)}$$

Thus, we have encrypted the desired text as text characters $\lceil M/n \rceil n$ (Anton,2019).

For example, taking n as 2, we'll use any matrix $K = \left[k_{ij} \right]_2 = \left[i + j \right]_2$, $i, j = \{1, 2\}$,

$$K = \begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix}. \qquad (1)$$

We want to encrypt the text "Turkish Youth! Your first duty is to preserve and to defend Turkish Independence and the Turkish Republic, forever.", since we take n as 2, only study a little part "Tu-rk-is-hY-ou-th-!" of the encrypt the text, the character "!" at the end remains single. In order to eliminate this problem, we will fill in the remaining gaps with a value that we have determined the end remains single. In our example, we can put the letter ! in the blanks.

"Tu-rk-is-hY-ou-th-!!"

Then we have to convert the parts of the text we want to encrypt into numbers. In our example, we will use the values that we determined ourselves for $k = 2$ and $p = 29$ in Table 1. So, the following table is established as

Table 2. The selected characters and values form Table 1

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P	Q	R	S	T	U	V	W	X	Y	Z	.	,	!	
17	18	19	20	21	22	23	24	25	26	27	28	29	30	

We can do this with the values in Table 2.

Table 3. The vectors and plaintext

T u	r k	i s	h Y	o u	t h	! !
$[21 \quad 22]$	$[19 \quad 12]$	$[10 \quad 20]$	$[9 \quad 26]$	$[16 \quad 22]$	$[21 \quad 9]$	$[30 \quad 30]$

Then we will multiply each of these parts $T^{(m)} = \left[t_{1j}\right]_n$, $m = 1,2,...,7$ with the key matrix in (1). If the multiplication results may not be within the range that we have determined for the number equivalents of the letters, so much larger numbers may come out, then we must take the mod of 29 of all the products since we have obtained by using 29 characters in Table 2.

$$T^{(1)}K = [21 \quad 22]\begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix} = [108 \quad 151] = D^{(1)}$$

$$[108 \quad 151] = [21 \quad 6](mod\ 29) \tag{2}$$

$$T^{(2)}K = [19 \quad 12]\begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix} = [74 \quad 105] = D^{(2)}$$

$$[74 \quad 105] = [16 \quad 18](mod\ 29) \tag{3}$$

$$T^{(3)}K = [10 \quad 20]\begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix} = [80 \quad 110] = D^{(3)}$$

$$[80 \quad 110] = [22 \quad 23](mod\ 29) \tag{4}$$

$$T^{(4)}K = [9 \quad 26]\begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix} = [96 \quad 131] = D^{(4)}$$

$$[96 \quad 131] = [9 \quad 15](mod\ 29) \tag{5}$$

$$T^{(5)}K = [16 \quad 22]\begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix} = [98 \quad 136] = D^{(5)}$$

$$[98 \quad 136] = [11 \quad 20](mod\ 29) \tag{6}$$

$$T^{(6)}K = [21 \quad 9]\begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix} = [69 \quad 99] = D^{(6)}$$

$$[69 \quad 99] = [11 \quad 12](mod\ 29) \tag{7}$$

$$T^{(7)}K = [30 \quad 30]\begin{bmatrix} 2 & 3 \\ 3 & 4 \end{bmatrix} = [150 \quad 210] = D^{(7)}$$

$$[150 \quad 210] = [5 \quad 7](mod\ 29) \tag{8}$$

Finally, we consider all the values in (2)-(8), obtain side by side in order, and find out which letters the number values in the matrix $D^{(m')}$ correspond from Table 2.

Table 4. The vectors and ciphertext in Table 3

[21 6]	[16 18]	[22 23]	[9 15]	[11 20]	[11 12]	[5 7]
T E	O Q	U V	H N	J S	J K	D F

Thus, the word "Turkish Youth!" have been encrypted as "TEOQUVHNJSJKDF" in Table 4.

The Decryption of The Hill Cryptography Algorithm

Let's understand the logic of the decryption process: The decryption process also includes the same encryption steps, basically again matrix multiplication and mode calculation (Anton,2019; Bedasa, Bedada and Mulatu, 2020).

Let's denote the parts of the text we want to encrypt with $T^{(m)} = \left[t_{1j}\right]_n$, $m = 1,2,...,\lceil M/n \rceil$, the key matrix as $K = \left[k_{ij}\right]_n$, and the parts of the encrypted version with $D^{(m)} \equiv D^{(m')} \left(\mathrm{mod}\ p\right)$.

Accordingly, what we do, simply it can be shown as

$$D^{(m')} \equiv T^{(m)}\ K\ (mod\ p), \quad m = 1,2,...,\lceil M/n \rceil.$$

We know that the product of a matrix by its inverse is the unit matrix: $K\ K^{-1} = K^{-1}\ K = I$. According to this, we find that

$$D^{(m')}\ K^{-1} = T^{(m)}\ K\ K^{-1},$$

$$T^{(m)} \equiv D^{(m')} K^{-1} (mod\ p).$$

Here we understand that we need the inverse of the key matrix in order to decipher the encrypted text, we have to find the inverse of the key matrix, but not every matrix can be found. The condition for finding the inverse of the matrix is that the determinant of the matrix is nonzero. For this reason, we cannot use every matrix as a key.

First of all, we know that there are many methods to find the inverses of matrices whose determinant is nonzero. So, the determinant of our key matrix has to be non-zero, if $det(K) \neq 0$, then we have a matrix K^{-1}.

Methods such as adjugate matrix, the eigen decomposition, the Gaussian elimination and the Cholesky decomposition can be used to find the inverse of the matrix, we have studied the inverse of key matrix K with the adjugate matrix method;

$$K^{-1} = \frac{1}{det(K)} Adj(K) \tag{9}$$

where $det(K)$ is the determinant of K, $Adj(K)$ is the matrix transpose of cofactors. However, when we find the inverse in (9), the matrix elements can be fractional, which can cause calculation problems and miscalculations (Anton,2019).

For this reason, the inverse of the key matrix should be found with additional operations in the adjugate matrix method used for the Hill encryption algorithm. Firstly, in order to obtain integer values in the inverse matrix, we have to express the adjugate matrix method differently. We well know that $det(K) = 1 / det(K^{-1})$, an inverse matrix in (9) is

$$K^{-1} = det(K^{-1}) Adj(K) \tag{10}$$

In that case, we get the formula $det(K^{-1})$, we have to solve the following equation

$$det(K) det(K^{-1}) \equiv 1 (mod\ p). \tag{11}$$

The determinant of the key matrix and the mode value (for our example, the mode value 29) must be prime between them. Otherwise, incorrect results may be obtained during decoding. For this reason, the matrices that we can choose as keys are limited.

Finally, we found $det(K^{-1})$ If we multiply their values in (10) and take the mode of each value we find, we have found our inverse matrix

$$K^{-1} \equiv det(K^{-1}) Adj(K) (mod\ p) \tag{12}$$

Now we can perform the inverse matrix process for the matrix $K=\left[k_{ij}\right]_2=\left[i+j\right]_2$, $i,j=\{1,2\}$ given in (1). Firstly, this process follows the determinant and the adjugate matrix of the matrix K

$$det\left(K\right)=-1,\quad Adj\left(K\right)=\begin{bmatrix}4 & -3\\ -3 & 2\end{bmatrix}. \tag{13}$$

Next, we need to solve the equation given in (11), but, haven't need to calculate the value $det\left(K\right)=-1$, because its values are not fractional. Simply, this value can be written as

$$det\left(K^{-1}\right)\equiv -1\left(mod\ 29\right)\ \text{ or }\ det\left(K^{-1}\right)\equiv 28\left(mod\ 29\right).$$

Finally, the inverse expression in (12) is given as

$$K^{-1}\equiv\left(-1\right)\begin{bmatrix}4 & -3\\ -3 & 2\end{bmatrix}\left(mod\ 29\right)\ \text{ or }\ K^{-1}\equiv 28\begin{bmatrix}4 & -3\\ -3 & 2\end{bmatrix}\left(mod\ 29\right).$$

We calculated that

$$K^{-1}\equiv\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}\left(mod\ 29\right)\ \text{ or }\ K^{-1}\equiv\begin{bmatrix}25 & 3\\ 3 & 27\end{bmatrix}\left(mod\ 29\right).$$

Now we can perform the decryption process. We'll split the ciphertext into 2-length chunks and find their numeric equivalents.

Table 5. The ciphertext and vectors in Table 4

T E	O Q	U V	H N	J S	J K	D F
$[21\quad 6]$	$[16\quad 18]$	$[22\quad 23]$	$[9\quad 15]$	$[11\quad 20]$	$[11\quad 12]$	$[5\quad 7]$

We will multiply each of the parts by the inverse of the key matrix and get the mode of each product.

$$D^{(1)}K^{-1}=\begin{bmatrix}21 & 6\end{bmatrix}\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}=\begin{bmatrix}-66 & 51\end{bmatrix}=T^{(1)}$$

$$\begin{bmatrix}-66 & 51\end{bmatrix}\equiv\begin{bmatrix}21 & 22\end{bmatrix}\left(mod\ 29\right) \tag{14}$$

$$D^{(2)}K^{-1}=\begin{bmatrix}16 & 18\end{bmatrix}\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}=\begin{bmatrix}-10 & 12\end{bmatrix}=T^{(2)}$$

$$\begin{bmatrix}-10 & 12\end{bmatrix}\equiv\begin{bmatrix}19 & 12\end{bmatrix}\left(mod\ 29\right) \tag{15}$$

$$D^{(3)}K^{-1}=\begin{bmatrix}22 & 23\end{bmatrix}\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}=\begin{bmatrix}-19 & 20\end{bmatrix}=T^{(3)}$$

$$\begin{bmatrix}-19 & 20\end{bmatrix}\equiv\begin{bmatrix}10 & 20\end{bmatrix}(mod\ 29) \tag{16}$$

$$D^{(4)}K^{-1}=\begin{bmatrix}9 & 15\end{bmatrix}\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}=\begin{bmatrix}9 & -3\end{bmatrix}=T^{(4)}$$

$$\begin{bmatrix}9 & -3\end{bmatrix}\equiv\begin{bmatrix}9 & 26\end{bmatrix}(mod\ 29) \tag{17}$$

$$D^{(5)}K^{-1}=\begin{bmatrix}11 & 20\end{bmatrix}\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}=\begin{bmatrix}16 & -7\end{bmatrix}=T^{(5)}$$

$$\begin{bmatrix}16 & -7\end{bmatrix}\equiv\begin{bmatrix}16 & 22\end{bmatrix}(mod\ 29) \tag{18}$$

$$D^{(6)}K^{-1}=\begin{bmatrix}11 & 12\end{bmatrix}\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}=\begin{bmatrix}-8 & 9\end{bmatrix}=T^{(6)}$$

$$\begin{bmatrix}-8 & 9\end{bmatrix}\equiv\begin{bmatrix}21 & 9\end{bmatrix}(mod\ 29) \tag{19}$$

$$D^{(7)}K^{-1}=\begin{bmatrix}5 & 7\end{bmatrix}\begin{bmatrix}-4 & 3\\ 3 & -2\end{bmatrix}=\begin{bmatrix}1 & 1\end{bmatrix}=T^{(7)}$$

$$\begin{bmatrix}1 & 1\end{bmatrix}\equiv\begin{bmatrix}30 & 30\end{bmatrix}(mod\ 29) \tag{20}$$

Finally, we will add all the values we have obtained side by side and find out which letters the number values correspond to.

Table 6. Decrypted text-vectors of ciphertext-vectors in Table 5

[21 22]	[19 12]	[10 20]	[9 26]	[16 22]	[21 9]	[30 30]
T U	R K	I S	H Y	O U	T H	! !

In Table 6, the word “TURKISHYOUTH!!” have been decrypted text “TEOQUVHNJSJKDF” in Table 5. Thus, we have regained the word “Turkish Youth!”. When the text we specify cannot be divided into equal parts by the width of the matrix, we add the text to the end of the text to meet the condition, for example, we encrypt the text “TURKISH YOUTH!” as “TURKISHYOUTH!!”. For some texts, this may cause misunderstandings for the recipient. For this reason, the algorithm is limited in terms of understanding.

Conclusion

Thanks to this study, information was obtained about encryption methods with matrices and how to decrypt the encrypted message. As explained in the above example, the system designed on encryption with matrices can be considered as a successful and reliable encryption method. Since one of the parameters that increase the reliability of the system

in such encryption systems is the use of any multidimensional key matrix, when long text encryption and decryption will be performed, the use of any key matrix of different sizes can be evaluated in terms of the security and speed of the system. A key matrix is required to decrypt an encrypted text. Key matrices can be found by performing crypto analysis with the help of any computer with detailed key search methods. Here, the size of the key matrix can be chosen high, so that the crypto analysis time can be long. However, using a multidimensional key matrix also causes delays in encryption and decryption processes. So it is clear that key matrix sizes are important in encryption.

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CHAPTER 10

Artificial Intelligence Methods Applied in Wood Species Identification

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Artificial Intelligence Methods Applied In Wood Species Identification

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Introduction

Wood identification has a very important place in fields such as plant taxonomy, wood material trade, illegal logging, archeology, conservation and restoration, art history, and even criminology (Ross, 2010). In order to rationally utilized the wood raw material, which is considered a scarce resource, and to choose the right place of use, it is necessary to correctly identify the tree species (Dogu, 2013; Wheeler & Baas, 1998). Classical wood identification methods based on examining the macroscopic and microscopic structure of wood material are accepted as the most reliable methods today (Ross, 2010). However, as these methods are labor-intensive, require relatively long preparation and examination times, and need wood anatomy specialists. So, this situation has led to a need for different diagnostic methods in recent years (Dormontt et al., 2015). The development of new technologies in the world and our expectation for rapid access to information are seen as a need for industries working with wood materials. In order to meet these needs, studies are emerging for rapid and effective species identification, which will provide a base for industrial applications. In general, while it is sufficient to determine the genus of trees in industrial fields, it is seen that species identification was required in many cases (Dormontt et al., 2015). Although some species which belong to the same genus are endangered and their trade is restricted, there is no commercial restriction for some species with similar appearance (Gasson, 2011; Shou et al., 2014; Snel et al., 2018). At the same time, it is stated that species identification is vital in many situations where information about cultural and historical structures is needed (Hwang et al., 2016). Some wood species are difficult to distinguish from each other microscopically (Tuncer, 2020). Today, image processing techniques have achieved great momentum with cutting-edge technology.

Wood anatomy

There are two groups of wood: softwoods and hardwoods. The respective characteristics for each of these species are significantly different (Figure 1). Softwoods have simpler anatomy than hardwoods, with much more related features and greater variety within each trait (Martins, 2018).

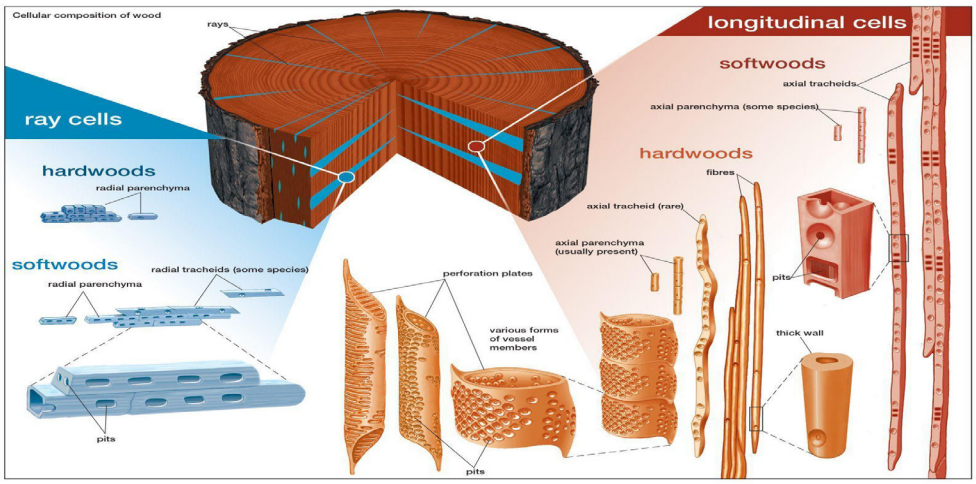

Figure 1. Types of cells are present in hardwood and softwood (Tsoumis, 2022).

Softwood consists mainly of tracheids and parenchyma, while hardwood consists of parenchyma, vessel members, fibers, and sometimes tracheids (Tsoumis, 2022). Some of these properties can be detected in different sections, so their analysis is needed (Martins, 2018). Softwood is also called conifers. Tracheids, resin canals, passage types, and rays play a key role in the diagnosis of coniferous trees. On the other hand, hardwood has complex cellular structures and clearly distinguishable cellular differences between species. Trachea, fibers, parenchyma, perforation plates, and rays are considered in the identification of leafy tree species (Hermanson & Wiedenhoeft, 2011).

Image types

The types of images are utilized as X-ray computed tomographic (CT) images, macroscopic images, stereograms, and micrographs (Figure 2) for wood identification. Macroscopic images are shooted by a standard digital camera without magnification. Stereograms are taken at 10× magnification, larger magnifications can also be used. Micrographs which are optical microscopic images are widely used in traditional wood identification. X-ray images are a slice of the images created by X-ray CT scans (Hwang & Sugiyama, 2021).

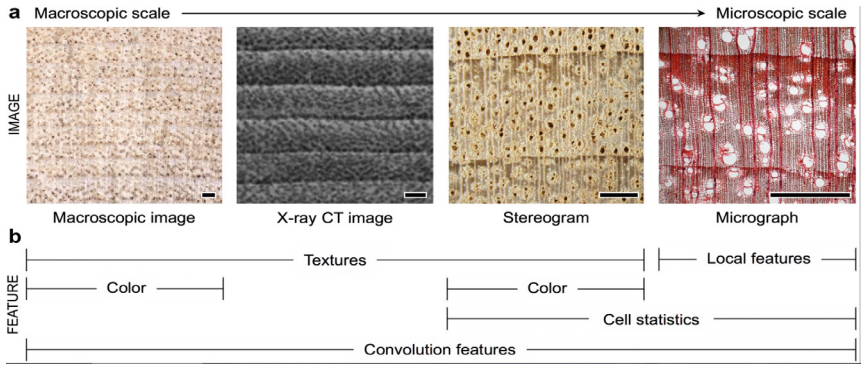

Figure 2. Preferred properties by image type a) types of images available from wood, b) corresponding extractable image properties. (Scale bars = 1 mm). (Hwang & Sugiyama, 2021).

Identification of Wood Species

Wood species identification for computer vision typically focuses on microscopic or macroscopic images of wood samples. Wood surface images photographed at 10-15× magnification are used in the macroscopic situation (Fabijańska et al., 2021). Microscopic techniques make use of images of samples obtained by microscopy at magnifications ranging from 25 to 100× (Yadav et al., 2015; Silva et al., 2017). The main limitation of method is that they require special equipment to acquire images (Filho et al., 2014).

The microscopic description of wood is based on three different cuts that form three distinct sections in the wood sample: the cross section (horizontal cut), the radial section (the vertical cut through the wood core), and the tangential section (tangential vertical cut of the bark). For identification, images of three different sections are analyzed. This is so complex that a list of anatomical features has been developed by the International Association of Wood Anatomists (IAWA) (Wheeler, 1989).

Although analysis of microscopic wood anatomy is currently the most reliable method to provide initial identification, only specialists can perform this task with accuracy. The training required to train an experienced wood anatomist can take decades and there are very few wood anatomists available in the world (Dormontt et al, 2015), so automation of this process is important. There are also studies that use microscopic images and define them by measuring various anatomical features (Ergun, 2021a; Jiang et al., 2013; Turhan & Serdar, 2013; Boztoprak & Ergun, 2017; Ergun, 2021b).

Image-Based Traditional Methods

Traditional identification is slow and costly, experts must determine the wood type by examining the cross-sectional features of the wood (Ibrahim et al., 2018). The distinguishing features of the wood such as vessel arrangement, pore orientation, ray, parenchyma, fiber and other information presented on the surface should be determined. Next, their species are identified according to the tree type identification standard defined by the IAWA list (Ruffinatto et al., 2015).

In image-based classification, images must be converted to numerical data for analysis by classification algorithms. A widely used technique in the wood species recognition problem is the use of recognition models based on texture features. In this context, Gray Level Co-Occurrence Matrices (GLCM) are generally used. By comparing the gray level differences between the pixels on the image with GLCM, various features including the image texture characteristic are found. The resulting properties form the inputs for wood classification applications. (Piuri & Scotti, 2010; Tou et al., 2009; Sun et al., 2011; Mallik et al., 2011; Martins et al., 2013; Hasan et al., 2013; Yadav et al., 2013; Khalid et al., 2008).

A typical wood type identification method includes two important steps feature ex-

traction and classification. Feature extraction methods; boundary detection algorithm, Gray Level Co-occurrence Matrix (GLCM) (Manik et al., 2020), color test statistical method (Zhao, 2013), etc. includes.

The final step in defining a typical tree type is to train tree samples to create a statistical model and then use a classifier to classify new samples by wood species. The most popular classification methods are support vector machine (Martins et al., 2013; Turhan & Serdar, 2013; Filho et al., 2014; Barmpoutis et al., 2018; Souzas et al., 2020), KNN (Kobayashi et al., 2015), neural network (Ibrahim et al., 2018; Filho et al., 2010; Yusof & Rosli, 2013; Zhao et al., 2014; Huang et al., 2020), etc. But other classifiers are also applied (Kobayashi et al., 2017; Khairuddin et al., 2011).

Microstructures of wood samples are analyzed via a microscope in different sections. Microscopic identification of wood is based on three different cuts that form three distinct segments in the wood sample: cross-section, radial, and tangential. Several image processing techniques are utilized to analyze images of different sections to aid the identification process. Methods for different types of images, such as macroscopic and stereograms, are usually cross-sectional. Important information from other sections such as radial and tangential is ignored (Martins, 2018).

Wood species classification mainly depends on the identification of morphological differences in cell structures such as canals, axial parenchyma, and rays (Castellani & Rowlands 2008; Wiedenhoeft 2005). These morphological differences were determined in all three parts of the wood. For experts, wood recognition involves recognizing structural features on the wood surface. Some experienced wood-recognition professionals can determine the wood type by observing the wood cross-section. These features are evident throughout the wood since trees grow vertically (Huang et al., 2021). Barmpoutis et al. (2018) experiment showed that the recognition accuracy of a wood section image is relatively high.

Using CNN in Wood Identification

The difficulty of classifying species with similar morphological and anatomical features has required the development of techniques to detect the main features that help to obtain a reliable classifier (Murat, 2018). Conventional classification and recognition of wood species is time-consuming and requires detailed knowledge and experience of wood anatomy. Therefore, convolutional neural networks (CNN), a deep learning tool, have replaced traditional methods. In the following, studies with CNN in the literature for wood recognition are given. Some methods are applicable only to hardwood, while others are more general and can be applied to both hardwood and softwood. Recently, studies with micro and macro images have been elaborated on.

Sun et al. (2021), a transfer learning method based on a small dataset was proposed to

recognize tree species. This method used ResNet50 feature extraction, LDA key feature optimization, and KNN classifier. A total of 25 tree species were selected for training and testing. The samples were obtained from wood factories in China's Yunnan Province, Wood Herbarium of Southwest Forestry University (SWFU). 120 images were selected for each species and 3000 images were obtained for 25 species.

Fabijańska et al. (2021) used a network of convolutional encoders in a sliding window arrangement for tree species identification. The study was limited to a macroscopic dataset of 14 hardwood and softwood species commonly found in Europe. They further extended the divide-and-conquer classification strategy proposed by Hafemann et al. (2014). A model with ResNet-inspired jump connections (He et al., 2016) was proposed and a patch-based, floating window strategy was applied regardless of image spatial resolution. Especially, the use of a sliding window setup also increased the number of training examples, as many train patches can be extracted from a single input image. The source code of the proposed method was published with the dataset to facilitate duplication of results and a direct comparison with future competitors.

Ravindran et al. (2018) implement the VGG16 model to 10 neotropical species macroscopic images. Lens et al. (2020) compared the performance of CNN models on a microscopic dataset of 112 neotropical wood species. The results showed that the CNN models significantly outperformed the classical classifiers. ResNet gave the best results with classification rates of 98%. The ResNet model (Hu et al., 2019) was used to describe nine timber types. The above-mentioned studies deal with high-quality images. Therefore, Lopes et al. (2020) tested the performance of the ResNet v2 model by applying it to images taken from a commercial mobile phone with a macro lens. The model identified 10 hardwood species with an accuracy of 92%, significantly lower than images carefully acquired with specialized equipment. Also, cutting-edge CNN models require fixed-size inputs that are not always available (Fabijańska et al., 2021).

In a similar study (Huang et al., 2021), a new approach for tree species recognition was proposed for 12 wood species using the same database (Barmpoutis 2019). Transfer learning technology was used to extract wood textural features. Global average pooling (GAP) was introduced to reduce the number of features and improve the generalization ability of the model (Lin et al. 2013). An extreme learning machine (ELM) algorithm was used for wood species recognition. Based on the ResNet50 model, the number of extracted features is even greater than the original input. Therefore, the GAP layer has been added to the model. Experimental results showed that this process can greatly reduce the number of features, reduce the overfitting of the model, and improve the recognition accuracy of the model. The combination of deep learning and machine learning can take advantage of both technologies. While deep learning has a strong ability to extract abstract features of wood image texture, machine learning has an advantage in small

sample classification (Huang et al., 2021).

In another study (Kirbas & Cifci, 2022), transfer learning was used to classify tree species in the Wood-Auth dataset. The current study is based on the dataset obtained at the Wood Technology Laboratory of the Aristotle University of Thessaloniki, School of Forestry and Natural Environment (Barmpoutis et al., 2018). The data set consists of macroscopic images of 12 tree species belonging to three different tree section types, cross-section, radial, and tangential. Transfer learning adapts it to the relevant problem using pre-trained models rather than developing a deep learning model from scratch. The classification performances of ResNet-50, Inception V3, Xception, and VGG19 deep learning architectures with transfer learning were evaluated. ResNet (Residual Network) (He et al., 2016) was developed to avoid the problem of vanishing gradients in multilayer deep networks. It has 50 layers of which there are 48 convolutional layers. Inception network is based on the simultaneous application of filtering and pooling in convolutional layers. It works with modules. Inception V3 the number of parameters can be reduced without reducing network efficiency (Szegedy et al., 2015). Xception network offers two different approaches in addition to the improvements in Inception V3. These are deep convolution and point convolution (Chollet, 2017). VGGNet has two structures, VGG19 and VGG16. The VGG16 network has 41 layers. It consists of 13 convolutional layers, three fully connected layers, pooling, activation function, dropout, and classification layers. The VGG19 network has 47 layers. It has more convolution layers than VGG16 (Simonyan & Zisserman, 2014).

Experimental findings indicated that Xception outperformed the other models in the study and the Wood-Auth dataset, providing a classification accuracy of 95% (Kırbaş & Farmer, 2022).

In general, studies have used a regional database and focused on a certain number of species. We are aware that the datasets used in the studies are not the same and that the comparisons of different methods should be made on the same database. Many studies have been published together with the dataset to ease replication of results and a direct comparison with future competitors.

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CHAPTER 11

Artificial Intelligence Methods Used in Microstrip Antennas

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Artificial Intelligence Methods Used in Microstrip Antennas

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Introduction

Recently, with the development of computer technologies, artificial intelligence has succeeded in changing the foundations of numerous industries and fields of work, including the design and optimization of antennas. The fact that artificial intelligence methods work effectively in complex, unsolved problems and perform classical calculations quickly and efficiently has led to a rapid rise in the literature. Classical optimization algorithms, one of the solution ways of artificial intelligence methods, can be applied to multidimensional problems and provide short-term and effective solutions from classical analytical approaches in antenna design.

The increasing use of microstrip antennas in satellite communication systems and their compatibility with the place they are used create an incentive for antenna designers to try original design methods in different geometries. In order to improve the disadvantages of microstrip antennas such as narrow bandwidth and low gain, new production methodologies are developed by making different studies on the physical and electrical parameters of antennas.

Approaches that do not require much calculation time by using artificial intelligence methods have enabled the realization of different microstrip antenna designs working with high efficiency in the literature.

Today, the increasing use of microstrip antennas in the electronic communication market makes it essential to use simpler and more effective methods for performance analysis. Many related technologies are needed to operate microstrip antennas with high efficiency in desired environments. Therefore, in recent studies in the literature, microstrip antenna designers prefer simple approaches that do not require much computation time. With the rapid developments in computer science, artificial intelligence methods inspired by nature and artificial intelligence-based techniques such as artificial neural networks and

optimization algorithms, called heuristic algorithms, have become powerful alternative tools that produce more flexible and useful results.

There are parameters such as geometric shape, operating frequency, bandwidth, etc. of the microstrip antenna, which greatly affect the antenna performance. Microstrip antennas are designed in many ways for the place and purpose of use. Since most of the studies presented in the literature are easy to analyze and design, there are studies on known geometries such as rectangle, triangle and circle. However, since the dimensions of microstrip antennas with these known geometries are relatively large for high bandwidth applications, designs in other geometries are also carried out.

Antenna Designs Using Artificial Intelligence Methods

Jayasinghe et al.,(2015) a non-uniform aliasing method is applied together with the Genetic Algorithm, which shows significant improvements in the desired bandwidth of the proposed patch antenna design.

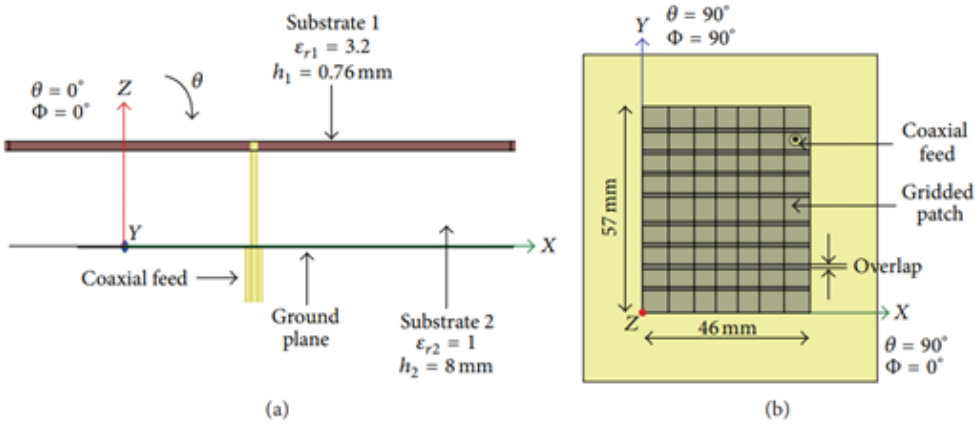

Figure 1. Antenna configuration. (a) Side view of the antenna. (b) 63-cell split patch

The fitness function for the genetic algorithm is identified as the sum of the reflection coefficient values taken in the frequency ranges. The desired problem solving frequencies for the microstrip antenna problem range from f_1 to f_4. The $L(f_i)$ parameter evaluates the reflection coefficient according to the desired frequency. The fitness function created for the antenna problem is defined in such a way that broadband solutions are preferred over the narrow bandwidth disadvantage solution with the least reflection coefficient values. N, total number of samples, and IF values shown in the equation represent frequency ranges.

$$-\frac{\sum_{fi=f1}^{f2} L(fi) + \sum_{fi=f3}^{f4} L(fi)}{IF.N} \quad (1)$$

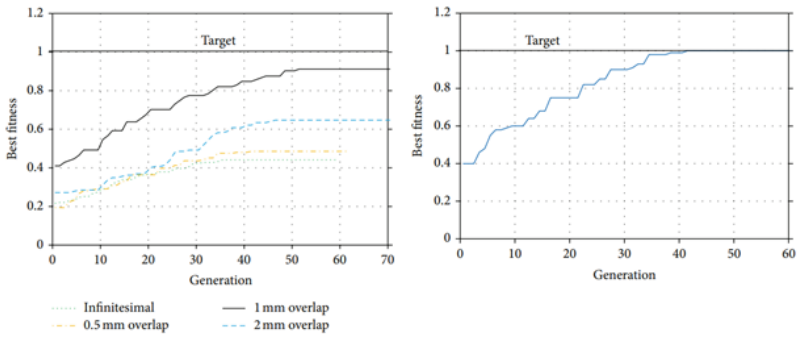

Figure 2. Best fit for generations. (a) For infinitesimal connections and smooth overlaps (b) For uneven overlaps.

The optimized design achieved using fixed overlap sizes shows quad-band performance covering GSM1800, GSM1900, LTE2300 and Bluetooth bands. In contrast, using non-uniform overlapping sizes has resulted in a pentaband design with a fractional band of 38% covering the GSM1800, GSM1900, UMTS, LTE2300 and Bluetooth bands in order to extra design flexibility.

In the study conducted by Gangopadhyaya et al., 2015, Differential Evolution algorithm was applied to optimize the resonance frequencies of the inline fed rectangular microstrip patch antenna, considering the geometric design parameters such as patch length, patch width and infeed line length as unknown variables. Simulations were made with Zeland IE3D software for different microwave frequencies (3 to 18 GHz) for optimized antennas.

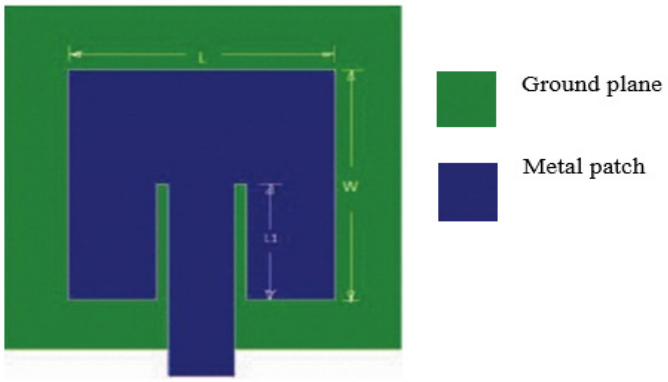

Figure 3. Microstrip Line Feed Rectangular Microstrip Antenna

The fitness function of the optimization algorithm is shown below. Here f_0 is the desired resonance frequency (3-18 GHz), L_r is the desired return loss, F_0 and L_0 are the optimized resonance frequency and return loss, respectively.

$$Fitness\ Function\ =\ |f_0 - F_0| + |L_r - L_0| \qquad (2)$$

The obtained results show the effectiveness of the Differential Evolution Algorithm for

the optimization of the infeed microstrip patch antenna. Figure 4 shows that the convergence speed of the algorithm from the best fit graph of DE is significant and effective. The DE algorithm appears to be a promising approach for antenna problems involving optimization and minimization.

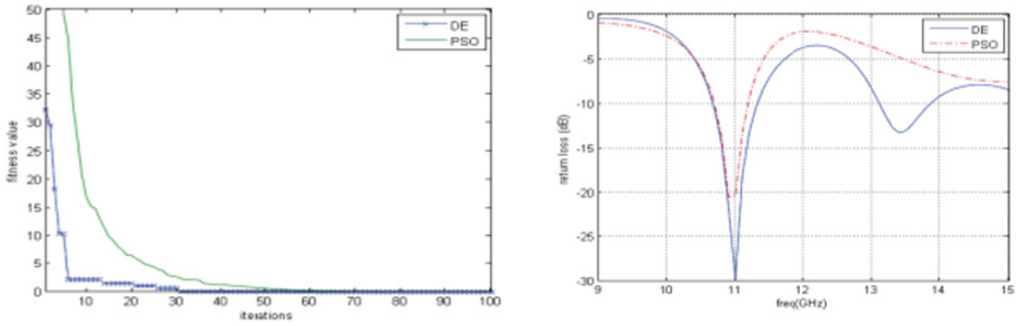

Figure 4. Comparison of differential algorithm and particle swarm algorithm used in optimization

In the study by Islam et al.,(2009), an inverted E-shaped microstrip patch antenna designed for the IMT-2000 band (2.1GHz) was designed to demonstrate an optimization technique using Particle Swarm Optimization (PSO) with Curve fitting. Curve fitting data was designed from Zealand IE3D software as in Figure 5 by varying different geometric parameters of the antenna.

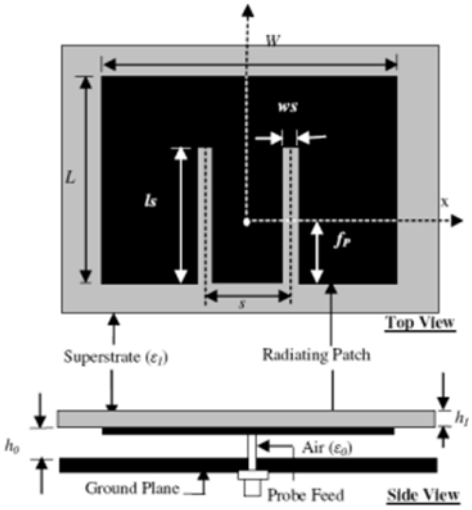

Figure 5. Inverted E-Shaped microstrip antenna geometry structure

$$F(x) = sqrt(M * \quad [\![(fc - fctarget)]\!] \hat{} 2 + N * \quad [\![(BW - BWtarget)]\!] \hat{} 2) \qquad (3)$$

The fitness function used in the study is shown in the equation given above. M and N are constants used to control which parameter contributes more to the overall fitness function of each term. M and N values were chosen as 0.1 and 1, respectively. Optimization was carried out by completing 60 iterations with 36 particles. Patch length (L) and width (W), slit length (l_s) and width (w_s) were used as optimized parameters and it was aimed to reach the desired operating frequency and bandwidth.

Using the microstrip antenna parameters data, equations representing the relationship between different parameters of a microstrip antenna and obtaining the requested antenna properties are written. Graphmatica curve fitting software was used to generate the required curve to solve the problem. Particle Swarm Optimization software was developed and implemented in the MATLAB program, which is widely used in the literature. The antenna, which has been optimized at the desired ranges, has been simulated with the Zealand IE3D program. By comparing the conventional built antenna with the PSO optimized antenna based on curve fit, a significant improvement in bandwidth was observed. The observed bandwidth is increased by 15% for the inverted E-shaped microstrip patch antenna.

Gupta et al.,(2018) ,explored the potential of a nature-inspired soft computation technique known as adaptive bacterial foraging optimization (ABFO) for the optimization of the geometric parameters of a compact coplanar waveguide (CPW) fed microstrip patch antenna with imperfect ground structure.

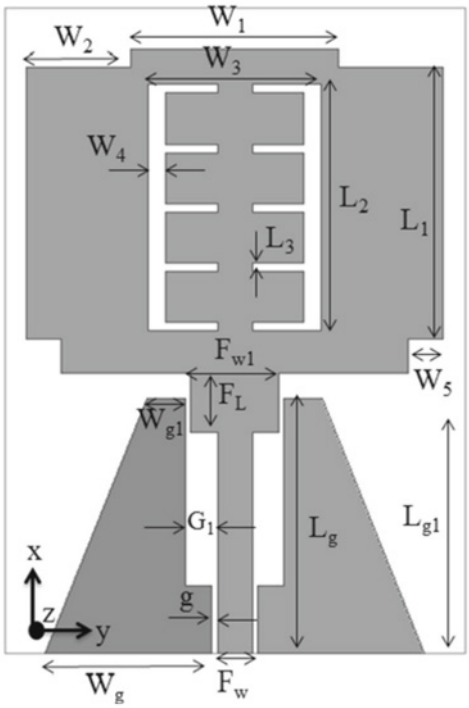

Figure 6. Geometry of CPW fed microstrip antenna with imperfect ground structure

The research study consists of three stages as the process carried out. In the first stage, the antenna was designed and analyzed for the desired parameters using the finite element based electromagnetic simulator Ansoft HFSS 15.0 as in Figure 6. Analytical equations of various design parameters related to other parameters to be optimized are modeled in MATLAB using curve fitting technique. Then, a joint cost function created by combining the individual fitness functions in the optimization algorithm used in the model was evaluated.

In the last part of the work, a variation of the BFO algorithm as the adaptive system

named constrained ABFO is projected and designed to fit the limited constraints imposed by the projected antenna structure. The modified algorithm is effectively used joint optimization of certain design parameters to convert dual-band performance to broadband performance for high-speed point-to-point wireless services.

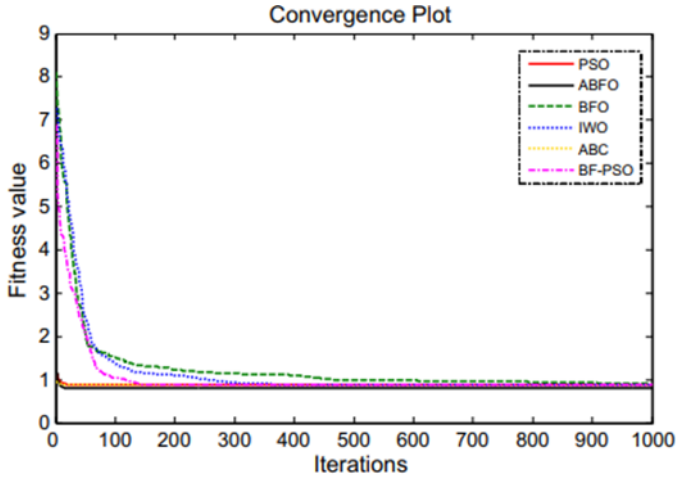

Figure 7. Convergence features comparing ABFO algorithm with other evolutionary algorithms

Design in bio-inspired algorithms using constrained ABFO, original bacterial foraging optimization (BFO), particle swarm optimization (PSO), hybrid bacterial collector particle swarm optimization (BF-PSO), weed optimization (IWO), and artificial bees. The performance of optimization colony (ABC) techniques is demonstrated. The dual-bandwidth of the designed microstrip antenna turns into wide-bandwidth performance (6.95 GHz–9.79 GHz) when the antenna structure with optimized parameters is simulated using an EM simulator.

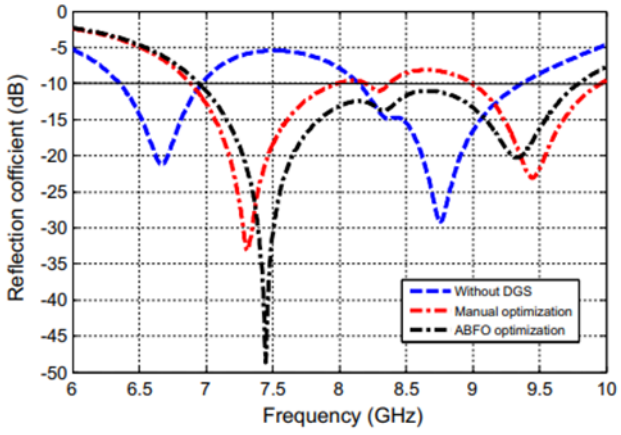

Figure 8. Reflection coefficient characteristics of the antenna optimized for ABFO

The ABFO optimized antenna was fabricated and tested as in Figure 8 to validate its experimental results, which are in close agreement with the simulated results. In conclusion, optimization using constrained ABFO has proven to be a competent approach to improve the performance of high-frequency antennas, especially where numerical modeling techniques are computationally expensive.

Gandopadhyaya et al. 2016, The resonance frequency of the probe fed Rectangular Microstrip Antenna (RMA) is optimized using the Cuckoo Search (CS) algorithm. Investigation was made for different microwave frequencies between 3 GHz and 18 GHz. Three variables of the microstrip antenna as patch length, patch width and position of the feed were used for optimization.

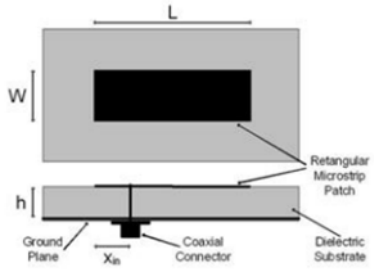

Figure 9. Rectangular microstrip antenna structure

Table 1. Rectangular Shaped Microstrip Antenna Parameter Constraints

Patch Length Upper Limit	$\lambda_0 / 2$
Patch Width Upper Limit	λ_0
Feed Position Upper Limit	Patch Length

Table 1 lists the limitations of the optimized parameters of the microstrip antenna. The following equation is used for the fitness function of the Cuckoo Search Algorithm.

$$Fitness\ Function = |f - fr| + |Z_{real} - 50| + |Z_{im} - 0| \quad (4)$$

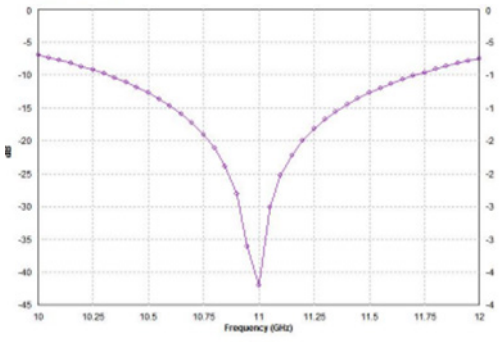

Figure 10. Return loss value at 11 GHz

Figure 10 shows the return loss of the antenna designed using the Cuckoo Search Algorithm at 11 GHz. Observations show that the cuckoo search algorithm is an efficient algorithm for optimal design. It was analyzed by optimizing the radius of the patch (a) and the height of the substrate (h) for a circular microstrip antenna to resonate at 5 GHz.

Firefly Algorithm, one of the metaheuristic optimization algorithms, was used as the optimization algorithm. Optimization was made using the MATLAB R2009b program and the results obtained helped to simulate the antenna model using CST Studio Suite 2011 (Sahoo et al., 2015). The firefly algorithm was run with 10 fireflies in 100 iterations. The fitness function used is shown below.

$$\text{Fitness Function} = |F_{desired} - F_{calculated}| \quad (5)$$

Firefly Algorithm Convergence Graph is shown in Figure 11.

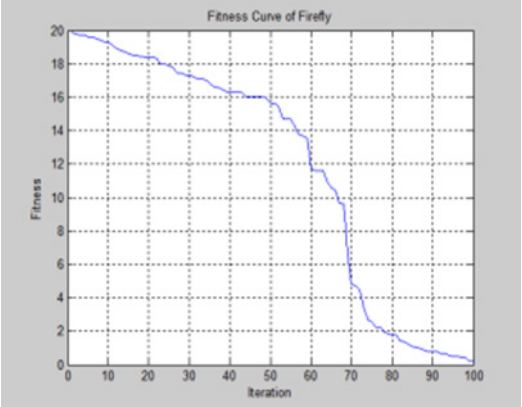

Figure 11. Firefly algorithm convergence graph

In the obtained S parameter graph, the return loss of -26.365567 dB at 5.004 GHz was obtained as in Figure 12.

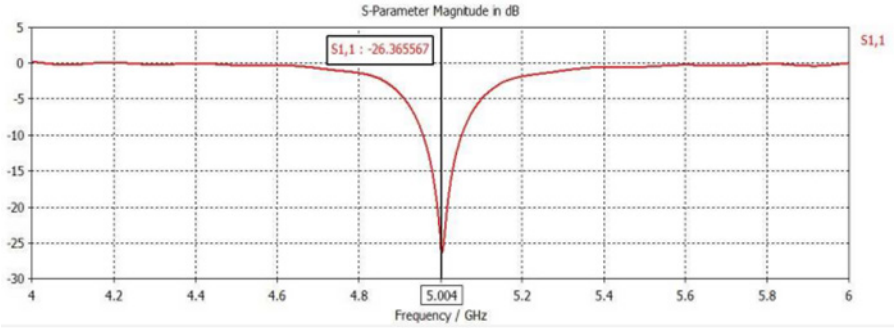

Figure 12. Return Loss Graph obtained in the simulation

Dastranj, (2017) In the literature, a problem approach is presented to optimize microstrip antenna parameters using invasive weed optimization (IWO), a global optimization algorithm used in antenna problems. It provides a general approach to designing printed ultra-wideband (UWB) antennas. Variable geometric parameters of the microstrip antenna were chosen as optimization variables to obtain input impedance and good radiation characteristics together with wide bandwidth.

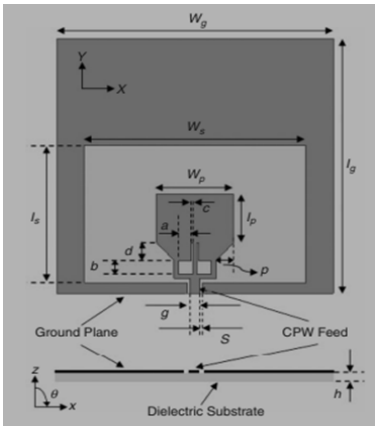

Figure 13. Antenna geometry to be optimized

Table 2: Boundary Conditions of Antenna Parameters to be Optimized

Antenna Parameters	Search Boundary Conditions
a	$0.03\lambda_0 < a < 0.08\lambda_0$
b	$0.03\lambda_0 < b < 0.15\lambda_0$
c	$0.004\lambda_0 < c < 0.02\lambda_0$
d	$0.03\lambda_0 < d < 0.2\lambda_0$
p	$0.03\lambda_0 < p < 0.1\ \lambda_0$
lp	$0.1\lambda_0 < lp < 0.35\ \lambda_0$
wp	$0.2\lambda_0 < wp < 0.6\ \lambda_0$
ls	$0.5\lambda_0 < ls < 0.75\ \lambda_0$
ws	$0.75\lambda_0 < ws < 1.08\ \lambda_0$

The fitness function used for the Invasive Weed Optimization algorithm is expressed by the equation below. E_1 is the relative error of the desired S11 value, E_2 is the difference between the obtained and the desired gain. W is the weight coefficient, m is the number of sample frequencies.

$$\text{Fitness Function} = 1/m \sum\_(j=1)\text{^}m \left[\!\left[W[E\_1+E\_2]\right]\!\right] \quad (6)$$

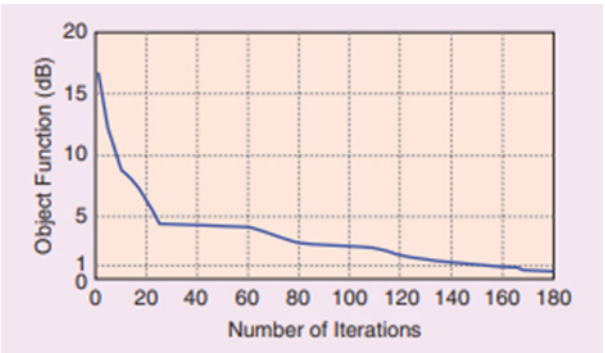

Figure 14. IWO convergence graph

In Figure 14, the IWO algorithm has been successfully used and demonstrated for the optimization of the compact CPW supported printed antenna in the 1.6–11.2 GHz frequency range. Some of the geometric dimensions of the antenna were chosen as the

optimization parameters to be used in the algorithm. Then, the bandwidth, input impedance and antenna gain for the designed microstrip antenna are optimized according to the specifications required by the designer. Antenna geometric dimensions are optimized using the fitness function related to the resonant frequency of an antenna with optimum weighting coefficients to obtain the desired electromagnetic properties over the entire frequency range. At the same time, a small size of 50 mm × 50 mm was obtained by applying constraints to the optimization parameters. The measured results were found to be in good agreement with the full-wave simulations, which proved the validity of the presented optimization technique.

The designed antenna was compared with several previously proposed designs and the comparison results showed that the optimized antenna outperformed other designs.

In the study conducted by Yelken et al., (2020), a Seljuk Star microstrip antenna (SSMA) was designed based on the hybrid Artificial Neural Network model for frequency values in the 0.5-3.5 GHz range. Seljuk Star microstrip antenna is designed on DE104 as double-sided, 1.55mm dielectric and 35um conductor thickness, electrical conductivity 4.37 and loss tangent 0.002. Firefly optimization algorithm is used to update weight values for training in Hybrid Neural Network structure. 272 Seljuk Star microstrip antennas were designed with HFSS software and 90% of this data was introduced to the Artificial Neural Network as training and 10% as testing. In Figure 15, Seljuk Star Shaped Microstrip Antenna structure is seen.

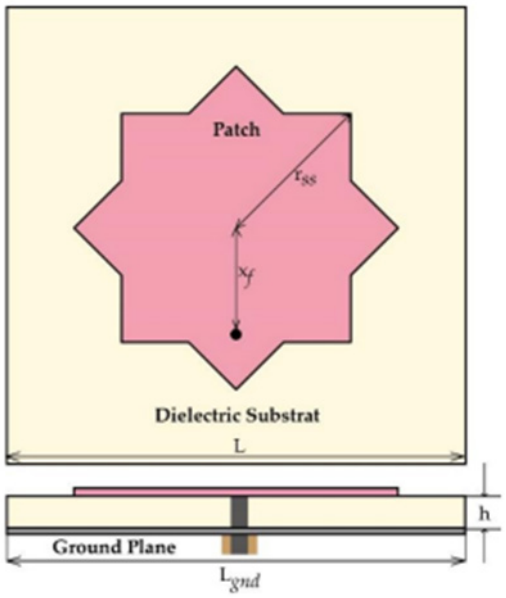

Figure 15. Seljuk Star shaped microstrip antenna structure

In this study, Firefly optimization algorithm was used in Artificial Neural Network training. Mean Square Error (MSE) was used as the cost function of the optimization algorithm.

$$MSE = \frac{1}{n}\sum_{i=1}^{n} (y - \hat{y})^2 \quad (7)$$

The dielectric coefficient ⟦(ε_r), substrate thickness (h), X_f, Y_f, patch radius(r) values of the Seljuk Star shaped microstrip antenna were tried to be trained with the trained Artificial Neural Network. Resonant frequency and Bandwidth are defined as output parameters. It has been seen that the result of the Artificial Neural Network trained with the optimization algorithm is in harmony with the simulation results.

In order to determine the operating frequency of A-shaped patch antennas (APA), two machine learning methods, namely multilayer perceptron (MLP) and K-nearest neighbors (KNN) algorithm models, were used in UHF band applications(Pal,2017).

Firstly, datasets were obtained from 144 antenna simulations with the help of Hyper-Lynx® 3D EM electromagnetic simulator using moment method (MoM) technique. The models entered with 124 APA parameters were trained and their accuracy was tested with 20 APAs. In MLP and KNN models, mean absolute error (MAE) values were calculated for different numbers of hidden layer neurons and different neighborhood values, respectively. Figure 16 shows the A-Shaped Microstrip Antenna Geometry.

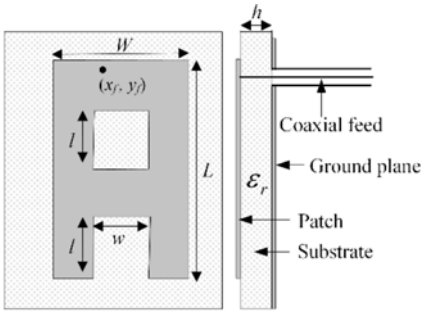

Figure 16. A-Shaped microstrip antenna geometry

The performances of MLP and KNN models were compared during the training and testing process. The lowest MAEs were obtained with 6 hidden layer neurons for MLP and 2 neighborhood values for KNN. These results show that APAs can be successfully applied to computational operating frequencies.

Considering the line ratios obtained between the MLP and KNN models, the MLP model achieves the best performance for the training and testing process. For MLP and KNN training, the working frequencies MAE determined in terms of the problem were obtained as 0.025 and 0.067, respectively. The proposed models were then tested and MAE values of 0.038 for MLP and 0.072 for KNN were achieved. It is seen from the results obtained that MLP and KNN model approaches have short processing time and easy modeling for convenience, and that they give more suitable data for the operating frequency of APAs without using complex mathematical expressions and long simulation

processes.

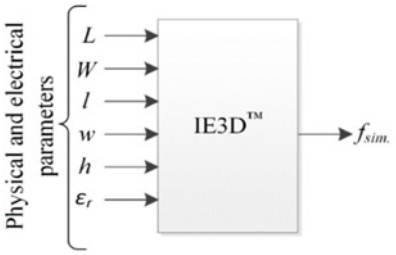

Figure 17. Simulation process

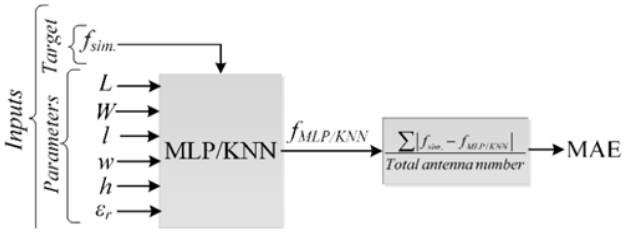

Figure 18. Machine learning process

Figure 17 shows the Simulation process and Figure 18 shows the Machine Learning process. In the study by Akdağlı et al., a method-based artificial neural network (ANN) was first applied to calculate the resonance frequency of the circular ring compact microstrip antenna (ARCMA) created by loading a circular slot in the center of the patch antenna. A multilayer perceptron model based on feedforward backpropagation ANN was used and the created model was separately trained with 8 different learning algorithms to obtain the best results regarding the resonance frequency of ARCMAs in dominant mode.

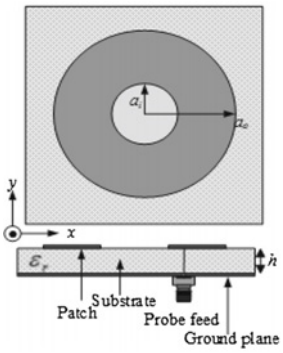

Figure 19. Circular ring compact microstrip antenna structure

Ring inner and outer radius, substrate dielectric coefficient and thickness, and antenna operating frequency were tried to be estimated in ANN training. The resonance frequencies of 80 ARCMAs with various sizes and electrical parameters were simulated with IE3DTM, a numerical electromagnetic calculation tool based on the torque method. Then, an ANN model was created with the simulation data, and 70 ARCMAs were used for training and the remaining 10 ARCMAs for testing. When the performances of 8 learning algorithms were compared with each other, the best result was obtained with the Levenberg-Marquardt algorithm. Figure 20 shows the ANN structure.

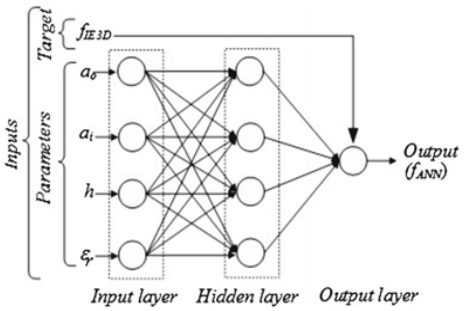

Figure 20. ANN structure

The results obtained in this study show that learning ANN model with LM algorithm can be successfully used to calculate the resonant frequency of ARCMAs without using any complex methods.

In this study, a unique ANN model is proposed for equilateral triangle microstrip antenna (ETMSA) designs used in suspended air as well as glass epoxy suspended surfaces. The two configuration runs used in the study, ETMSA and ETMSA, are discussed in suspended air produced on a glass epoxy substrate (er = 4.3, h = 0.16 cm, tan d = 0.02) suspended above the ground plane using a finite air gap Deshmukh et al., 2018). As the first step to be used in training the ANN model, the ANN network was trained using datasets containing data such as substrate thickness, resonance frequency in terms of working wavelength, simulated patch side length and half wavelength value. Training data sets were taken in the frequency range of 800-6000 MHz in every 400 MHz frequency range. Also, using this trained ANN model, the side length of the ETMSA was estimated for different substrate thicknesses over the 600-6000 MHz frequency spectrum. Figure 21 shows (a) Top and (b) Side Views of the Equilateral Triangle Microstrip Antenna. The ANN model created is given in Figure 2.

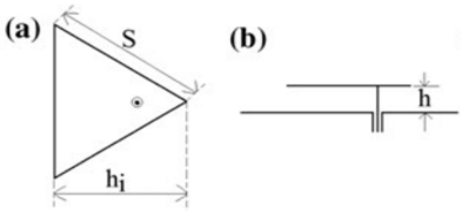

Figure 21. Equilateral triangular microstrip antenna (a) Top View and (b) Side View

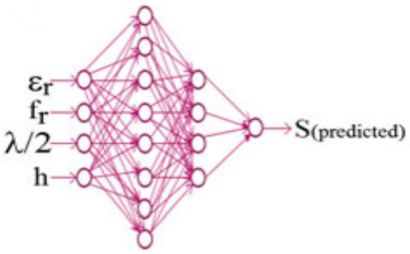

Figure 22. Created ANN model

When simulated using the obtained length, it gives almost the same resonance frequency for ETMSA with less than 2% error for both air and suspended dielectric substrate. Therefore, the proposed ANN model will be helpful in estimating the edge length of ETMSA in air as well as the preferred suspended dielectric configurations in broadband high-gain variations of ETMSA designs.

It offers a deep neural network to re-express the design parameters of an internally fed rectangular microstrip patch antenna. A multilayer perceptron-based deep neural network is proposed to estimate the antenna's resonance frequency and gain values. Rectangular MSA structure and Deep Learning Model Block Diagram in Figure 23 are given in Figure 24(Pal et al..,2019).

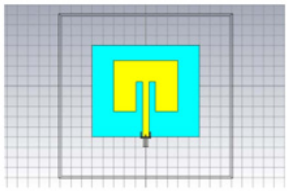

Figure 23. Rectangle shaped MSA structure

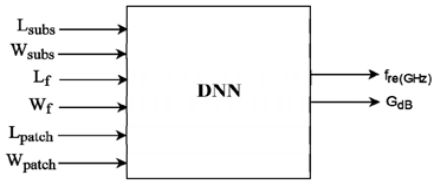

Figure 24. Deep learning model block diagram

Rectangular microstrip patch antenna, dielectric substrate dimensions (L_{subs}, W_{subs}), feedline size (L_f, W_f) and patch geometry dimensions (L_{patch}, W_{patch}), length (L) and width (W) parameters are given as input to the model. Resonance Frequency (freqGHz) and gain (GdB) are estimated as output of the model. Root mean error (RMSE) and mean absolute error (MAE) were used as performance measures of the network. Compared to results simulated by CST, mean absolute percent error (MAPE) values were less than 1.30% and 1.56%, respectively. Therefore, it is proposed that the created artificial intelligence model can efficiently predict the resonance frequency and antenna gain of any size microstrip patch antenna with high accuracy. It is stated that in future studies, with a larger data set to be obtained from microstrip patch antennas, the performance of the network model can be made much more suitable for the problem in the future.

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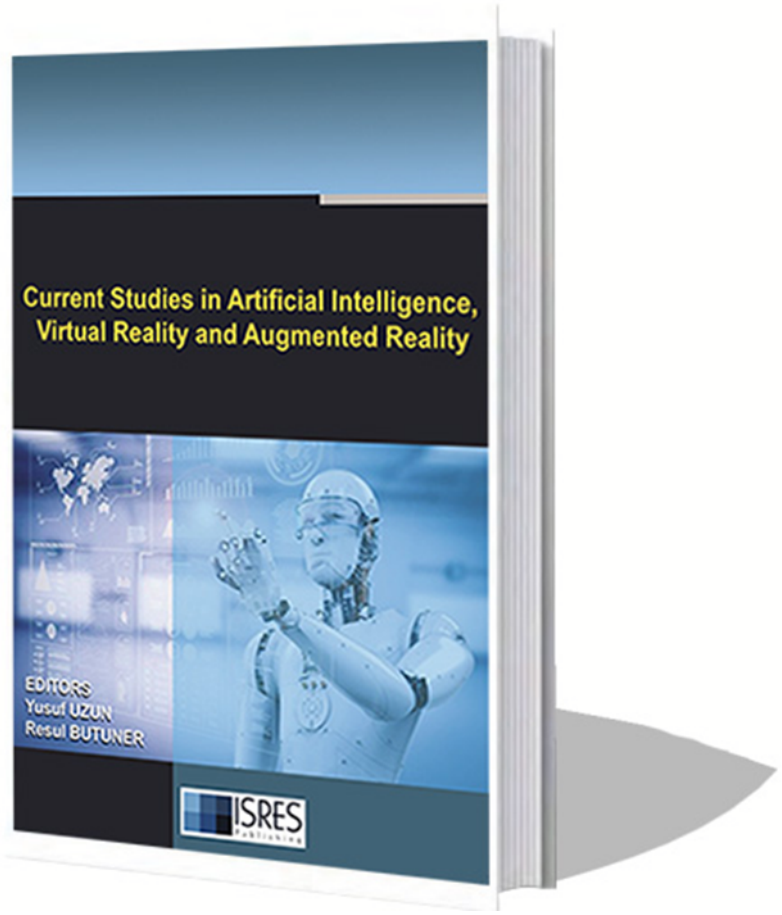

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