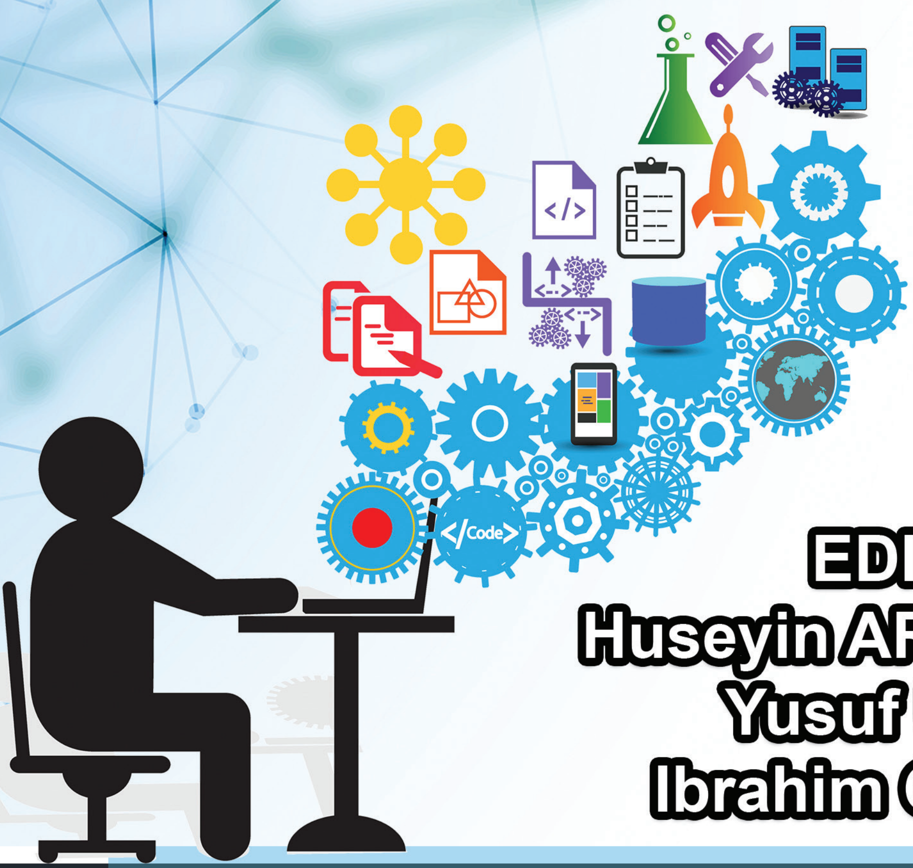
CURRENT STUDIES IN BASIC SCIENCES, ENGINEERING AND TECHNOLOGY 2023



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Current Studies in Basic Sciences, Engineering and Technology 2023

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PREFACE

Dear Readers,

The fields of science, engineering, and technology demonstrate constant progress and innovation in pushing humankind's limits. This work, titled "Current Studies in Basic Sciences, Engineering, and Technology 2023", brings together the most current studies, research, and discoveries in these fields.

Today, research conducted in a wide range from basic sciences to engineering and technology aims to find solutions to the challenges faced by humanity. This book includes studies presented by distinguished researchers in a wide range of fields, from physics to biology, from chemistry to computer science. Each article and chapter aim to provide the reader with in-depth information on the subject.

The content of the book focuses on the challenges, innovations, and discoveries faced by scientists and engineers. In this way, we believe that our readers will not only update their current knowledge but also gain a perspective on the technological and scientific trends of the future.

While preparing this work, we brought together many valuable pieces of content that are the product of intense collaboration between editors and authors. We believe that these studies will foster progress in academia and industry.

Finally, we hope that this book, "Current Studies in Basic Sciences, Engineering and Technology 2023", will increase your interest in the fields of science, engineering, and technology and enable you to gain more in-depth knowledge of these subjects.

We wish you a good reading.

December 2023

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IN THIS BOOK

In Chapter 1, On the one hand, the human spirit and on the other hand the digital spirit (the digital world that we bring to life with algorithms and software), very rapid technological transformations and changes are experienced. These transformations and changes have brought disruptive technologies to every moment of our personal development, education, production-oriented lives when we look at the balance of work and life from the past to the present. In this sense, the Internet of Things, artificial intelligence, cloud, edge computing, 5G, 6G, digital twins, blockchain, artificial intelligence of objects, drones, web3 (built on 3 pillars: blockchain, smart contracts, digital assets) and metaverse can be listed as disruptive technologies, some of which have existed in our lives for decades and some of which have existed in a process we call “new normal”. In today’s world where everything is now interconnected, these technologies make an indisputable contribution to the continuous increase in performance and productivity in developing and developed industrial structures. In this case, it leads us to ensure continuity in production and to achieve positive results on the production value chain. In looking at this context, artificial intelligence as a destructive technology influences our live considerably and as solution partner it strengthens its positions in manufacturing based applications with all of ways.

In Chapter 2, Robotic surgery, which has a fairly new history, is a type of surgical practice in which robotic systems are used to perform surgical procedures. It has various advantages and disadvantages for the patient compared to classical surgical methods. The popularity of robotic surgery continues to grow worldwide. In this process, a new definition for operating room nurses comes to the fore, robotic surgery nursing. A robotic surgery nurse is a specialist operating room nurse who works with the surgeon in the use of robotic systems in surgical operations. While the responsibilities of the operating room nurse in robotic surgery are still being defined, robotic surgery nursing is becoming an indispensable field of expertise in health sciences and for society. In this section of the book, robotic surgery is explained in basic terms, and robotic surgery nursing is examined for the entire perioperative process. Additionally, the relationship between robotic surgery and nursing education and the perspectives of surgical nurses on robotic surgery are also discussed. Robotic surgery is a team effort, just like traditional surgery. For this reason, discussing the role, responsibilities, and position of surgical nurses, who are part of the team, in robotic surgery will create a perspective for the future of surgical nursing as well as robotic surgery.

In Chapter 3, This section presents the “permanent mold casting technology which is one of the special casting methods. This process is a special casting method that is widely used in the casting of aluminum alloys, especially light alloys. AA 7075, 6082, and 6013 aluminum alloys, whose usage have been rapidly increasing in application areas such as aerospace, automotive, military, and defense industry in recent years, were used in permanent mold casting applications. The purpose of the study was to manufacture a metal mold to produce a tensile test bar mold (for manufacturing a single metal tensile bar) in accordance with ASTM B108 standard in metal mold casting applications. This mold was used in melting and casting studies. The tensile bar obtained after solidification as a result of the casting process was processed in accordance with the standards. Tensile tests, hardness measurements, and microstructural examinations were performed using the prepared tensile bar.

In Chapter 4, A composite material is a new material that is formed by the macro-scale combination of at least two or more materials with sufficiently different physical or chemical properties and different from the initial properties. Today, the aerospace, aviation and mobility industries are demanding more and more properties from structural materials. Materials for these industries must have excellent lightness and high strength. These properties can only be achieved with composite materials. Nano-additives are also increasingly being developed to provide exceptional mechanical and electrical properties. Composite materials have more than one advantage over other materials thanks to their properties. They are demanded and preferred due to their many advantages such as long service life, lightness, thermal and mechanical durability, corrosion resistance. Composites are classified according to matrix materials and reinforcing elements. Thermal analysis is a group of methods in which the physical (melting and other phase transitions, glass transition) or chemical (degradation, oxidation) properties of a material are measured as a function of temperature and a controlled temperature is applied to the material.

In Chapter 5, Proteins are fundamental components of cells and are involved in nearly every biological process. Their diverse functions underline their critical importance for the structure, function, and regulation of living organisms. Protein-protein interactions are fundamental for the structure, function, and regulation of cells. Investigating these interactions provides invaluable insights into cellular processes, diseases, drug development, and the overall complexity of biological systems. While there are publicly available databases and resources providing protein-protein interaction data, navigating, integrating, and making sense of this information can present challenges. Researchers often employ a combination of databases, computational tools, and expertise to effectively utilize and interpret PPI data for their studies. In this section of the book, a web based model has been introduced for the analysis of protein sequences, extraction of protein characteristics, and prediction of potential interactions. This model offers the advantage of accelerating the process of protein inquiry, enabling the identification of proteins exhibiting similarities to a specified sequence segment. Moreover, researchers can conveniently access sets of amino acid attributes using this model, facilitating their integration into computational inquiries. Additionally, the predictive capacity of the model for interactions serves as a valuable tool for biologists, aiding in the selection of protein pairs suitable for experimental interaction assessments in laboratory settings.

In Chapter 6, Games and toys help children develop their physical skills. During the games, children use their bodies to move, expend energy, and develop their motor skills. They are also important for mental development. Games contribute to the development of children's thinking, problem-solving, and exploration abilities. Toys encourage children's creativity and develop their imagination in this process. When parents choose games for their children, they prefer interactive playgrounds that develop emotional intelligence, social skills, physical activity, use of technology, and originality and creativity. In interactive playgrounds, children develop their decision-making mechanism at a young age with the experience of changing or directing games according to their wishes.

In Chapter 7, Success in the holiday industry is possible not only by offering a beautiful place to stay but also by understanding the emotional and practical needs of holidaymakers and providing them with a special and unforgettable experience. The studies carried out in this direction will enable businesses to gain a competitive advantage and help them gain a solid place in the sector by increasing customer satisfaction. In addition, the presentation of the flavors of different cuisines gives holidaymakers an unforgettable experience. Another issue that businesses should consider is the various services they offer to families with children to make their holiday experience more enjoyable and comfortable. Another important issue for holidaymakers is the health and safety of the operators. How much attention is paid to hygiene standards and health measures, especially during the pandemic period, plays an important role in the preferences of holidaymakers. Investments in cleanliness and hygiene can enable holidaymakers to determine their accommodation preferences with confidence. Providing the most suitable services for these requests and needs, ensuring customer satisfaction, causes businesses to stand out in the sector.

In Chapter 8, it was thought that the double slit nozzle that we originally designed could solve three main problems. The first of these is to contribute to the transmission of gas from the sonic region to the atomization region at low pressure and speed by controlling the viscosity of the liquid metal and to help the formation of smaller spherical grains. Secondly, to eliminate the solidification problem and the formation of positive pressure at the metal flow pipe end, which is one of the biggest problems of closely matched systems. The third is to prevent the closure of the gas expansion zone, also called the closed transition zone, by keeping the pressure constant with the supersonic nozzle geometry. With the double slit nozzle integrated into the gas atomization system, we can calculate the production parameters (gas pressure, melting temperature, flow pipe diameter, etc.) by optimizing aluminum metal powders with high added value. It was determined that the average grain size of the powders produced in the study using argon gas at a pressure of 35 bar, a melting temperature of 830 °C and a 3 mm flow pipe for optimal efficiency was 25.4 micrometers and the powder shape was spherical by 97%.

In Chapter 9, Breast milk is an essential nutrient for the baby. Infants should receive no food other than breast milk when they are born, be exclusively breastfed for the first 6 months, and then continue to receive breast milk along with other foods until 24 months. Guidance on breastfeeding provided by healthcare professionals is crucial for parents to follow this process. In recent years, population growth, an increase in the number of individuals per healthcare professional, and the impact of disasters such as pandemics have caused disruptions in this process. With technological advancements, telehealth services have also gained prominence within healthcare. One such service is tele lactation, which refers to supporting parents on breastfeeding through the use of technology. These services are delivered synchronously or asynchronously through telephone and text support, video-conferencing, mobile health applications, and online web-based consultations. Telelactation has certain advantages such as increased accessibility, lower costs compared to face-to-face consultations, and allowing real-time evaluation, early detection, and intervention of problems arising during breastfeeding. Therefore, enhancing the knowledge and experience of healthcare professionals regarding these services and further developing services technologically will significantly contribute to increasing breastfeeding rates.

In Chapter 10, we aimed to introduce you rehabilitation robots, which are engineering and technological wonder devices in the field of health. In today's world, where technology is advancing rapidly every moment and we have difficulty in following and keeping up, it has become very important to produce solutions that make people's lives easier. The development of rehabilitation robots in parallel with technology, especially in the last 20 years, has contributed to the ability to move freely, one of the most basic needs of many patients. Rehabilitation robots have become an indispensable part of rehabilitation programs due to their advantages such as reducing the workload of healthcare professionals, enabling patients to participate more actively in the treatment program and performing plenty of repetitive exercises. For all these reasons, we owe a lot to technology and rehabilitation robotics. We hope that our book chapter titled "Rehabilitation Robotics" will be useful to all readers.

In Chapter 11, there will be three different options for sentiment analysis. Analysis will be made through text, photos, and videos. In the video analysis option, analysis will be made by selecting a video recording. The same method will be valid for emotion analysis with photography. In analysis with text, analysis will be performed according to the entered text. Artificial neural network models will be used for all three cases. Which ANN models will be used will be explained in detail in the later stages of the project. Python language will be used to train sentiment analysis models. Since the project will be written as web-based, the server of the application will be prepared with Flask. The interface of the project will be implemented with Vue.js.

In Chapter 12, discusses the advantages of incorporating augmented reality in education. Augmented reality can offer students access to visual resources such as videos and virtual 3D elements, which can be particularly beneficial in fields like mechanical engineering. Providing laboratory infrastructure for each student can be costly, but augmented reality applications can help reduce these expenses. This chapter specifically focuses on the use of augmented reality with a flexural strength tester in a mechanical engineering mechanics laboratory. The application showcases the potential of augmented reality in real engineering applications and provides an illustrative example of the project.

In Chapter 13, In today's modern industrial needs, a gripper becomes a vital element for handling components. The recent technological advances enable gripper-equipped robots to perform many tasks traditionally associated with the human hand, allowing the use of grippers in a wide range of applications. For any gripper to function effectively, its end application along with the work environment parameters has to be kept in mind while designing the gripper. Dexter hands with several fingers seem to be the solution. Two major issues are generally addressed: the design of hands with high dexterity and the development of an acceptable quality of the closure of the seizures through the realization of an adequate closing force. With this in mind, many multi-finger mechanical hands have been developed and tested in different environments. The present paper provides a comprehensive review of dextral and mechanical hands that integrate either three fingers or a thumb opposite to three or four fingers. It identifies their benefits, drawbacks and compares their respective designs by considering the actuation mechanism, the degrees of freedom (DOF), the grasping capabilities with regard to diverse objects and applications. The present paper provides a comprehensive review of mechanical and dextral hands that integrate either three fingers or a thumb in opposition to three or four fingers. It identifies their benefits and drawbacks and compares their respective designs with regard to their diverse objects grasping capabilities and applications.

In Chapter 14, The application of social network analysis in midwifery can provide a straightforward method to understand how various health outcomes may be influenced by human interaction. This book chapter aims to raise awareness about using social network analysis in midwifery practices. In recent years, the application of social network analysis has become a research topic in various fields, including sociology, politics, business organization, and healthcare services, offering opportunities for gaining more insights. However, the use of social networks, particularly in the field of midwifery, has not received sufficient attention. It is anticipated that the social network analysis method can provide insights into the interactions among individuals, midwives, and other individuals.

In Chapter 15, the main methods used to characterize the fracture behavior of Polymer Composites will be discussed. The methods will be classified as the initial notch depth method, the compliance method, the J-integral method, and the critical opening

(CMOD) method. The theoretical foundations of the methods and the advantages and disadvantages of their practical applications will be examined.

In Chapter 16, Microscopy is a powerful tool that allows us to see things too small for the human eye to see. Light microscopes are limited by the resolution of light, but electron microscopes can provide resolution at the atomic level. Electron microscopes can be divided into two categories: scanning electron microscope (SEM) and transmission electron microscope (TEM). While SEM provides information about the surface of a material, TEM helps reveal information about the internal structure of the material. Both SEM and TEM microscopes provide high-precision examination by sending a focused high-energy electron beam onto the sample in a vacuum chamber. This study will discuss SEM and TEM, two imaging techniques that form the basis of advanced research, and reveal the fundamental differences between these two microscopes.

In Chapter 17, The advancements in natural language processing (NLP) and machine learning and their applications in various sectors such as healthcare, finance, and text mining have been widespread in recent years. NLP, which aims to enable computers to comprehend, interpret, and produce human language, has experienced significant progress due to machine learning and neural networks. These advancements have led to the widespread use of NLP and machine learning in sectors like chatbots, virtual assistants, healthcare, and finance. The use of artificial intelligence (AI) for cancer diagnosis, prognosis, and treatment is discussed. It also addresses the potential of NLP for identifying delirium phenotypes and behavioral disturbances in critically ill patients in the ICU. The study presents the process flow and algorithms involved in extracting use cases and actors from textual requirements and demonstrates the effectiveness of the proposed approach through case studies. The potential and effectiveness of these technologies in addressing critical challenges in various domains and the diverse applications of NLP and machine learning in healthcare, suicide risk prediction, neonatal mortality assessment, cancer concept extraction, and the automatic construction of use cases and actors from natural language needs are highlighted. The potential and effectiveness of these technologies in addressing critical challenges in various domains.

CONTENTS

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CHAPTER 1

Artificial Intelligence in Manufacturing

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Introduction

When considering the global market, advanced industrial firms have the potential to secure consistent sustainability in both performance and productivity growth through the implementation of disruptive technologies within the production value chain (Goering et al., 2018).

Based on this argument, it can be concluded that industrial firms that have incorporated disruptive technologies in their production, particularly in the recent years, have experienced advantageous outcomes that must not be disregarded in the context of enhanced productivity and efficiency. Over the past two decades, the productivity of American industrial laborers has risen by 47%, attributed to the application of conventional techniques, specifically Lean Manufacturing, Six Sigma, a customer-centric methodology, and Total Quality Management. However, it is important to note that the incremental benefits provided by these structures are decreasing and require further attention. In this context, it can be inferred that major industrial companies are currently embracing disruptive technologies in their future operations for the sake of sustainable outcomes (Goering et al. ,2018).

Many organizations have begun integrating technologies such as machine-to-machine digital connectivity (also known as the Industrial Internet of Things or IIoT), artificial intelligence, advanced automation, robotics, and additive manufacturing into their production systems. Due to its revolutionary impact, this transformation is deemed the Fourth Industrial Revolution or Industry 4.0 (Goering et al., 2018).

Disruptive Technologies and Manufacturing

Disruptive technologies and innovative trends create opportunities for companies to gain a competitive advantage by improving business methods throughout all value chains. Furthermore, these technologies can ensure production sustainability and efficiency (Goering et al., 2018).

It is important to recognize that these opportunities vary depending on value factors, market dynamics, and different business structures. However, companies that have successfully undergone technological transformations through high levels of technology use to maintain a competitive advantage. For instance, manufacturers experiencing high labor costs and production issues that do not involve quality can significantly decrease their error rates in production from 3% to approximately 0% whilst concurrently improving productivity at substantial levels through the implementation of advanced automation and information technology transformations alongside augmented (Goering et al., 2018).

Similarly, manufacturers who aim to maximize their highly-maintained automation processes could create solutions by analyzing available data to identify micro-losses in capacity concerning the utilization of production equipment. Automatic material handling vehicles and palletizing robots can help manufacturers with high-cost production stages to effectively eliminate material handling personnel (Goering et al., 2018).

Companies that establish appropriate objectives and perform outcome-driven actions to accomplish those objectives can take advantage of cost reductions offered by technological solutions. This enables production-focused businesses to achieve quicker transformations and obtain increased value benefits in the medium and long term by reconfiguring their networks and upgrading their IT and operating technology architecture (Goering et al., 2018).

Leading industrial companies are creating scenarios for utilization in three major areas to acquire value through digitalization across manufacturing and the supply chain: connectivity, artificial intelligence, and automation (Goering et al., 2018).

Connectivity

The realm of connectivity is expanding rapidly through the Internet of Things, with over 8 billion connected devices constituting the infrastructure. This expansion causes digital devices to link with IT-based systems instantly, thus favorably impacting the assessment and decision-making processes concerning any workflow-related matters. Ultimately, it clears the road to resolving productivity hindrances (Goering et al., 2018).

Artificial Intelligence

Advanced analytical and artificial intelligence solutions can be developed using big data related to our business to achieve superior outcomes in production, predictive maintenance, quality management, and demand forecasting. As computing power and data volume increase, machine learning algorithms become increasingly powerful. The full potential of artificial intelligence in decision-making has yet to be realized in production environments that only use a small portion of big data during production phases (Goering et al., 2018)..

In this context, it is evident that businesses in industries like automotive, aerospace, and heavy engineering are adopting artificial intelligence to automate their systems to enhance decision-making processes in response to the challenges they face managing the growing complexity of product types. To achieve this, a corporate production intelligence system can be established which collects data from numerous IoT sensors. This system facilitates the use of predictive intelligence applications for maintenance, quality, and parts supply. It can be said that this approach has increased and will enhance the overall equipment efficiency of the system as well as the percentage of right-first-time deliveries (Goering et al., 2018).

Automation

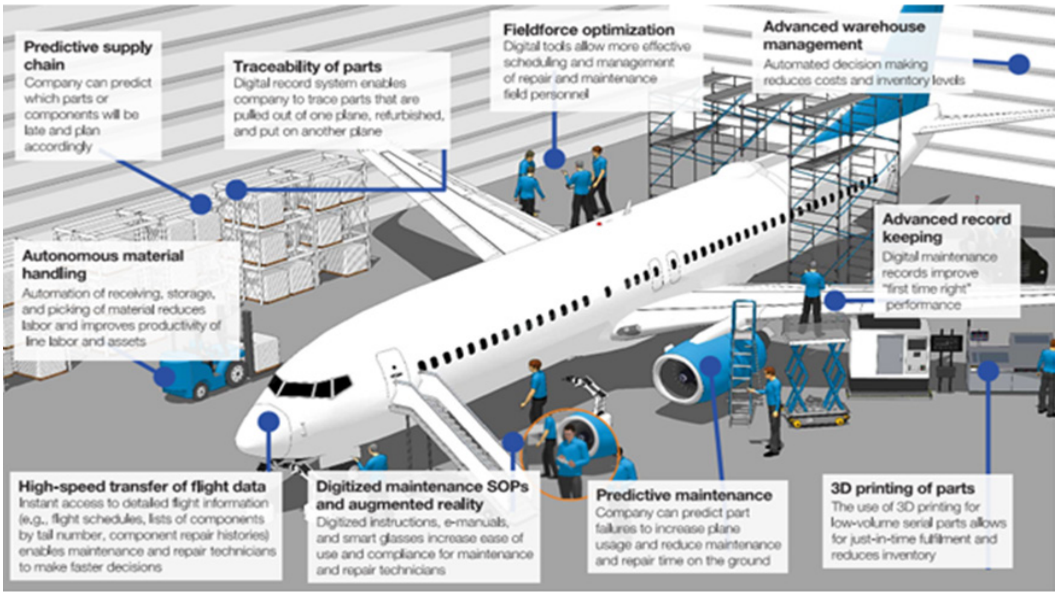
Automated manufacturing has been in existence for many years and has recently witnessed increased integration of robotics and automation into production operations. This is due to the reduced costs of technology development and the growing possibilities of expanding safe and effective work environments for robotic implementation. The implementation of modern robotics technology in product assembly, storage, and logistics activities offers the potential to enhance productivity, quality, and safety. Potential related applications encompass self-driving vehicles employed in distribution centers, computerized systems for managing warehouses, and collaborative robots (cobots) that operate in cooperation with human workers during production processes. Projections anticipate that 60% of manufacturing duties will involve automation in the future, yet such technologies remain underused even amongst pioneers in the field (Goering et al., 2018).

Automating the entire production process, encompassing material handling, quality testing, and packaging, could reduce both direct and indirect labor costs by over 80% in several industries, including electronics (Goering et al., 2018).

These benefits facilitate companies to produce their goods in high-cost countries that are located near appealing markets. As a result, transportation costs are lowered, customer responsiveness is increased, and speed to market is improved (Goering et al., 2018).

Examples of implementing connectivity, intelligence, and automation in an aerospace manufacturing context are illustrated in Figure 1 (Goering et al., 2018).

Figure 1.
Examples of digital production at an aerospace products manufacturer (Reference: www.mckinsey .com (Charalambous et al., 2019))



Artificial Intelligence in Manufacturing As A Disruptive Technology

Companies in a producer position can enhance their business volumes, reduce energy consumption, and increase profits through the use of artificial intelligence (AI) solutions designed specifically for production (Charalambous et al., 2019).

The concept of AI, which first emerged in the mid-1950s, has increasingly become a disruptive technology in our daily lives in recent years. Digital assistants like Alexa and Siri, navigation and weather predictions, the stock market, and applications such as ChatGPT are omnipresent in our daily lives (Charalambous et al., 2019).

When examining the corporate production world, many companies, particularly cement manufacturers, are piloting schemes that exploit artificial intelligence in their restructuring processes (Charalambous et al., 2019)..

To attain enhanced production levels through pilot schemes, it is conceivable that

Artificial Intelligence could empower firms to scrutinize considerable volumes of data they frequently accumulate and assess the outcomes following their private frameworks. This could lead to decreased expenses (Charalambous et al., 2019).

Nonetheless, although AI techniques have yielded conspicuous enhancements in administrative structures and logistics, producing systems still have a ways to progress. For instance, cement plants have implemented automation and digital systems for several decades. However, they are in the experimental phase of integrating AI into production (Charalambous et al., 2019).

For decades, companies have been digitizing their production facilities with supervisory control systems and advanced process controls for production monitoring, observations, and operator decision-making processes (Charalambous et al., 2019).

Even though this digitalization provides great convenience to operators in their work, it is another issue that the need for operators cannot be reduced even though many companies in the producer status have implemented artificial intelligence solutions in analytical and decision support systems. This means that in companies that implement digitization and use artificial intelligence in production, operators rely on their intuition and decision-making skills developed based on their experience (Charalambous et al., 2019).

For instance, in modern control rooms, teams of operators are required to visually monitor the signals displayed on screens and make corresponding adjustments to ensure accurate outcomes. Concurrently, they must engage in tasks like troubleshooting, testing, and experimenting, which challenge the limits of human-scale performance for operators (Charalambous et al., 2019).

Due to the excessive dependence on operator-employee expertise in production-based firms, it can become problematic for someone else to fill the position of an experienced operator after their retirement. The disparity in operators' capabilities can have a direct impact on production performance and profitability. Therefore, the role of artificial intelligence in preserving, enhancing, and standardizing knowledge becomes increasingly crucial. For businesses experiencing challenges in recruiting and retaining proficient operators during the business cycle, the implementation of artificial intelligence algorithms capable of making intricate operational set point decisions independently can promote dependable, foreseeable, and unwavering production outputs (Charalambous et al., 2019).

From this perspective, it could be argued that artificial intelligence has surpassed or has the potential to surpass traditional decision-support technologies that rely on human operators for enhancing operations and streamlining work and production. Furthermore, by considering the dynamism of equipment and market conditions, artificial intelligence will enable companies to create their algorithms in-house at a reasonable cost and achieve sustainable outcomes. This is due to the emergence of the latest, high-performance algorithms, more speedy processing power, and memory units with larger capacity. Furthermore, artificial intelligence can fully automate intricate assignments, allowing for consistent and accurate optimal set points on autopilot. This results in a reduced reliance on human resources for maintenance and, importantly, the capacity to rapidly implement fresh solutions when production schemes and plans are updated by company management (Charalambous et al., 2019).

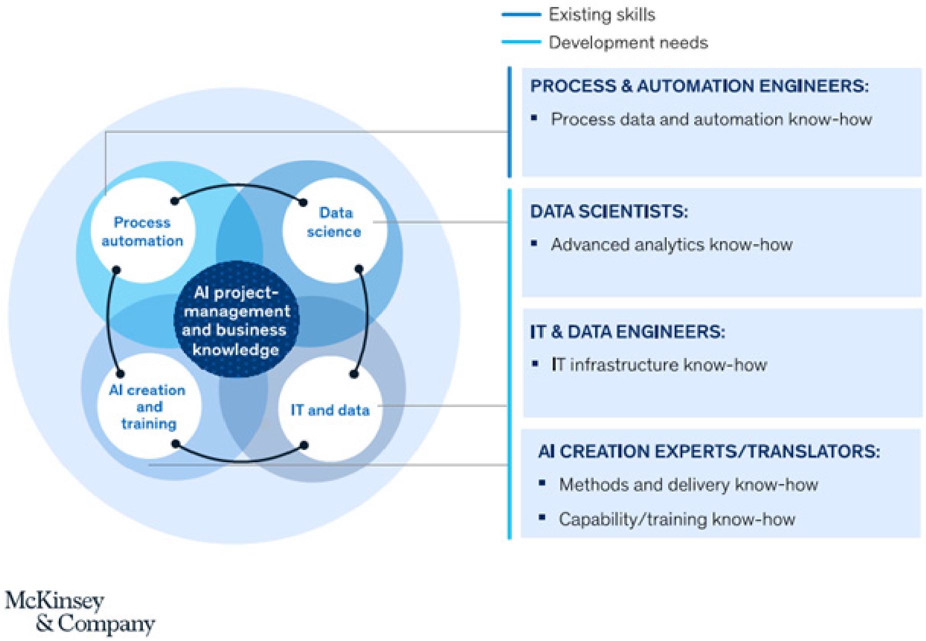
From a manufacturing standpoint, artificial intelligence (AI) has revolutionized the production landscape and presents numerous advantages. Enhanced efficiency, cost-effectiveness, and heightened quality resulting in minimal downtime are just a few of the many potential benefits that can be attained through the implementation of AI-based improvements. Small, medium, and large-scale manufacturers all have access to high-value, low-cost solutions making use of AI. It is essential to acknowledge that AI solutions provide considerable cost and efficiency benefits (Charalambous et al., 2019).

However, if a manufacturer desires to construct and uphold its AI, it must acknowledge that assembling the right team is essential. Individuals who possess expert proficiency in designing, constructing, connecting, optimizing, and sustaining an AI solution are the correct selection - those with worldwide experience who are highly skilled, possess an overview of the big picture, and have the capability to work together harmoniously towards a mutual objective (Charalambous et al., 2019).

But, with the high demand for qualified workers, and the shortage of individuals with the necessary experience to fill open positions, companies should explore the possibility of providing in-house training to current employees, specifically those who possess a background in data engineering. Alternatively, companies may need to look outside their organization to hire external experts when internal talent is insufficient (Charalambous et al., 2019).

Irrespective of the source of the skilled workforce, it is imperative for management to foster particular roles to attain favorable outcomes in AI (Refer to Figure 2) (Charalambous et al., 2019).

Figure 2.
Roles that need to be developed to create in-house artificial intelligence (Reference: www.mckinsey .com ((Charalambous et al., 2019))



Project managers (translators) and AI creation experts are critical as employees with the business skills and experience to manage technical change in the creation of in-house AI (Charalambous et al., 2019).

It is possible for employees to utilize Project Managers and Artificial Intelligence Experts as described below: (Charalambous et al., 2019).

- To offer an impartial viewpoint to staff concerning the objectives they are required to attain about artificial intelligence.
- To create knowledge, foresight, and awareness about artificial intelligence in employees
- To cultivate the competencies of personnel in process engineering, data science, business, and management.

In businesses, experts in domains such as process and production engineering should comprise the individuals who comprehend and incorporate how processes respond and how plants are configured and run. This cluster of specialists requires adequate training to efficiently collaborate with professionals from varying perspectives to construct and exhibit valuable knowledge of optimization models, particularly focused on real-time optimization of AI (Charalambous et al., 2019).

Building an experienced team of IT and data experts in-house is indispensable due to their training in core aspects of AI, comprising computer science, databases, data architecture, modeling, analytics, statistics, and mathematics. It is also prudent to incorporate data engineers competent enough to manage and devise data storage solutions and protocols, along with data scientists who can decode, analyze, and manipulate data and formulate customized models and algorithms (Charalambous et al., 2019).

It is imperative to recognize that effective internal formation and development of artificial intelligence will require advanced tools and applications. Primarily for proficient processing of big data, data visualization, data cleaning, data classification, and data model design, new and strong tools and applications that produce sustainable outcomes will be indispensable. If finding, recruiting, and retaining highly skilled data science talent poses a challenge, utilizing user-friendly data curation and AI design tools can bridge the gap. Additionally, the development of in-house engineering capabilities is of great importance (Charalambous et al., 2019).

New, efficient AI design tools can be developed in open-source languages like R or Python to automate time-consuming tasks such as data extraction, cleaning, structuring, visualization, and result simulation. These in-house apps don't need data science expertise and can be used by data-experienced engineers and other technology-oriented users to build dependable AI models. The tools yield sustainable results and don't call for specialized knowledge (Charalambous et al., 2019).

Why AI is being adopted in manufacturing?

In the context of production processes, artificial intelligence is utilized to analyze data and deliver faster, more accurate, and more sustainable outcomes than a human operator can achieve. This encompasses data supervision and decision-making (Charalambous et al., 2019).

If there is adequate data history and volume to generate predictions about production, employing artificial intelligence (AI) in the production process is feasible. This elucidates why data can yield divergent results when an operator uses identical data on the same machines, and when an analyst interprets the outcomes. Occasionally, monitoring production by observing it on screens can be fatiguing for an operator or analyst, who will interpret the outcomes based on their workload. This is where artificial intelligence can assist and help avoid or entirely eradicate human mistakes, which is also relevant in obtaining consistent results from identical data produced by the same machines. It is vital to remember that production encompasses a holistic approach. In this comprehensive procedure, a piece of data with quantifiable value in one segment of the process might be interconnected with another segment of the same process. As an operator or analyst, if you are solely examining one area, it can be difficult to comprehend the overall picture. Utilizing artificial intelligence may be crucial for an exact and constant solution (Charalambous et al., 2019).

There are five areas where AI is making a significant financial impact (Charalambous et al., 2019).

1. Predictive maintenance involves using historical maintenance data to anticipate a machine's performance under future workloads. This helps determine if and when repairs are necessary and outlines how to carry them out based on previous

outcomes. Employing this approach can significantly reduce downtime.
2. Predicting and mitigating failures through predictive quality can lead to substantial cost savings.
3. Metrics can be used to anticipate product behavior across specifications, resulting in enhanced product quality and reduced scrap.
4. Improving Efficiency and Throughput. Predicting when machines or processes will fail to meet specifications allows for corrective action to be taken in advance, resulting in a reduction of quality defects.
5. Demand and inventory forecasting can result in substantial inventory cost savings. This is achieved by gaining a comprehensive understanding of plant operations and production data to anticipate the movement and demand of essential components.

Best Practices and Potential Pitfalls

There are many questions and doubts about whether it is right to incorporate artificial intelligence solutions into production and related investments. It is important to know what approaches will lead to the successful application of artificial intelligence (Rapp, 2022).

The successful application of AI can be reduced to three approaches: problem, people, and process. Let's take a quick look at them (Rapp, 2022).

Problem: A suitable problem for AI to solve must be carefully defined.

People: The right people are needed, including people from leadership, business, production, IT, technology, digital transformation and finance, all of whom play an important role in the successful application of AI.

Process: There is a necessity to establish a method for addressing the issue related to artificial intelligence. To achieve this, it is essential to ascertain the availability of relevant data to solve said problem.

Figure 3.
Best practices and potential pitfalls
(Sourrce: www.nist.gov/blogs/manufacturing-innovation-blogs (Rapp, 2022))

When introducing any new technology, it is prudent to commence with a pilot, like deploying AI on one manufacturing line. We develop an iterative process to resolve any issues that emerge before expanding the pilot to other machines or lines. Gradual scaling of the technology can prove to be cost-effective, and it will not disrupt the financial structure of smaller manufacturers. It is imperative to prioritize return on investment when constructing a building. ROI doesn't arise from excavating the basement. One should not anticipate immediate returns upon establishing the foundation for the implementation of AI. What are the indicators of a company being prepared to incorporate AI? (Rapp, 2022).

Consider it to be much like a three-legged stool - without all elements in situ, successful implementation is highly unlikely, rendering the company unready for AI (Rapp, 2022).

1. Top-down leadership. Top-down leadership is imperative for the successful implementation of data-driven decision-making in business. Without clear organizational priorities and initiatives supporting the use of data, the endeavor is bound to fail.
2. Invest in collecting data consistently. Without a consistent investment in data collection, disregarding data loss, and individuals saving data, success is unlikely.
3. Identify the issue and calculate the financial benefit. Can you measure the exact monetary effect of a specific problem, such as unexpected halts, waste, or production output? If not, it will be ineffective.

Let's examine some useful tips for effectively implementing AI, grounded in the expertise of Delta Bravo (Rapp, 2022).

It is recommended that mid-sized manufacturers with multiple branches establish a center of excellence for testing AI. Begin AI deployment at a single location with one production line, and then advance to 2-3 lines before expanding to other sites. Assign an implementation leader who is responsible for communicating with your supplier and overseeing this endeavor. This person should not take on a third job (Rapp, 2022).

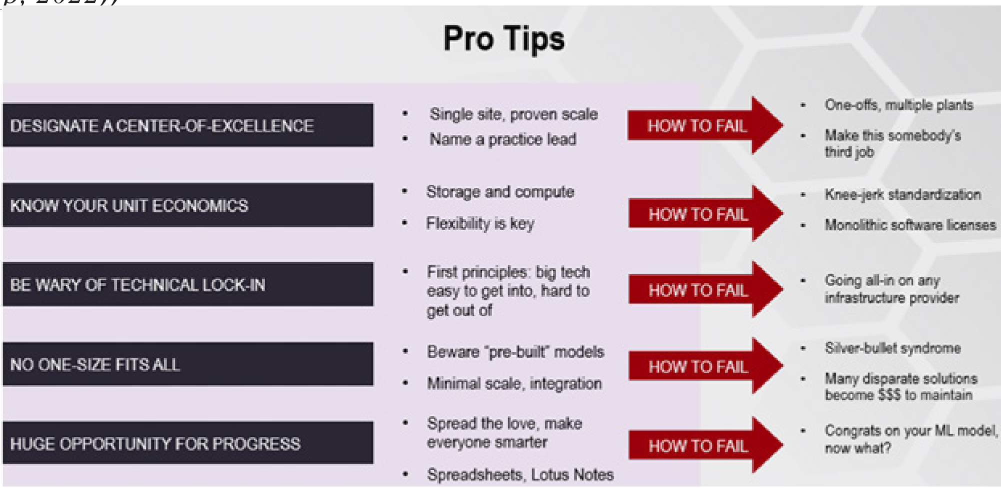
It is important to understand your unit economics. The cloud is often discussed in regard to AI deployment as it provides an effortless method of accessing computing resources. This is accomplished by using CPUs, memory, and disks to create virtual machines with minimal maintenance. However, cloud providers do not disclose their profit structures. While they offer cost-effective data storage, costs rise significantly as soon as computing resources are utilized. It is crucial to have the ability to scale across various cloud providers or storage solutions, depending on which is most economically advantageous (Rapp, 2022).

Be cautious of being locked into a specific technology or platform. Once all of your data is in one cloud provider, migration becomes laborious and costly. Remember that committing to big technology may be easy in the beginning, but difficult to disentangle from later on. Remember, there is no one-size-fits-all solution. Avoid becoming fully dependent on any particular provider (Rapp, 2022).

Some vendors claim to offer a pre-built solution for predictive maintenance that requires only inputting your data. However, it is important to approach these claims with caution. The truly necessary solution involves comprehending your process and tailoring it to your priorities. A pre-built model is not a cure-all and can prove to be more trouble than it's worth (Rapp, 2022).

Instead of relying on a fancy machine learning model, it is crucial to consider many other factors for successful progress. This function has the potential to enhance the knowledge of all employees within the organization, not exclusively to operational personnel. An instance of this would be the automation of spreadsheet processes using machine learning, thus providing the data visualization in an analytical display that updates regularly and is accessible anytime (Rapp, 2022).

Figure 4.
Professional tips (Reference: www.nist.gov/blogs/manufacturing-innovation-blogs (Rapp, 2022))



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CHAPTER 2

Robotic Surgery Nursing

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Introduction

Robotic surgery, which has a fairly new history, is a type of surgical practice in which robotic systems are used to perform surgical procedures. It has various advantages and disadvantages for the patient compared to classical surgical methods. Robotic surgery, which offers various advantages for the surgeon as well as the patient, stands out with its benefits in general, although it creates various risks. For this reason, while robotic surgery technology continues to develop, its prevalence and preference are also increasing. Undoubtedly, this situation changes the practice processes of physicians and nurses and creates different responsibilities.

The popularity of robotic surgery continues to grow worldwide. In this process, a new definition for operating room nurses comes to the fore, robotic surgery nursing. A robotic surgery nurse is a specialist operating room nurse who works with the surgeon in the use of robotic systems in surgical operations. While the responsibilities of the operating room nurse in robotic surgery are still being defined, robotic surgery nursing is becoming an indispensable field of expertise in health sciences and for society. In this section of the book, robotic surgery is explained in basic terms, and robotic surgery nursing is examined for the entire perioperative process. Additionally, the relationship between robotic surgery and nursing education and the perspectives of surgical nurses on robotic surgery are also discussed. Robotic surgery is a team effort, just like traditional surgery. For this reason, discussing the role, responsibilities, and position of surgical nurses, who are part of the team, in robotic surgery will create a perspective for the future of surgical nursing as well as robotic surgery.

Definition, History, and Present of Robotic Surgery

Robotic surgery is a type of surgical practice in which robotic systems are used to perform surgical procedures. These systems usually include a set of robot arms specifically designed to control surgical instruments (Kantarcioglu vd., 2022). The surgeon performs surgical procedures through robot arms, which are usually controlled remotely with the help of a console. Robotic surgery can offer notable advantages, such as being less invasive, less blood loss, faster recovery times, and less tissue damage with smaller incisions (Bastug vd., 2023).

The historical development of robotic surgery started in the middle of the 20th century and progressed its process with the development of technology. The first surgical robots began to be used in the 1980s, but the wider acceptance and use of robotic surgery in the medical field dates to the early 2000s. In 2000, the robotic surgery system called "da Vinci Surgical System" received FDA approval in the United States, and this was a period when robotic surgery began to be used more widely (Karabiyik & Macit Aydin, 2018).

Today, robotic surgery is used in many surgical fields around the world. These systems are used for genitourinary surgery, cardiac surgery, gastrointestinal surgery, orthopedic surgery, and many other fields. There are many commercial robotic surgery systems, such as the Da Vinci Surgical System. These robotic surgical systems allow surgeons to move more precisely, provide better visual control with 3D imaging, and often work through smaller incisions (Akbulut & Calik, 2019).

Robotic surgery is developing in parallel with the developments in technology and medicine and finds more use in surgical applications. However, it cannot be used in a wide range due to some disadvantages such as its cost and training process.

Robotic Surgery Technology in Operating Rooms

Robotic surgery systems used in operating rooms usually include a set of robotic arms designed to control and manage surgical instruments. These systems allow the surgeon to manage the surgery remotely from a console and are often used by a surgical team. The most used da Vinci Surgical System robotic surgery system is shown in Figure 1.

Figure 1.
da Vinci Surgical System (Reference: www.intuitive.com)

The da Vinci Surgical System, developed by the Intuitive Surgical company in the USA, is used in many surgical applications. This system consists of arms that allow surgeons to control surgical instruments, a surgeon's console, and a control panel on the operating table. The surgeon sits at the surgical console of the system and directs the robot arms to the surgical instruments with the help of the control panel next to the operating table. The robotic arms mimic the hand movements of the surgeon with high precision. The robotic arms, in which a camera system is integrated, display the surgical site on a three-dimensional magnified screen. Robotic surgery technology is designed to enable surgeons to work with more precision and controllability. However, this technology may not be suitable for every patient's surgical situation. In addition, special training is required to use this technology effectively and efficiently.

The advantages, disadvantages, and usage areas of robotic surgery are listed below (Isik vd., 2022; Long & Kew, 2018; Martins vd., 2019).

Advantages:

- Less Invasive: Robotic surgery can often be performed with smaller incisions and less tissue damage, allowing patients to recover faster. In addition, less blood loss occurs in surgical procedures.
- Three-Dimensional Imaging: Robotic surgical systems allow the surgeon to see the surgical field in three dimensions, which allows them to work more precisely and in detail.
- Optical Lens: Especially with optical lenses, the image of the surgical area is enlarged, allowing more comfortable operations to be performed on sensitive areas.
- Better Mobility: Robot arms can mimic the surgeon's hand movements more precisely. This, in turn, helps the surgeon to perform more challenging and complex procedures.
- Remote Control: The surgeon can control the robot arms from a console next to the operating table, which provides the surgeon with a more comfortable and ergonomic working position.
- Patient Comfort: The patient gains more satisfaction with the result of robotic surgeries.

Disadvantages:

- Cost: The high cost of robotic surgical systems requires a significant investment in infrastructure for hospitals and health institutions.
- Training Requirement: To use robotic surgery systems effectively, surgeons need to receive special training from specialized institutions. This situation requires additional time and effort on the part of surgeons.
- Shortage of Financial Resources: Financial resource shortages in robotic surgery cause surgeons to not receive the necessary training and experience to specialize.
- Technical Problems: Several technical problems may occur in robotic surgery systems. Due to system failures that may occur during surgery, there may be a risk of causing serious problems in operations.

Uses:

- Genitourinary Surgery: It is used in genitourinary surgical operations such as prostate cancer and kidney cancer.
- Cardiac Surgery: It can be used in cardiac surgery procedures such as heart valve replacement, and coronary artery bypass graft (CABG).
- Gastrointestinal Surgery: It is used in gastrointestinal surgery applications such as gastrointestinal surgery and gallbladder operations.
- Orthopedic Surgery: It can also be used in orthopedic applications such as joint surgery and spine surgery.
- Head and Neck Surgery: It can also be used in head and neck surgery such as thyroid surgeries and tongue root cancer surgeries.

Civil Liability

Civil liability can often vary depending on the specific circumstances of the case. The surgical team should inform the patients as well as the technical team and act by ethical standards. The determination of any civil liability usually requires the assessment of a legal professional (Parlak Boru, 2019).

The legal responsibilities arising from robotic surgical interventions may vary depending on many factors. The surgical team that will use robotic surgery systems must have received the necessary training and gained competence. This is important in minimizing possible errors and complications. In case of lack of training, the responsibility of the surgical team may increase. This situation should not be ignored to avoid legal problems. The patient should be informed about all risks and possible complications before the operation is performed with robotic surgery. The patient should be informed about all the risks of the intervention to be applied and should consider the recommendations. Technical problems or malfunctions may occur in robotic surgery systems. The competence of the surgical team in dealing with such situations can determine the technical responsibility (Parlak Boru, 2019). It is necessary to have the ability and competence to intervene in these malfunctions on-site and quickly.

Robotic surgery should be by standard surgical practices performed in the field of medicine. If established protocols and standards regarding the use of the robotic surgery system are violated, civil liability may arise. Therefore, there should be protocols in which the rules are fully laid out. In any surgical intervention, possible complications should be considered, and the causes of these complications should be examined. If an error or omission is detected, civil liability may arise. In such cases, commissions should be established equitably and equitably, and decisive steps should be taken to resolve the incident. Since robotic surgery procedures are usually performed within a healthcare facility, the organization has responsibility for patient safety and compliance with standards. The surgical team and the healthcare provider must have appropriate insurance and legal protections. This can protect the company financially in case of possible civil liability.

Informatics Competence of Healthcare Personnel

The informatics competence of healthcare personnel in robotic surgery is critical for safe and effective surgical applications. The effective use of technology by healthcare personnel enables them to solve problems that occur and provide quality service in patient care (Merih vd., 2019).

Since robotic surgery is a surgical application that requires the effective use of advanced technology, the informatics competence of healthcare personnel is of great importance. Healthcare personnel, especially surgeons, should have the competence to use robotic surgery systems effectively. Their understanding of the controls and other features of robotic surgery systems greatly helps them to increase their usage skills (Borycki & Foster, 2014).

In cases where technical problems occur in robotic surgery systems, healthcare personnel should have the competence to identify and solve these problems. Imaging systems used during robotic surgery are usually high-resolution and three-dimensional. Healthcare personnel should be able to monitor and analyze the surgical process by using these imaging systems effectively. Robotic surgery often generates large amounts of digital data. Medical personnel must be able to effectively analyze and interpret this data correctly. The security of the data used in robotic surgery systems is of great importance. Healthcare professionals should be conscious about protecting the patient's privacy and ensuring the security of the data.

Healthcare personnel should follow the developments in the field of robotic surgery and continue to receive regular training. This will help them adopt new technologies and methods. Robotic surgery often requires multidisciplinary teamwork. Healthcare personnel should have effective communication and collaboration skills in harmony. In the process of patient care and recovery after robotic surgery, healthcare personnel should be able to effectively educate patients on robotic surgery results, care processes, and monitoring processes (Borycki & Foster, 2014).

Overview of Robotic Surgery Nursing

A qualitative descriptive research article published by Kang and colleagues in the journal Computer Informatics Nursing in 2016 examining nurses' experiences of working in robotic surgery identified major themes in the field of robotic surgical nursing that we discuss today and are still trying to shape. Patient safety in robotic surgery, control of robot functions, errors and malfunctions caused by the robotic system, feeling of burden on the robotic surgery team, and finally the need and desire for more information and training. Just by taking these themes as a reference, the burden and roles arising from robotic surgery for surgical nurses are understood (Kang vd., 2016).

Surgical treatment offers faster and more radical solutions than medical treatment for various health problems. On the other hand, more complex and complex units, more technical equipment, and technological applications are required. Today, many surgical procedures require the use of high-precision devices and materials. All professional healthcare professionals involved in surgical treatment and care must have the skills to use devices and materials related to their field of responsibility and must be able to understand and manage the technological impact. This is possible if each member of the team gains qualifications in technological devices and applications. Just as a chain is only as strong as its weakest link, in surgical units, which are considered a high-risk environment, the success of the patient's treatment and care depends on the quality of each member of the healthcare team. Surgical nurses undertake various duties at multiple points during the treatment and care process. The surgical patient experiences a three-phase experience called the perioperative period. The first phase of the process is the preoperative period when the decision for surgery is made and the necessary procedures for the surgery are performed. This is followed by the intraoperative period, which takes place in the operating room, and finally, the postoperative period, which begins with the end of the surgery. The intraoperative period takes place in the operating room, in an isolated environment. The roles of scrub and circulation nurses working in this phase are quite different from surgical nurses working in the perioperative and postoperative phases. Only operating room nurses work during the intraoperative period of the surgical process. Although surgical nurses have very different duties and responsibilities in each phase of perioperative care, the main goal of surgical nurses is to provide and continue patient-centered care without interruption.

From the past to the present, operating room nursing, which covers the intraoperative period, has been accepted as the most technical part of surgical nursing. However, today, with the development and increasing use of technological equipment and applications in surgical treatment and care, the entire surgical process has turned into a more technical experience. The perioperative process carried out in line with all the technical and technological developments that will be explained in this section does not change the focus of surgical nursing. The focus is on people. Surgical treatment and care, which takes place within a complex network of machines, puts the responsibility on nurses to complete the surgical process safely for the patient. While all the technical equipment and devices used make more sensitive and critical surgical interventions possible, they also create various risks. For this reason, the roles played by surgical nurses are extremely important and vital in robotic surgery Redondo-Sáenz vd., 2023; Uslu vd., 2019).

Perioperative Care in Robotic Surgery

Developments in robotic surgical technology and its widespread use are changing the operating room environment and affecting the way nurses provide care to patients. The nursing discipline is in the process of producing immature scientific knowledge about care and other nursing roles in robotic surgery. The main reason for this is that robotic surgery is at the beginning of its development and widespread use. Current publications cover the preoperative, intraoperative, and postoperative care and roles of the nurse. The references used in this section specifically focus on informing and supporting the patient about the robotic surgery process, giving the patient an appropriate surgical position for robotic surgery, and drawing attention to the risks and complications associated with this position and the prolongation of the surgery time. In general, it has been emphasized that, in addition to the reported advantages of robotic surgery, it also poses risks in terms of patient safety and that the nurse has an important role in ensuring patient safety. Additionally, attention is drawn to the responsibility of the operating room nurse in preparing the robotic surgical system for surgery (Martins vd., 2019).

Preoperative Period

Preoperative preparation is important as it positively affects the success of the surgery. Preoperative care in robotic surgery is like that in laparoscopic surgery. Completing physiological, psychological, and legal preparations, and informing and educating patients and their relatives are the issues of preoperative care. Patients and their relatives should be provided with adequate information about the robotic surgery procedure, questions about robotic surgery should be answered, and the patient's fears and concerns about the surgery should be eliminated. It is part of the nurse's professional responsibility to provide information and support to the patient when necessary. While the surgical treatment process is relatively more complicated than other options, robotic surgery can increase the level of unknowns and anxiety for the patient. For this reason, the clinical nurse should perform the function of informing and providing support to the patient by eliminating their own knowledge and training deficiencies and strengthening their skills based on robotic surgery. To provide qualified perioperative care in robotic surgery; i.) nurses should receive training on robotic surgery and patient care undergoing robotic surgery, ii.) professional and institutional standards should be developed in robotic surgery practices to ensure a quality environment that will ensure the safety of surgical patients, iii.) the knowledge required by robotic surgery in the patient's preparation for surgery, It is important to develop the materials required for training and support initiatives with a technological approach. All of these are beyond standard surgical nursing roles and require special effort to translate into practice (Martins vd., 2019; Francis, 2006; Lichosik, 2014).

Intraoperative Period

The scrub and circulation nursing roles for the operating room also apply to robotic surgery. The main division of labor should be in line with the principle of working within the limits of surgical asepsis. The nurse is responsible for directing the robotic device under the guidance of the surgeon during the intraoperative period. Unlike classical surgery, the preparation and calibration of the robot for surgery, the functions of sterile parts, and connector connections are within the responsibility of the nurse (Martins vd., 2019; Dusik-Fenton & Peabody, 2011). Table 1 shows the additional responsibilities of the operating room nurse arising from robotic surgery.

In robotic surgery, the operating time may be longer. Additionally, this form of surgery may require the patient to be placed in a position where the robotic arms will work most efficiently. This position can be challenging for the patient and sometimes even cause positional damage. Prolonging the duration of surgery and keeping the patient in the same position for a long time increases intraoperative risks and complications. To avoid these risks and complications, ensure patient safety, and minimize errors, it is important to use a standardized checklist specific to robotic surgery. Existing checklists may be insufficient in the transition from classical surgery to robotic surgery. For safe and successful surgical operations, current practices should be evaluated, evidence-based current checklists should be developed and standardization in this field is needed. Responsibility and space conflict in the operating room environment may be another risk for robotic surgery. Considering the importance of the operating room nurse in coordination, it can be said that they should also take responsibility for reducing this risk (Martins vd., 2019; Hortman & Chung, 2015).

Table 1.
Additional Responsibilities of the Operating Room Nurse in Robotic Surgery

- Providing and checking cable and connector connections of robotic equipment
- Checking robotic equipment and tools and making them ready for use
- Preventing contamination of tools and robotic equipment in the sterile field during surgery and protecting the sterile environment
- Detecting systemic and technical problems, and damaged equipment and reporting them to the relevant unit to resolve the problem.
- Implementation of emergency procedures in case of a malfunction/problem with the robotic system during surgery; Completion of appropriate surgical preparation for the procedure before surgery
- Making the necessary preparations in case of switching to laparoscopic or open surgery.
- Positioning the patient appropriately for the surgery and supporting pressure points
- Evaluating the patient's condition throughout the surgery and protecting it from possible injuries and risks
- Supporting the coordination between the operating room team, especially the surgeon, and the robotic system

Postoperative Period

Postoperative patient care in robotic surgery is in line with standard care principles. Due to the advantages of robotic surgery, the patient's hospital stay is generally shorter. Pain control is better, mobilization is faster, and the risk of infection is lower. Patients can return to daily life in a shorter time. This shortens the nurse's intervention time in postoperative evaluation and especially discharge education. It may be necessary to change the content and method of postoperative patient education. In addition to face-to-face education and information, the training content can be given to the patient in writing. Moreover, information-education resources should be recommended for patients and their relatives through web applications, mobile applications, and other digital media channels. The patient's questions regarding postoperative care should be answered, and the communication channel should be kept open for post-discharge information and training needs (Francis & Winfield, 2006).

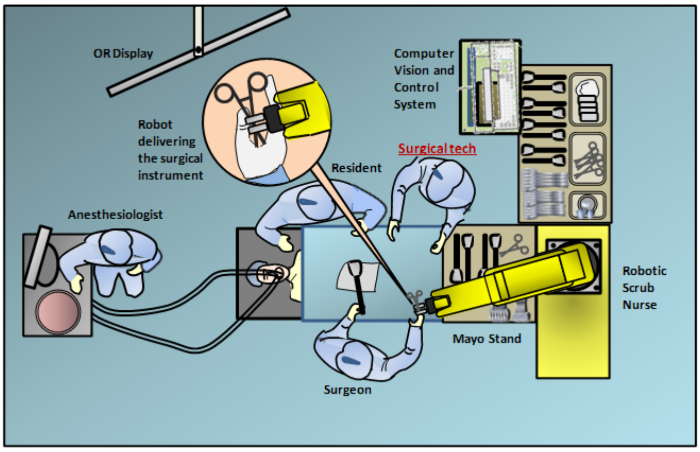
Nurses' Perception and Approach Towards Robotic Surgery

The care service provided in the preoperative and postoperative periods makes the nurse one of the healthcare professionals who have the most communication and interaction with the patient. In the intraoperative period, in addition to patient care, he was responsible for the preparation and coordination of the robotic surgical system and operating room. In robotic surgery, the nurse is always with and at the service of the patient throughout the perioperative process. These factors make nurses' perceptions and opinions about robotic surgery important for the future of robotic surgery. Nurses' perceptions and opinions regarding robotic surgery are also necessary to plan and update nursing education.

The literature examining nurses' views on robotic surgery is just beginning to emerge. According to the current literature, nurses' opinions and approaches to robotic surgery are generally positive. A significant portion of nurses consider robotic surgery preferable for both their patients and themselves. Although it is anticipated that the surgery will take longer and there will be an increase in risks due to the patient remaining in the same position for a long time, the advantages provided by robotic surgery are positively reflected in nursing care. The surgery can be completed with less invasive procedures, delicate interventions are possible with less incision and blood loss, and the level of success in difficult procedures increases; It positively affects the success of the treatment and the healing process. Thus, it is easier for the patient to recover and mobilize in the postoperative period. Early mobilization and recovery support the patient's independence and return to daily living activities. All of these are among the surgical nurse's care goals. The widespread use of robotic surgery offers a new area of expertise for nurses. The surgical nurse can be a bridge between the patient and other members of the team for robotic surgery. Although nurses' perceptions and opinions about robotic surgery are positive, some of them are experiential and the other important part is internet-based. To improve nurses' perceptions of robotic surgery based on scientific knowledge, the educational content and the curriculum in general need to be updated. Although nurses' perceptions and attitudes are positive, the lack of scientific knowledge also brings anxiety and reservations. Changes in nursing roles, patient and team expectations from the nurse, performance adequacy, standardization of authority and responsibilities, and the complexity of technology are among the main sources of concern. Eliminating these concerns and eliminating reservations will undoubtedly be possible through education. Failure to provide this adequately may result in nurses' resistance to technological change, alienation from their jobs, and a decrease in the quality of care (Alcan vd., 2019; Moloney vd., 2023; Uslu vd., 2019).

While technology transforms and optimizes some business processes in the healthcare industry, it can also cause changes in some professional groups. This chapter of the book you have in your hand covers the change that robotic surgery has created in the nursing process. Similar transformations and changes also apply to surgeons. The question arises whether the technological transformation and change provided by robotic surgery should cause professional concern for surgeons and nurses. Could Gestonurse, which produces an alternative to the surgeon-scrub nurse collaboration, be a symbol of an embodied source of professional anxiety? Gestonurse is a robotic system that acts like a scrub nurse in delivering surgical instruments to the surgeon, promising speed, and fewer errors. It is argued that Gestonurse, a robotic surgical nurse, can prevent assisting errors, especially those caused by communication gaps (Jacop vd., 2012). Despite such alternatives, technology continues to be used to support healthcare professionals and improve business processes. The human touch, empathy, and personal experience remain as important for the surgeon as for the patient. The human factor within the framework of professional healthcare professionals plays an indispensable role in the healthcare sector and will probably continue to do so.

Figure 2.
Scrup Nurse Gestonurse (Reference: https://web.ics.purdue.edu/~jpwachs/gestonurse/)



Increasing the knowledge level of surgical nurses about robotic surgery through various means, such as in-service training, reduces their anxiety and supports the increase in the quality of care. The training supports nurses to play a more active role in robotic surgical care. For this reason, it will be useful to update knowledge through regular and continuous in-service training (Ergin vd., 2023).

Nursing Training for Robotic Surgery

In this section of the book, as explained in 3 subheadings, perioperative nursing care shows similarities and differences in robotic surgery. Robotic surgery procedures differ from current practice, especially in the intraoperative period. However, there are also significant changes in preoperative and postoperative procedures. In addition to providing complete care in robotic surgery, the necessary training for the team to work in harmony should be added to the formal curriculum. Training programs for nurses for patient care in robotic surgery will enable them to gain professional competence and confidence. However, with updated training in this field, risks for patients can be reduced and positive results in nursing care can be contributed. Nurses who are members of the robotic surgery team should improve themselves in robotic surgery and increase their knowledge by participating in in-service training, congresses, conferences, and training and courses organized by companies that install robotic surgery systems. Well-trained personnel are as important as technological equipment and tools for the success and development of robotic surgery. Nurses who are professional in this field; should also undertake tasks such as guiding and supporting inexperienced people in the field, strengthening their competence, and contributing to the development of standards (Francis, 2006; Sarmanian, 2015).

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CHAPTER 3

Investigation of Structural Properties and Gravity Die Casting Technology in Aluminium Alloys

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Introduction

This section presents the "permanent mold casting technology", which is one of the special casting methods. This process is a special casting method that is widely used in the casting of aluminum alloys, especially light alloys. It is preferred for complex-shaped parts with narrow dimensional tolerances and a large number of parts. Special quality cast iron or steel is generally used as the mold material, which must have the refractoriness required by the metal to be cast. Up to 3,000-10,000 pieces of parts can be obtained by pouring iron-based materials into permanent molds, and up to 100,000 pieces of parts can be obtained by pouring low-melting materials such as aluminum into permanent molds. Since the cooling during solidification in the metal permanent casting method is faster than in sand molds, the internal structure is finer-grained. To increase the life of the mold, the mold cavity is coated with heat-resistant materials, and in this way, removing the part from the mold also becomes easier.

Al-Si alloys are widely used casting components due to their excellent casting properties, thermal properties, expansion coefficient, and corrosion resistance. It is known that Si element is added to Al alloys to increase the viscosity (improve the fluidity) of the liquid metal during casting, prevent hot cracking after casting, and reduce the density of the alloys (Timpel et. al., 2021; Nogita et. al., 2004). However, although silicon Al alloys have excellent corrosion resistance, the fact that their microstructure is in the form of plate/needle-like morphology negatively affects the mechanical properties (Rao et. al., 2009). To eliminate these disadvantages in the alloys, preserve corrosion resistance, and provide grain refinement/modification, elements such as strontium, sodium, antimony, calcium, scandium, and titanium are used for the modification of Al-Si alloys (Yan et. al., 2011; Jiahong et. al., 2018; Zhang et. al., 2022; Kim et. al., 2004; Li et. al., 2021). The modification of Al-Si alloys has become a common foundry practice used in recent years for both the improvement of mechanical properties and the preservation of corrosion resistance (Lian et. al., 2023). There are many scientific studies in which alkali metals, alkaline earth metals, and some earth metals are used for Si modification (Kobayashi et. al., 1985; Lu & Hellawell 1985; Jie et. al., 2003; Makhlouf & Guthy 2001; Bian & Wang 2000). The most commonly used elements commercially are Na, Sb, and Sr. Na increases microporosity, while Sb makes the modification effect permanent. However, the performance of Sr modification exhibits a relatively higher effect than the others, and this effect lasts for a long time; therefore, it needs to be investigated in detail (Hegde & Prabhu 2008; McDonald et. al., 2008; Lian et. al., 2002; Luo et. al., 2023; Lee et. al., 2023).

In a study conducted by Zhao et al., Al-Si-Mg alloy was modified by adding TiB_2 and the alloy's strength-ductility property was investigated. They emphasized that the TiB_2 additive has positive effects on the development of strength-ductility properties (Zhao et. al., 2022). In a study that investigated the effect of Sr modification on the microstructure and thermal conductivity of hypoeutectic Al-Si alloys, it was reported that the plate/needle-like microstructure decreased after Sr modification, thermal properties improved, and the increase in thermal conductivity reached a maximum level (Gan et. al., 2020). In another study, the authors stated that the eutectic modification process plays an important role in improving all mechanical properties of Al-Si alloys by changing the morphology of eutectic silicon. In addition, they reported that Sr addition is sufficient for a good eutectic modification and activation of the twinning mechanism in hypoeutectic Al-Si alloys (Gursoy & Timelli 2020).

6082 aluminum alloy (deformed Al-Mg-Si series alloy), which is one of the alloys used in permanent mold casting applications (along with 6005, 6061, and 6063), has advantages such as medium strength, good weldability, and corrosion resistance. It is mostly used in aerospace, transportation, and structural engineering applications. This alloy cannot be hardened by machining; however, it can be strengthened by heat treatment to obtain a higher strength, while ductility decreases in this material (Zhao et. al., 2020; Zhang et. al., 2020). This alloy provides the most favorable mechanical properties after the aging heat treatment process. 6082 aluminum alloy has recently become more widely used in automotive and aerospace applications because lightness is emphasized in these applications (Fadida et. al., 2015; Puga et. al., 2015; Asgari et. al., 2014). In addition to this alloy, the use of the 7xxx series (Al-Zn-Mg-Cu system), known as AA 7075 wrought aluminum alloys, is quite limited in casting due to the high hot tearing sensitivity of this series. Unlike some casting aluminum alloys, since the 7xxx series creates a wider solidification range, it maintains its ductile structure, especially over a wide temperature range. In addition, unstable solidification of 7xxx series alloys often leads to the occurrence of different microstructure and mechanical properties. Therefore, it can be said that the defects, microstructures, and mechanical properties of 7xxx series alloy parts prepared by casting are more difficult to control compared to wrought aluminum alloys (Yue 1997; Fang et. al., 2020; Jahangiri et. al., 2017; Guan et. al., 2016).

In this study, a new permanent mold was produced for casting experiments based on the ASTM B108 aluminum standard tensile bar mold. This mold was used in melting and casting studies. AA 7075, 6082, and 6013 aluminum alloys, whose usage have been rapidly increasing in application areas such as aerospace, automotive, military, and defense industry in recent years, were used in permanent mold casting applications. Following the melting processes of the mentioned aluminum alloys, the casting process was carried out at 800°C into the permanent mold. After the casting applications, the produced permanent mold was found to be suitable in terms of solidification and standard tensile bar in terms of runner and riser (feeder) design. The tensile bar obtained after solidification as a result of the casting process was processed by the standards. Tensile tests, hardness measurements, and microstructural examinations were performed using the prepared tensile bar.

Material and Methods

In this study, the metal mold casting technology, which is mostly used in the casting of aluminum alloys, especially light alloys, was investigated. The purpose of the study was to manufacture a metal mold to produce a tensile test bar mold (for manufacturing a single metal tensile bar) by ASTM B108 (Twilley 2012) standard in metal mold casting applications. In addition, it was aimed to provide error-free casting part production suitable for casting three different aluminum alloys (AA 7075, 6013, 6082) used in the study. Before the applications of casting to the metal mold, casting applications were carried out after the necessary runner and riser design to prevent any casting errors that may occur due to the mold both in industrial and experimental works.

The melting processes were carried out in a Reverber-type oven with a natural gas burner. Three different aluminum alloys supplied by Eti Inc. were used in the melting processes. The casting temperature of aluminum alloys was determined as 800 °C. Samples were taken from the oven to determine the chemical compositions of melted aluminum alloys. Three repeated measurements were made on different points of the samples, and spectral analysis results were obtained based on these measurements. Spectral analysis applications were performed using the Spectralab brand M5 model analyzer. After the melting process, before the casting operations, the cleaning and lubrication process of the permanent mold was carried out using a certain amount of graphite powder. Then, the permanent mold was subjected to heating with a vacuum cleaner (approximately 100°C), and preheating was applied to it. Finally, the melted liquid aluminum alloy was taken from the oven and permanent mold casting processes were performed. Melting and casting processes are shown in Figure 1.

Figure 1.
Melting and casting process

The permanent mold to be used for the production of a single tensile test bar was manufactured using H13 hot work tool steel. The image of the permanent mold used in the casting applications of aluminum alloys is presented in Figure 2. In addition, the metallic tensile bars obtained after the separation from the mold after the solidification process following the casting applications of 6013, 6082, and 7075 aluminum alloys are also shown in Figure 2.

Figure 2.
Metallic mould and tensile test specimens

The dimensions of the metallic tensile bars obtained as a result of the casting processes into the permanent mold are given in Table 1. The tensile tests of the tensile bars obtained after the casting process were performed on the DARTEC brand M9000 model 600 kN Universal Tester by TS EN ISO 6892-1 standards. Hardness measurements of aluminum alloys after casting application were carried out on REICHERTER brand BL 3 model experimental device by TS 139-1 EN ISO 6506-1 0 standards. Hardness measurements of the experimental samples were performed by applying a 0.5 mm^2 ball tip and a 500 kg load.

Table 1.
Tensile test bar dimensions

Test piece diameter do (mm)	Diameter of head d1 (mm)	Length of head h (mm)	first measure length Lo (mm)	Length of tapered part Lc (mm)	total length Lt (mm)	Curve radius R min
10	M18x2.5	25	50	60	110	10

The general metallographic studies of the cast aluminum alloys were carried out in terms of microstructural characterization. The cast aluminum alloys were subjected to sanding, polishing, and etching processes with Keller's solution (0.5 HF-1.5HCl-2.5HNO_3-95.5 H_2O), respectively. To understand the microstructural transformations of cast aluminum alloys and to determine the broken surface morphologies exhibited by the experimental samples after tensile test experiments, the Leica optical microscope was used in experimental studies.

Experimental Results

6013, 6082, and 7075 aluminum alloys were used in permanent mold casting technology applications. After the liquid metal was melted, casting applications were made with the permanent mold, and the production of tensile bars for each alloy was completed without errors. Immediately before the casting applications, a sample was taken from the melted liquid metal for each alloy, and spectral analyses were performed. For the three different alloys, the material chemical compositions obtained as a result of the analyses are given in Tables 2, 3, and 4, respectively. In the tables, the average material compositions obtained as a result of three repeated analyses performed for three different alloys were shown. It was determined that the chemical compositions of the obtained materials are compatible with the alloy compositions in the literature.

Table 2.
The chemical composition of casting 7075 alloy

Analysis	Al	Si	Fe	Cu	Mn	Mg	Zn	Ni	Cr	Ti	Zr
First	89,0	0,368	0,382	1,71	0,172	2.54	5,46	0,0133	0,163	0,0227	0,0466
Second	89,1	0,368	0,381	1,70	0,171	2,57	5,39	0,0119	0,163	0,0229	0,0468
Third analysis	89,1	0,373	0,382	1,69	0,171	2,57	5,35	0,0112	0,162	0,0223	0,0463
Average	89,1	0,370	0,381	1,70	0,171	2,56	5,40	0,0121	0,163	0,0226	0,0466

Table 3.
The chemical composition of casting 6082 alloy

Analysis	Al	Si	Fe	Cu	Mn	Mg	Zn	Ni	Cr	Ti	Zr
First	96,6	1,12	0,247	0,0851	0,612	1,03	0,0176	0,0104	0,163	0,0277	0,0059
Second	96,6	1,10	0,237	0,0842	0,612	1,05	0,0183	0,0070	0,163	0,0284	0,0061
Third analysis	96,6	1,10	0,230	0,0811	0,588	1,05	0,0190	0,0046	0,158	0,0288	0,0051
Average	96,6	1,11	0,238	0,0834	0,604	1,04	0,0183	0,0073	0,161	0,0283	0,0057

Table 4.
The chemical composition of casting 6013 alloy

Analysis	Al	Si	Fe	Cu	Mn	Mg	Zn	Ni	Cr	Ti	Zr
First	96,0	0,844	0,513	0,769	0,489	0,949	0,300	0,0133	0,0247	0,0184	0,0065
Second	95,8	0,878	0,561	0,782	0,494	0,994	0,308	0,0117	0,0240	0,0177	0,0071
Third analysis	95,9	0,854	0,521	0,797	0,491	1,00	0,305	0,0133	0,0244	0,0190	0,0069
Average	95,9	0,859	0,532	0,783	0,491	0,981	0,304	0,0127	0,0243	0,0183	0,0068

By using the permanent mold, which is manufactured with H13 hot work tool steel, melting and casting processes were performed for three different aluminum alloys. Microstructure images of aluminum alloys obtained as a result of metallographic studies performed after the casting processes are given in Figures 3, 4, and 5. When the optical microstructure images given for three different alloys are examined, it can be seen that there are coarsening and intermetallic phases at the grain boundaries.

Based on this, it can be said that microsegregation and coarse grain structures at grain boundaries may emerge, especially for high-strength 7xxx alloys during casting. In addition, the mechanical properties of 7xxx series alloys are seriously affected by the presence of different types of intermetallic phases during casting. It is well known that several main intermetallic phases such as ($MgZn_2$), ($Al_2Mg_3Zn_{3)}$), (Al_2CuMg), (Al_2Cu), and (Al_7Cu_2Fe) are formed during solidification of the Al–Zn–Mg–Cu below the solidification temperature (Ghosh & Ghosh 2018). In the 6xxx series alloy, the formation of Mg_2Si particles, which increases the corrosion resistance of this alloy microstructurally, occurs during solidification. In addition, magnesium-rich intermetallic particles mainly contain Al_3Mg_2 for the 5xxx series and Mg_2Si for the 6xxx series (Zeid 2019). In a study, it has been stated that semi-stable and stable strengthening phases (Mg2Si) are formed microstructurally in GP regions after heat treatment. In addition, it has been mentioned that during the hot processing of ingot casting, the inter-metal phase particles are located in a position parallel to the plastic deformation direction and allow the formation of a deformation band structure (Mrówka-Nowotnik 2010).

Figure 3.
AA 6013 aluminium alloy microstructure images

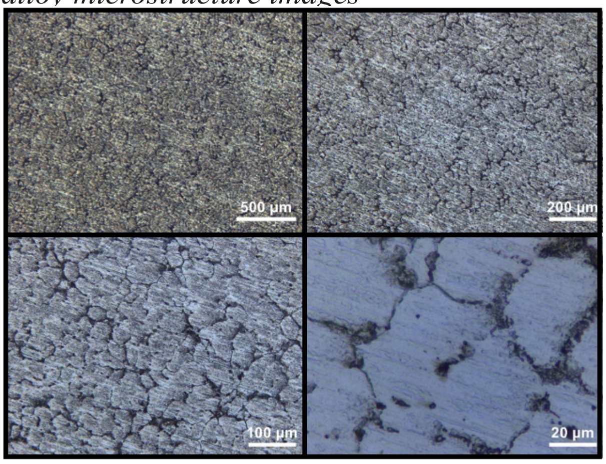


Figure 4.
AA 6082 aluminium alloy microstructure images

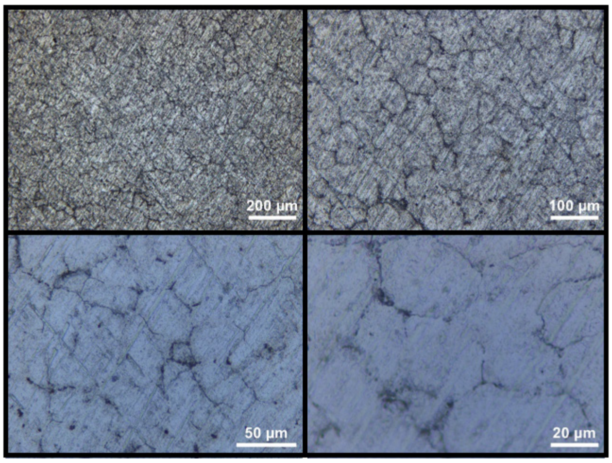
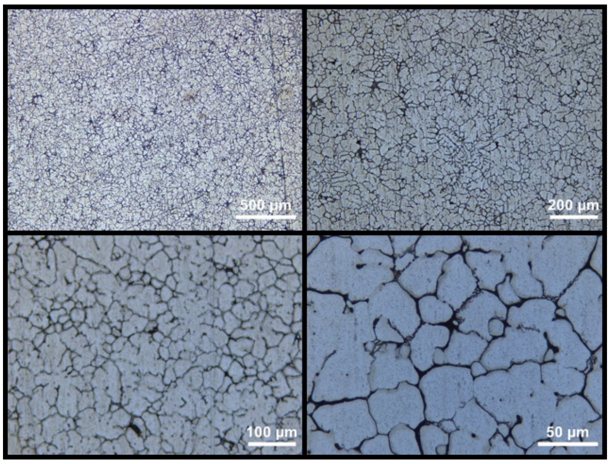
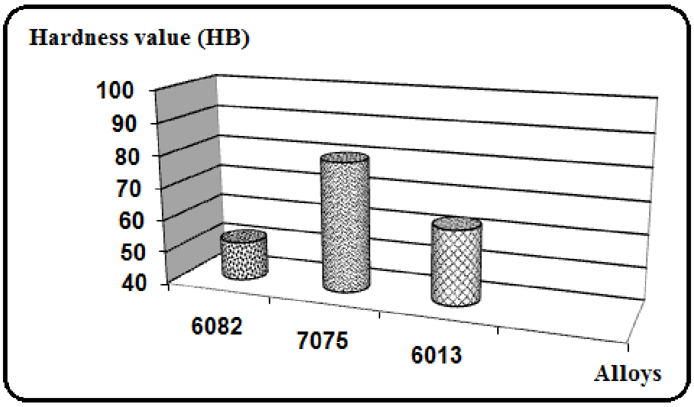


Figure 5.
AA 7075 aluminium alloy microstructure images



At the end of the casting experiments performed on the metallic mold at 800°C, three different aluminum alloys were examined microstructurally. The hardness results obtained are shown in Figure 6. When the hardness results of the cast aluminum alloys were examined, it was determined that the highest hardness (80HB) belonged to AA 7075 material. This aluminum alloy was followed by AA 6013 (63HB) and 6082 (50HB) aluminum alloys, respectively.

Figure 6.
Aluminium alloys hardness after casting



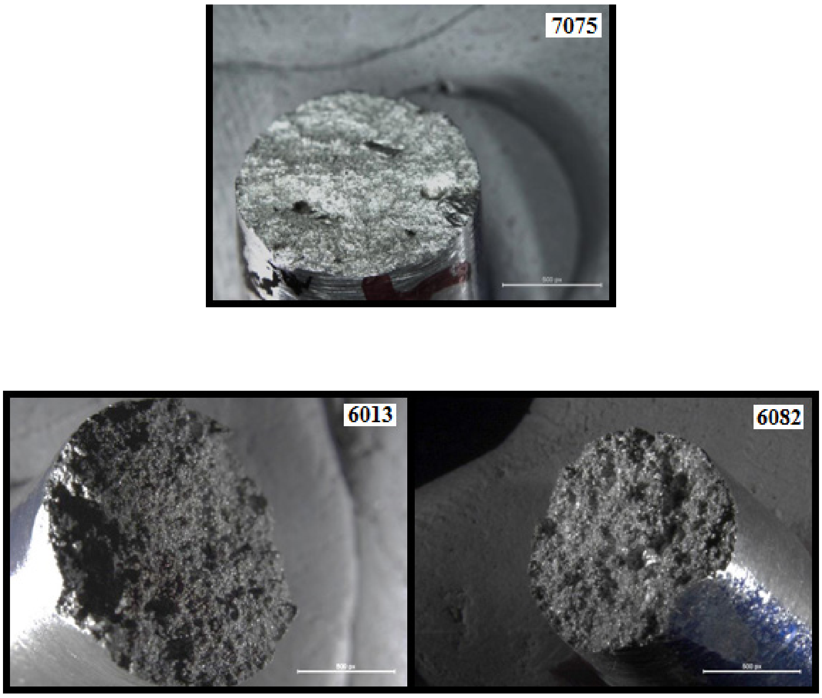
The tensile strength and percentage elongation test results of metal tensile bars obtained after casting experiments of three different aluminum alloys are shown in Table 5. When the tensile test results in Table 5 were examined, it was seen that the alloy with the highest hardness value was AA 7075 aluminum alloy. In addition, it was determined that this alloy had the highest percentage elongation (7%) and tensile strength (125.9N/mm^2). Al−Mg−Si(−Cu) alloys, also known as the 6xxx series, are listed among the most used aluminum alloys. Mg and Si chemicals are the main soluble elements and play a significant role in increasing the hardness and strength of the material.

Table 5.
Tensile test results of aluminium alloys after casting

Alloy	Percentage Elongation (%)	Tensile Strength (N/mm^2)
6013	5.1	144.1
6082	4.7	171.5
7075	7	125.9

To improve precipitation and increase mechanical properties, chemicals such as Cu can be added (Zhong et. al., 2014). In these alloy series, in particular, the increased Mg and/or Si content accelerates the natural aging response of the alloy. Therefore, they provide the desired increase in hardness and strength (Zhong et. al., 2013). 6xxx series alloys including aluminum alloyed with magnesium and silicon are a group of precipitation-hardening alloys that have sufficient specific strength and toughness and are relatively cheaper compared to the 2xxx and 7xxx Al alloy series (Dubey et. al., 2023). In this alloy, which was used in permanent mold casting, the hardness and strength of the material can be increased, especially by heat treatment. In such alloys, heat treatment can be performed in two ways. It can be applied as solutionizing and then as artificial aging. In the process of solutionizing, the alloy is heated to a certain temperature (400 ºC-530ºC). When the specified temperature values are reached, the quenching process is performed. At the end of this process, the material is subjected to a hardening process at about 200°C (in the case of Al alloys of the 6xxx group) (Rajaa et. al., 2018).

Figure 7.
Fractured surface results of aluminium alloys after tensile



When the broken surface morphologies exhibited by the alloys were examined in tensile tests applied after casting experiments (Figure 7), the presence of split (cleavage) type breaks was not observed on the breaking surfaces of AA 6013 and 6082 aluminum alloys, which have high ductility properties compared to AA 7075 aluminum alloy. In AA 7075 alloy, on the other hand, cleavage-type breaks were observed on the fracture surfaces. Moreover, in AA 6013 and 6082 aluminum alloys, it can be seen that ductile (dimple) breaks, which usually occur as a result of stress crack progression in ductile fracture mode, are located in the microstructure. In a study conducted on AA6061 aluminum alloy, it was stated that ductile fractures are observed when broken surfaces are examined. It was mentioned that fewer ductile pits appeared in samples whose hardness increases with aging heat treatment (Sevim et. al., 2014). It was determined that ductile pits and network structures were predominant in the images. Broken surface images of aged samples exhibit a smaller number of ductile pits. SEM images of broken surfaces are related to tensile graphs. In AA7075 aluminum alloy, breakage or fracture manifests itself in the form of cleavage morphology inside grains. In this case, mechanical properties such as ductility (total plastic deformation rate) and toughness occur low in these materials. Therefore, cleavage-type breaks are observed exactly instead of pits on the fracture surfaces of this alloy, which exhibits ductility value.

Conclusion

The results obtained within the scope of permanent mold casting technology, which is mostly used in casting applications as a special casting method, and casting of aluminum alloys are summarized below.
Permanent mold casting technology, which is usually used in the casting of non-ferrous metals, is preferred in the mass production of parts whose dimensional tolerances are narrow and the number of productions is high. In addition, when sand casting technology or other casting methods are considered, the mechanical properties of the material are very important depending on the chemical composition of the melted liquid metal before casting. In this case, especially tensile testing comes to the fore to able to determine

the mechanical properties of the material or quality control. The rapid transfer of melted liquid metal to the mold and the use of permanent molds in the production of the tensile bars stand out in terms of mass production and time-saving in aluminum and light alloy foundries. Therefore, in the melting and casting applications for the 6xxx and 7xxx aluminum alloy series, it can be seen that the gravity mold runner and feeder produce a faultless tensile bar after the liquid metal solidifies. In this study, as a result of casting applications, a tensile bar was produced in the desired dimensions, and the produced material was assessed in terms of hardness, tensile properties, and fracture morphologies. In addition, for the 6xxx and 7xxx aluminum alloy series, the microstructural characterization of the material was studied. The highest hardness value was measured in AA 7075 material as 80HB, and in AA 6013 and 6082 aluminum alloys as 63HB and 50HB, respectively. The highest percentage elongation and tensile strength were determined as 7% and 125.9 N/mm2, respectively, in AA7075 alloy. When the material fracture surface morphologies were examined, it was determined that AA 7075 material exhibited brittle fracture compared to the other two aluminum alloys.

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CHAPTER 4

Advantages of Thermal Analysis in Polymer Matrix Composites

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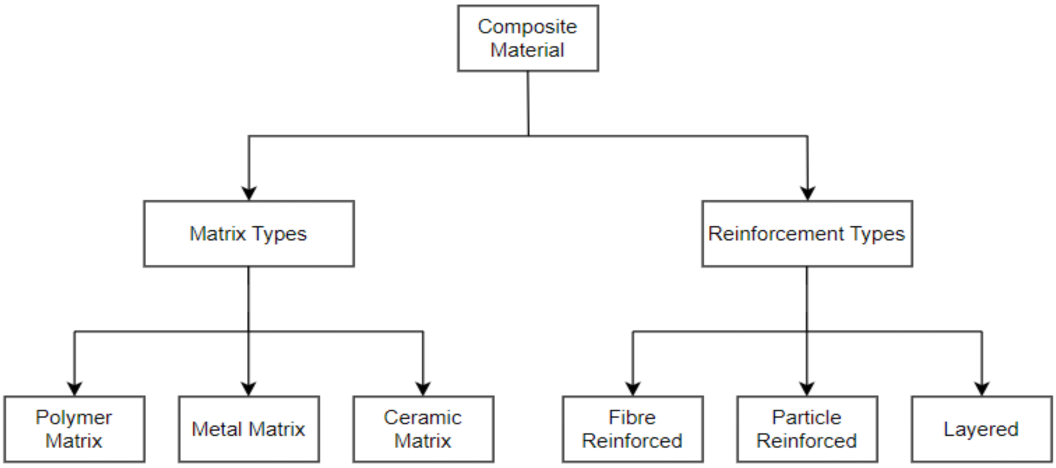
Introduction

A composite material is a new material that is formed by the macro-scale combination of at least two or more materials with sufficiently different physical or chemical properties and different from the initial properties (Kaya, 2016, p. 38).

Today, the aerospace, aviation, and mobility industries are demanding more and more properties from structural materials. Materials for these industries must have excellent lightness and high strength. These properties can only be achieved with composite materials. Nano-additives are also increasingly being developed to provide exceptional mechanical and electrical properties (Lijima, 1991, p. 57).

Composite materials have more than one advantage over other materials thanks to their properties. They are demanded and preferred due to their many advantages such as long service life, lightness, thermal and mechanical durability, and corrosion resistance (Gülmez, 2018, p. 74). Composites are classified according to matrix materials and reinforcing elements. This classification is shown in Figure 1.

Figure 1.
Composite Material Types



Polymer matrix composites have started to be preferred in the field of engineering due to their advantages, both due to the developments in high-yield fibres (carbon, glass, and aramid) and the developments in the use of polymers as matrix materials. Plastics are analysed in two groups thermoplastic and thermoset according to their properties in chemical bond structures (Asi, 2018, p.153).

- Thermoplastics are plastics that can be shaped and can be reshaped by heating.
- Thermosets are heat-resistant and long-lasting plastics that cannot be shaped and are subjected to a curing process.

Thermoplastics

- Polyethylene
- Acrylic Polymers
- Polypropylene
- Poly (Vinyl Chloride)
- Acetates
- Polystyrene
- Polyesters, PET
- Polyamides, PA (Nylon)

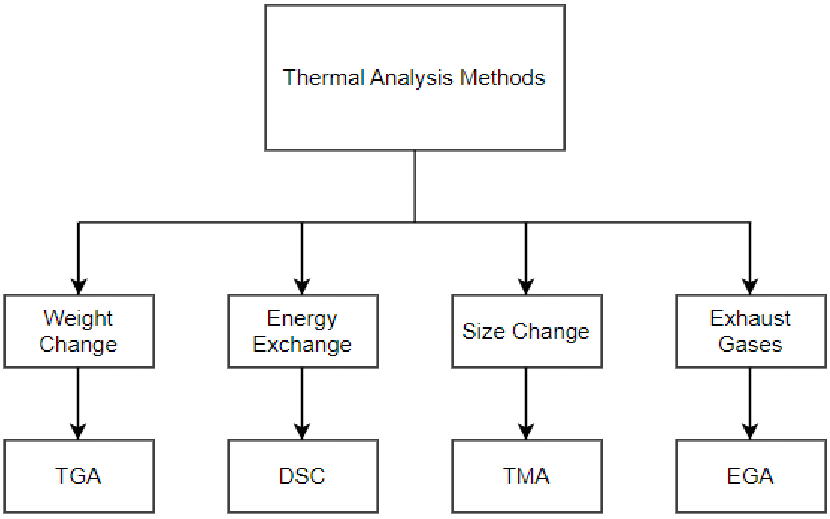
Thermosets

- Polyurethanes
- Phenol-Formaldehyde Resins
- Unsaturated Polyesters
- Reinforced Plastics
- Epoxies
- Styrene-Butadiene
- Amino resins
- Alkyd Resins

Thermal Analysis Methods

Thermal analysis is a group of methods in which the physical (melting and other phase transitions, glass transition) or chemical (degradation, oxidation) properties of a material are measured as a function of temperature, and a controlled temperature is applied to the material (Çelikbilek, 2009, p. 107). These methods are shown in Figure 2.

Figure 2.
Thermal Analysis Methods



Properties to be determined by thermal analysis methods (Coats & Redfern, 2018);

- Heat capacity
- Thermal diffusion
- Purity
- Creating phase diagrams
- Quantitative analysis
- Qualitative analysis
- Estimation of solvent composition
- Structural transformations
- Glass transition temperature
- Thermal resistance

Heat capacity is the amount of heat required for a 1 °C change in the temperature of the sample. In other words, it is the temperature derivative of the heat of a substance. It is obtained by multiplying the mass of the sample by its heat (Kou vd., 2019). Thermal diffusivity is the curve obtained as the sample cools over a certain time interval. During this cooling, heat is released by the phase transformation that will occur in the sample. This heat indicates that there will be a break in the cooling curve and its slope changes (Corcione & Frigione, 2012).

Purity allows us to recognize the sample and confirm its properties. If the sample is only a few milligrams, it allows us to recognize the sample (Groenewound, 2005). The temperature factor in the sample and the diagrams indicating the change in the phases of the compositions are called phase diagrams. Phase diagrams are used to determine the internal structure of the samples and the stable regions that do not change (Lin & Huang, 2010).

Analyses to determine the components used in the sample (qualitative) and the amount of each component (quantitative) (Saikia, 2020, p. 161). The glass transition temperature (Tg) is a phenomenon of amorphous polymers. At this temperature, polymers transition from the glassy to the rubbery state. Tg is an important characteristic of polymer behavior. It marks a region of significant changes in physical and mechanical properties (Fryer vd., 2000).

Thermogravimetric Analysis (TG or TGA)

Thermogravimetric analysis involves heating the initial temperature of the sample from room conditions to a temperature of approximately 1200 °C, while periodically monitoring the changes in its mass (Prime & Bair, 2009).

X (Solid) Y (Solid) + Z (Gas) (Mass decreasing)

Z (Gas) + Y (Solid) X (Solid) (Increasing mass)

The monitored data are expressed as temperature and mass percentage data in a graph called a thermogram or thermal decomposition curve. The parameters that vary periodically are related to the time to stabilize the sample at a certain temperature and the heating rate (D. C. Doyle, 1961).

The thermogravimetric analyzer consists of an oven, an oven temperature control unit, a precision analytical balance, and a data logger. The recorder plots the mass change of the sample under temperature. The precision balance is usually suitable for samples of 5-10 mg (Loganathan, Valapa, Mishra, Pugazethenthi & Thomas, 2017, s. 69).

Figure 3.
Schematic Representation Of The Thermogravimetric Analysis System

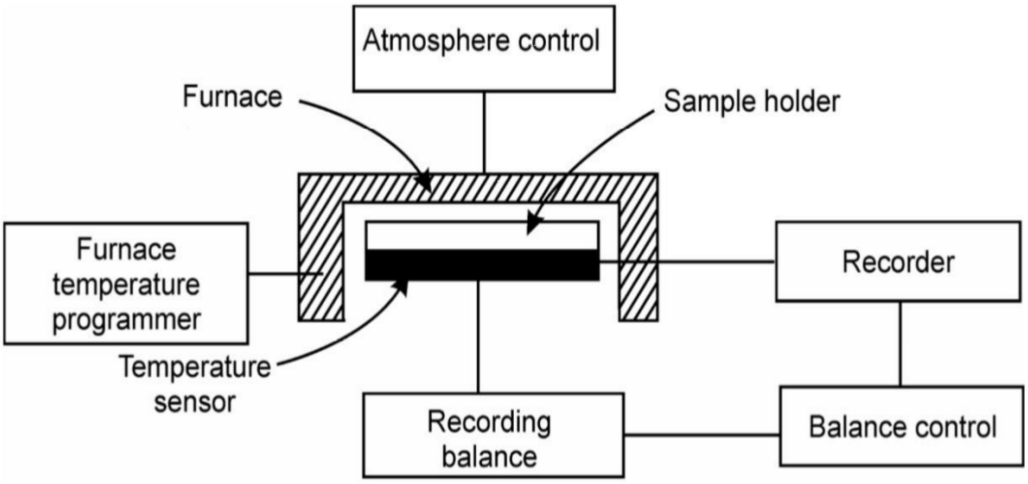
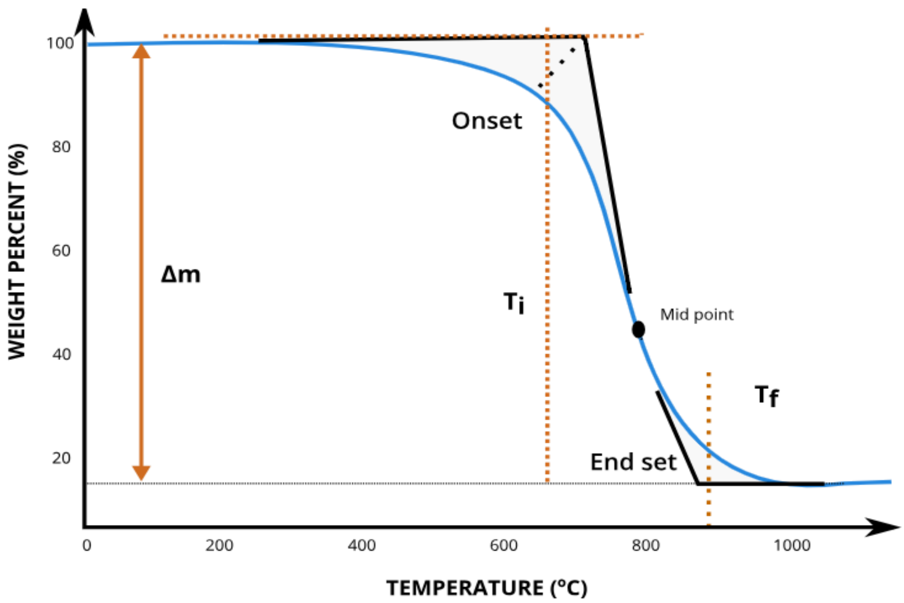


Figure 4.
A Typical Thermogravimetric Analysis Graph



- TGA detects the change in mass with the temperature change applied to the sample. With the change in mass, it is seen that the sample starts to decompose or evaporate. There are also ranges where the temperature change does not change the mass percentage. This indicates that the sample is stable.

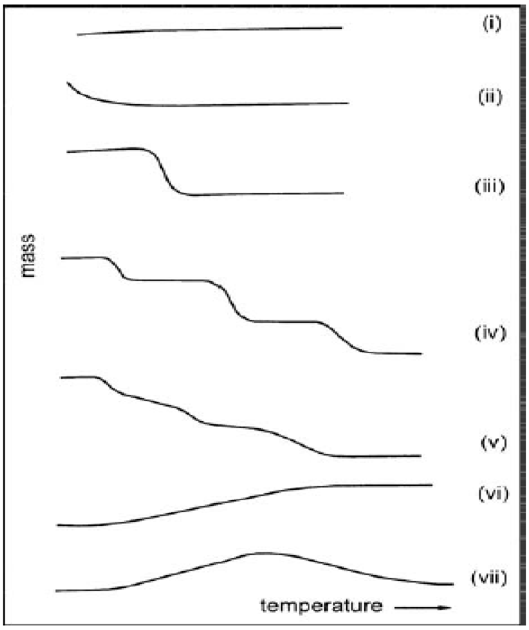
- TGA analysis of the sample heated in a certain temperature range provides mass loss information, composition determination, and ease of seeing the reaction status information in case of decomposition or evaporation. It also gives information about the percentage of composition in the mixture.
- Increasing the ratio of the components added to the mixture or the amount of sample may cause the heat given to be distributed unevenly and the gases released as a result of the reaction cannot be removed sufficiently. As a result of this situation, precise result data may not be obtained.
- The heating rate range applied to the sample is between 1-100°C/min. If the specified heating rate increases, the data to be obtained from the sample will not provide a more general and accurate measurement. If slow heating rates are applied, more accurate results are obtained in the results obtained.

The thermogram curve can be influenced by many factors during its formation. Factors affecting thermogram curves (Saadatkhah vd., 2020):

- Heating rate
- Reference particle size
- Atmosphere environment
- Thermal conductivity
- Sample size
- Gas flow rate

In the TGA analysis applied to the samples, many situations may occur and these situations should be interpreted separately. The situations that occur in TGA analysis are as follows:

Figure 5.
Various Thermogram Types



i. Indicates that the sample is not affected by temperature change or degradation.
ii. Indicates that weight loss is rapid at the beginning of heating or drying (desorption).
iii. The most common TG curve shows the temperature range in which the material is stable.
iv. Indicates multiple degradation, in a stepwise manner, with stable intermediate degradation products.
v. Indicates multiple degradations and unstable intermediate degradation products.
vi. This curve, which shows an increase in weight, shows the result as an example of the formation of oxidation that usually occurs in metals.

vii. It is a very rare type of curve. It shows first an increase and then a decrease in weight.

Differential Scanning Calorimetry (DSC)

DSC analysis is a thermal analysis method that examines the heat flow difference between the sample and the reference material as a function of temperature by applying for a controlled temperature program. Two techniques are commonly used, Heat Flow DSC analysis and Power Compensated DSC analysis. Heat Flow DSC analysis can directly measure temperature differences and convert them into heat flow differences. Heat Flow DSC analysis can also be expressed as "Quantitative DSC" (Devi vd., 2021).

The sample and the reference used during DSC analysis are placed in the oven. There are two crucibles in the oven. The prepared sample is placed in one of these crucibles and the sample material is placed in the other. The crucibles in the oven are heated with different heaters. Thus, the materials in the crucibles are not given the same heat. The different temperatures applied are measured by thermocouples under the crucibles. The heat difference caused by different temperatures is prepared as a function of temperature. When the thermocouples under the crucibles detect the temperature difference, they give heat to the cold material to equalize the temperature of the two samples (Corcione & Frigione, 2012).

This thermal method, which determines the temperature difference of materials, is widely used in the determination of polymeric materials. The changes that occur with the temperatures applied to the polymers are seen and monitored with differential thermograms (Drzeżdżon vd., 2019). These changes are shown in Figure 7.

Figure 6.

Schematic View of DSC Heat Flow System (Bibi vd., 2015)

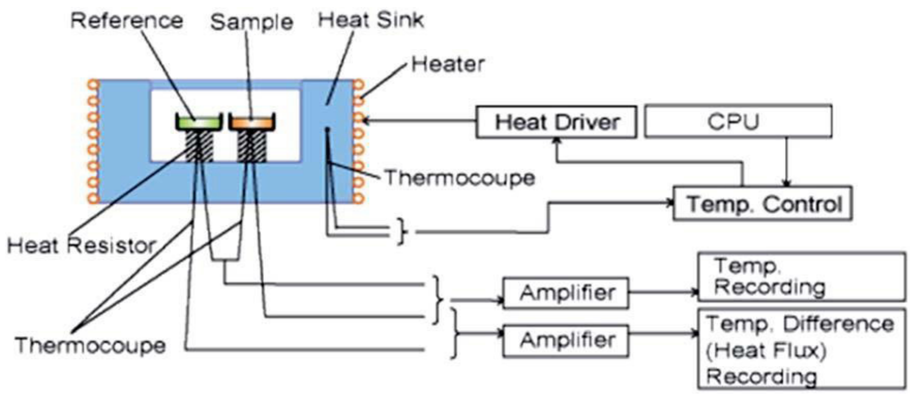
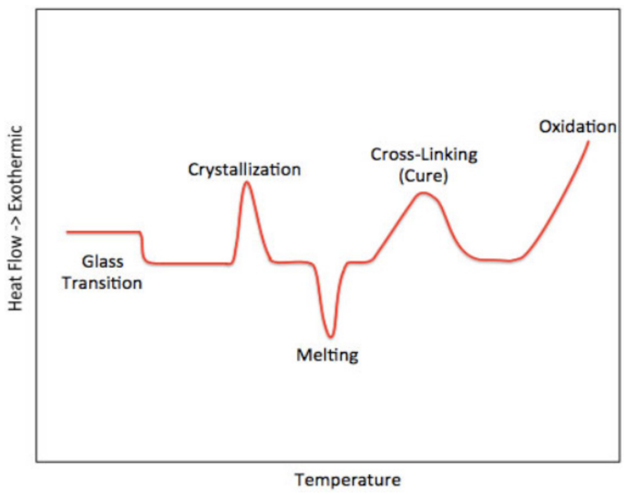


Figure 7.

Differential Thermogram Showing The Changes Encountered İn Polymeric Materials



Factors affecting the glass transition temperature (Tsagaropoulos & Eisenberg, 1995) :

- Heating rate
- Heating and cooling
- Obsolescence
- Molecular weight
- Plasticiser
- Crystallinity
- Copolymers
- Filling material
- Polymer main chain
- Hydrogen bonding

Thermomechanical Analysis (TMA)

TMA is a technique that determines the changes in the dimensions of physically solid or liquid samples as a function of the force and temperature applied to the samples and the elapsed time. This technique is used to determine the glass transition temperature (Tg), the thermal expansion of the sample (CTE), and the resulting compression modulus coefficients as the temperature changes and the force remains constant (Groenewound, 2005).

The expansion or contraction of the sample by the factors acting on the sample, the rubbery structure of the sample (Tg), or the deformation that occurs, determine the differences in the sample size. The data of this analysis method allow us to predict the response of the specimen under different temperatures.

TMA applies a controlled load to the sample in a temperature and atmosphere-controlled environment. This applied force is very small. This occurs without restriction on the expansion or contraction of the sample. A temperature-controlled LVDT (linear variable differential transducer) is used to measure changes in size.

TMA can be used in a wide range of materials, from polymers, composite materials, plastics, elastomers, paints, adhesives, hard solids, rubbers, thin films, liquids, gels, etc. As all materials have a Coefficient of Thermal Expansion (CTE), the technique applies to a wide range of industries (Startsev vd., 2020).

Evolved Gas Analysis (EGA)

It is the method used to determine and monitor the gas molecules released in the samples. This analysis detects the small amount of gas molecules that occur when the temperature reaches above room temperature. Evolved gas analysis can be used to determine the following three factors (Shiono vd., 2015).

- Composition of evolved gases,
- Concentration of evolved gases,
- Development profile according to heating temperature.

Gas molecules begin to form on the surface of materials heated above room temperature. The sample is vacuumed to remove the gases that will be affected by external factors in evolved gas analysis and to obtain more accurate results. If the gas reaction to be formed is dangerous and toxic, it is carried out in the fume chamber. With this analysis, it can be determined whether the gases formed evolve or not. EGA is a useful method for determining the composition of the sample and detecting thermal zones. To determine their composition by mass spectrometry, the chromatography-mass spectrometry (GC/MS) method is then used to determine the thermal event (Friedman, 1970). EGA can be analyzed as quantitative and qualitative methods (Risoluti vd., 2022).

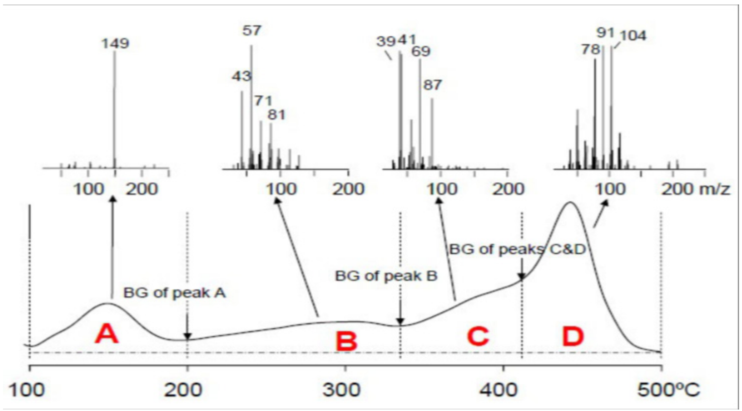
Semi-quantitative

- Comparative study: Good and bad examples

- Plate level failure analysis for hermetic electronic components
- Approval of cleaning quality in UHV quality for SS parts
- Comparative study for gas release at a given temperature
- Direct Gas analysis
- Gas outlet from gas-tight gaskets in hermetic devices
- Efficiency of the receiver in a vacuum cavity
- Gas exit rates
- Gas released in the cavity after the gas outlet (drilling in vacuum)

Figure 8.

Typical EGA thermogram graph



Qualitative screening

- Mass screening as the temperature rises
- The 3D plot of the temperature-mass signal
- Comparative screening: Good and bad examples

Ideal Application Areas of EGA

- Investigation of gas species in solid and gas samples
- Profiling of gas emission according to temperature
- Failure analysis for hermetic packages
- Degassing rates for metals and cleaning research

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CHAPTER 5

Using Computational Methods on Biological Databases

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Introduction

The first basic analyses of proteins were made in 1828s. The molecules that Gerardus Johannes Mulder, a Dutch chemist, examined in these analyses were first given the name "protein", derived from the ancient Greek word πρωτεῖος (proteios), by the Swedish chemist Jöns Jakob Berzelius in 1838 (Braun and Gingras, 2012).

The first study on the interactions between proteins was reported by Hedin (Hedin, 1906), who examined the inhibition and kinetic properties of trypsin, an enzyme found in the digestive tract. Studies accepting that protein interactions have vital importance in the formation of enzyme activities required for organisms began to be carried out in the 1960s (Crick and Orgel, 1964). The importance of protein interactions was understood later, and studies have made significant progress with the development of the yeast two-hybrid protein interaction method (Fields and Song, 1989). This method was developed as the first of the protein interaction prediction methods called high-throughput because it works with a large number of inputs and outputs.

It is known that proteins play vital roles in all biological processes and are at the center of the processes (Zeng et al., 2020). They perform important functions by making interactions with other proteins and breaking those interactions. Finding these interactions is an important process and it takes too much time and cost to make predictions about interacting proteins by in-vitro studies (Chen et al., 2019).

Computational methods can help and support biological experiments. There are plenty of studies to assist this research (Wang et al., 2020). For example, there are several types of research on protein structure prediction (Kulhman and Bradley, 2019), prediction of protein cellular attributes (Chou, 2001), and prediction of protein interactions (Wei et al., 2017; Goktepe & Kodaz, 2018).

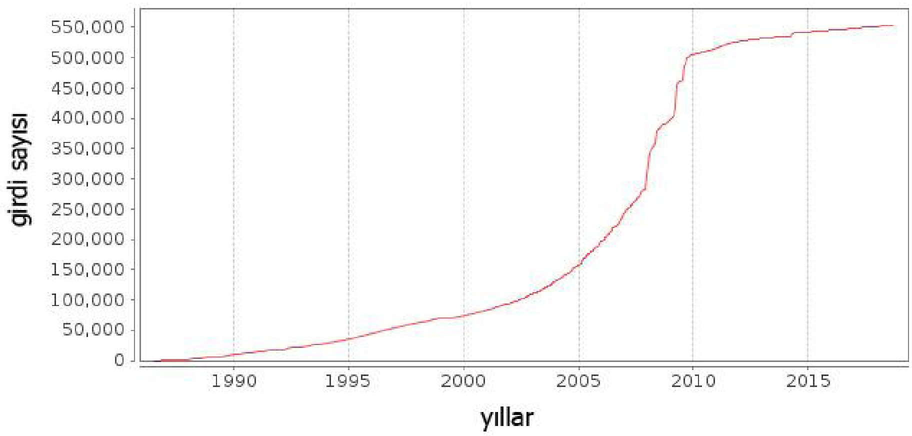
In this study, a web-based model is offered to investigate sequences, get properties of proteins, and make predictions of possible interactions (Taşdemir, 2023). One capability of this model is to expedite protein search. It is also able to find proteins that resemble a given sequence partition. Researchers can gather selections of amino acid properties easily with this model and use them in their computational studies. Moreover, the interaction prediction facility of the model can be used by biologists to decide which protein pair should they choose to make an interaction test in the laboratory.

Databases

In recent years, a significant amount of protein interaction information has been obtained through studies. Protein interaction data revealed by researchers with different experimental or computational methods are added to databases managed by universities and institutes. Although there are over 100 databases created for this purpose, almost all of the data is in the few most widely used databases.

The data on protein sequence, function, and interactions obtained by new research are constantly increasing. UniProtKB/Swiss-Prot 2019_02 version published on 13 February 2019 by UniProt, a comprehensive database of protein sequences and functions, contains 559,228 sequence information. Figure 1 shows the increase in the number of sequence entries contained in the UniProtKB/Swiss-Prot database between 1985 and 2019 (UniProt, 2019).

Figure 1.
Increase of protein data in UniProtKB/Swiss-Prot database over years (UniProt, 2019)



With the motivation of technological advances, the studies presented by researchers interested in bioinformatics and biomedical issues are increasing day by day. One of the most important databases in which studies on this subject are kept is Medline (Medline, 2023). In 2022, 1,369,611 new citations were added to the Medline database established by the U.S. National Library of Medicine (NLM), and the increase in the number of citations included in the database over the years can be seen in Table 1.

Table 1.
Number of PUBMED production statistics (Medline, 2023)

	FY2022	FY2021	FY2020	FY2019	FY2018
MEDLINE Citations Indexed (Annual)	1,369,611	1,291,807	952,919	956,39	904,636
MEDLINE Citations Cumulative Total	29,807,639	28,444,654	27,149,277	26,196,358	25,239,968
MEDLINE Journal Titles	5,282	5,282	5,274	5,243	5,251
PubMed Citations (Annual)	1,714,780	1,733,089	1,514,199	1,366,447	1,329,148
PubMed Citations Cumulative Total	34,693,538	33,136,289	31,563,992	30,178,674	28,934,389
PubMed Searches	2.58 Billion	2.57 Billion	3.3 Billion	3.1 Billion	3.3 Billion
Web/Interactive	1.283 Billion	1.186 Billion	1.076 Billion	896 Million	831 Million
Script/E-Utilities	1.303 Billion	1.391 Billion	2.2 Billion	2.2 Billion	2.5 Billion

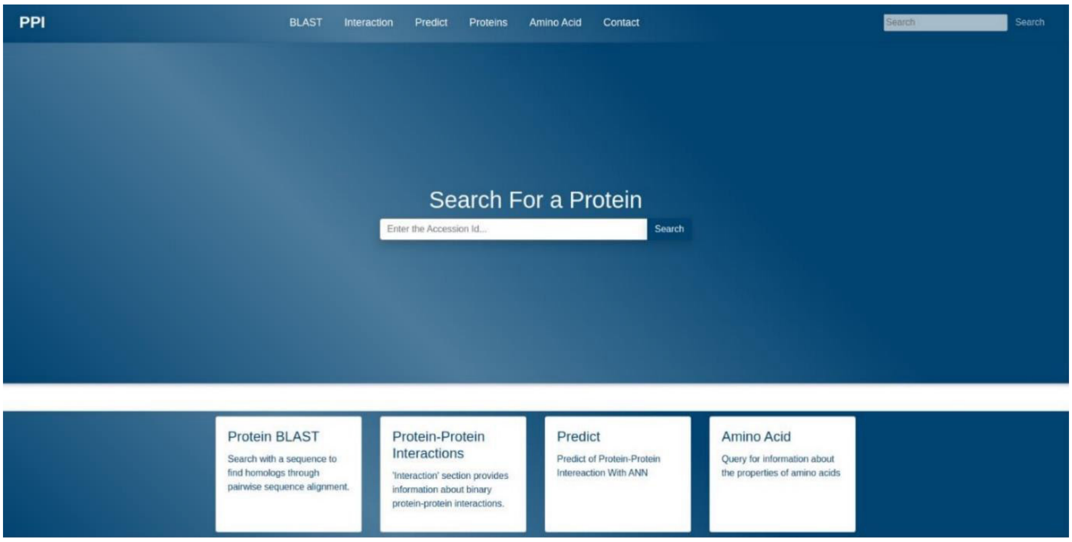
It is often indicated that the known protein networks are far from being complete yet (Kotlyar et al., 2015). Since the number of data used in studies on this subject is constantly increasing, we can say that the need for information accession models such as the one suggested in this study has also increased.

Web-Based Protein Information Accession Model

On the main screen, there is a navigation bar as seen in Figure 2. The main screen of the project provides access to the offered features (Taşdemir, 2023). Using this bar, a blast search can be done, or some useful information can be accessed such as protein information, amino acid sequences, and interactions of proteins. Interaction predictions of a query protein can be obtained using the "Predict" menu of the bar.

Figure 2.

The main screen of the project



Accessing Protein Data by ID

Information about a query protein can be obtained by entering its protein_id (accession) data at the center of the main screen. Accession code, full name, gene and organism information, and sequence data of the protein are shown in the result page (Figure 3). All of this information can be obtained in json form by clicking on the sequence data.

Figure 3.

Search result of a sample query protein

Protein Info

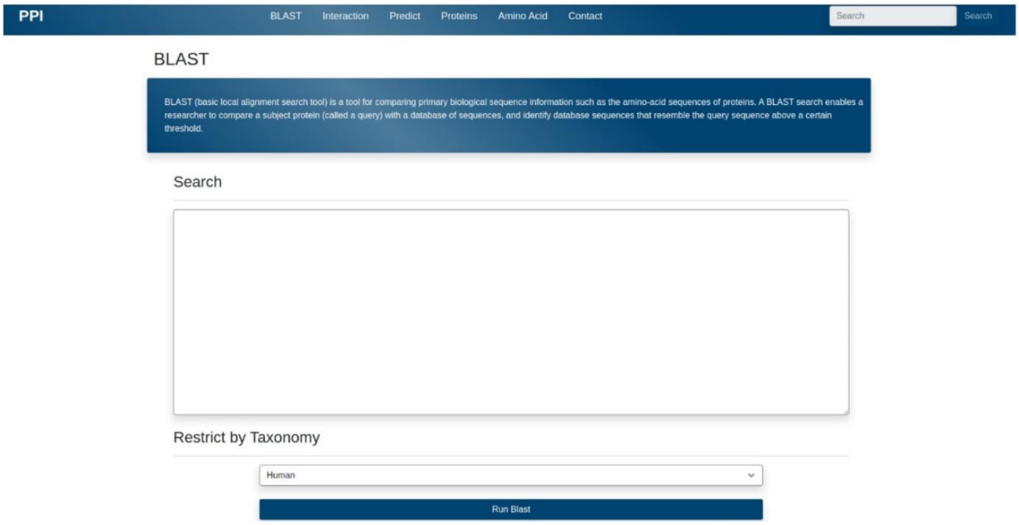
Accession	Protein Name	Gene	Organism	ⓘ Sequence
A2RU14	Transmembrane protein 218	TMEM218	Homo sapiens	MAGTVLGVGAGVFILALLWVAVLLLC...

BLAST Search

On the BLAST (Basic Local Alignment Search Tool) screen (Figure 4), an algorithm was written that gives the similarity of protein sequences (Blast, 2023). This algorithm works as follows;

- Input a sequence (or part of a sequence),
- Choose an organism type,
- Compare all proteins with the one entered by the user.
- Proteins that are similar with a max-margin of difference of 5% to the query sequence are listed as output.

Figure 4.
BLAST search interface of the project



Searching for Known Interactions

Known interactions of a query protein can be listed via its ID (accession number) or full name. A list of interactions is listed on a result page. Moreover, interaction can be searched by giving a sequence or part of a sequence. In such a situation, proteins that involve a given sequence are taken into account and known interactions of these proteins are listed in the result page by using pagination (Figure 5).

Figure 5.
Interactions are listed on a result page with pagination

Interaction Info

Protein1		Protein2	
Accession1	Interactor1	Accession2	Interactor2
A1A4S6	EBI-1390944	Q6P5Z2	EBI-1384335
Q6P5Z2	EBI-1384335	A1A4S6	EBI-1390944
Q6P5Z2	EBI-1384335	Q9UNA1	EBI-1390913
Q6P5Z2	EBI-1384335	Q08379	EBI-618309
Q6P5Z2	EBI-1384335	Q15323	EBI-948001
Q6P5Z2	EBI-1384335	Q5JR59-3	EBI-11522433
Q6P5Z2	EBI-1384335	Q8ND90	EBI-302345
Q6P5Z2	EBI-1384335	Q9UBB9	EBI-1105213
Q6P5Z2	EBI-1384335	Q8N1B4	EBI-2799833
Q6Y5D8	EBI-4396535	Q29502	EBI-4406512
Q6Y5D8-1	EBI-4396677	Q29502	EBI-4406512
Q29502	EBI-4406512	Q6Y5D8	EBI-4396535
Q29502	EBI-4406512	Q6Y5D8-1	EBI-4396677
Q5T5U3	EBI-1642518	P29692	EBI-358607
Q5T5U3	EBI-1642518	P63104	EBI-347088

Showing 1 to 15 of 160 results

‹ 1 2 3 4 5 6 7 8 9 10 11 ›

AAIndex Properties of Amino Acids

AAindex is a widely used database that contains several indices about the physicochemical and biochemical properties of amino acids. AAindex is a widely used database in research that contains several indices about the physicochemical and biochemical properties of amino acids. It consists of 3 parts, the first of which is AAIndex1 which contains an amino acid index of 20 numeric values. The latter is AAIndex2 which contains an amino acid mutation matrix and the last part is AAIndex3 gives statistical protein contact potentials (Kawashima et al., 2008).

In this section of the project, a sequence or part of a sequence is given, and requested amino acid properties or properties are selected. The system finds numerical values of requested properties and lists them as a result using pagination as seen in Figure 6.

Figure 6.
Numerical values of amino acid index properties

Seq / AA	ANDN920101	ARGP820101	ARGP820102	CHOC750101	CHOC760102	CHOC760103	CHOP780214	CHOP780215	CHOP780216
M	4.52	1.18	2.67	170.80	31.00	0.40	0.01	0.06	0.51
A	4.35	0.61	1.18	91.50	25.00	0.38	0.04	0.06	0.64
G	3.97	0.07	0.49	66.40	23.00	0.36	0.19	0.15	1.63
I	3.95	2.22	1.45	168.80	18.00	0.60	0.01	0.06	0.29
I	3.95	2.22	1.45	168.80	18.00	0.60	0.01	0.06	0.29
K	4.36	1.15	0.06	171.30	97.00	0.03	0.07	0.10	1.13
K	4.36	1.15	0.06	171.30	97.00	0.03	0.07	0.10	1.13
Q	4.37	0.00	0.72	161.10	71.00	0.07	0.04	0.10	0.84
I	3.95	2.22	1.45	168.80	18.00	0.60	0.01	0.06	0.29
L	4.17	1.53	3.23	167.90	23.00	0.45	0.04	0.07	0.36
K	4.36	1.15	0.06	171.30	97.00	0.03	0.07	0.10	1.13
H	4.63	0.61	0.31	167.30	43.00	0.17	0.09	0.05	0.77
L	4.17	1.53	3.23	167.90	23.00	0.45	0.04	0.07	0.36
S	4.50	0.05	0.97	99.10	44.00	0.22	0.13	0.11	1.52
R	4.38	0.60	0.20	202.00	90.00	0.01	0.10	0.09	1.05

Showing 1 to 15 of 60 results ‹ 1 2 3 4 ›

Making Predictions

In the prediction section, there is an algorithm that predicts about 2 query proteins to provide information to researchers on whether there is a high probability to be an interaction between them or not.

Interaction prediction is made by IDs of query proteins and the system gives a result that includes whether there is a possible interaction or not and the accuracy of this prediction as seen in Figure 7.

Figure 7.
Interaction prediction result of 2 query protein

PPI Predict Info

Accession1	Accession2	Accuracy	Predict Ratio	Result
A0PK11	Q8N6S5	94.39	100.00	Interaction

This prediction algorithm is developed with Python using the Keras module of the Tensorflow library. Keras is a widely used high-level neural network library.

Conclusions

Proteins play an important role in almost every process in cells of organisms. Thus, there is a lot of research using them and researchers are in search of ways to access the properties of proteins. This study exhibits a new system that makes an effective search for proteins. It can make BLAST searches, enabling researchers to find similar proteins that resemble a query sequence with a %5 difference tolerance. It also gathers various physicochemical and biochemical properties of amino acid sequences which are widely used in biological and bioinformatics research.

Moreover, given 2 query proteins the proposed system makes predictions whether there could be a possible interaction between them or not.

Gathering information about proteins is labor-intensive work. It takes too much time to select a potential interacting protein pair in laboratory studies. This study would help researchers by searching proteins, gathering useful information about them, and making predictions about protein pairs.

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CHAPTER 6

Contributions of Watery Interactive Playgrounds to Children's Development

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Introduction

Games and toys help children develop their physical skills. During the games, children use their bodies to move, expend energy, and develop their motor skills. They are also important for mental development. Games contribute to the development of children's thinking, problem-solving, and exploration abilities. Toys encourage children's creativity and develop their imagination in this process.

When parents choose games for their children, they prefer interactive playgrounds that develop emotional intelligence, social skills, physical activity, use of technology, and originality and creativity. In interactive playgrounds, children develop their decision-making mechanism at a young age with the experience of changing or directing games according to their wishes.

Aim and Problem of the Research

Research model

In this study, research on the place of interactive playgrounds in the development of children was obtained and articles published in various sources were used.

The place of play in the development of the child

What is a game?

TDK defined the game as "Entertainment that develops talent and intelligence, has certain rules, and is used to have a good time". While games help children explore the world, develop social skills, and learn, it is an important phenomenon that does not support the physical, mental, and emotional development of children, develop their social skills, and encourage them to learn while having fun (Başal, 2007).

Historical development of the game

The history of games and toys dates to ancient times (Başal, 2007). When the historical background of the concept of game is examined, its origins date back to ancient times. In ancient Egyptian, Greek, and Roman civilizations, simple games such as dice, stones, and board game boards were common. When these games are examined, it is seen that children create their games by changing the games played by adults. Games have developed and changed in the historical process and kept up with the requirements of the age and technological developments (Başal, 2007).

When the games of the 20th century are examined, the development of computer technology has enabled the digitalization of games (Başal, 2007). With this digitalization, children's games have become a versatile activity and game design has been handled for many different purposes (Başal, 2007). We can take educational games as an example. Games for educational purposes have begun to be used for children not only for entertainment purposes but also for educational purposes. Designed as interactive educational materials that help educators and teachers, games help children develop problem-solving abilities while teaching math, language, science, and other subjects. Such games have fostered abilities such as reasoning, analytical thinking, and strategic planning. As a result of all these developments, children's games, which have changed with digitalization, have become a versatile activity. Instead of focusing solely on entertainment, game designers now design games for a variety of purposes, such as education, problem-solving, communication, strategy development, and more.

This provides a fun learning experience while contributing to children's development. But at the same time, it is an important factor for parents and educators to balance children's gaming habits and choose appropriate content.

Holiday choices for families with children and interactive playgrounds

TDK defines vacation as "the time spent without working to have fun and rest". While families offer the opportunity to relax and have fun for their children during the holiday, they also want to include activities that support learning and development by offering different experiences to their children. Hotel businesses want to create areas where children and families can spend time together to be preferred within the scope of families with children. Children have different experiences with their families with the interactive playgrounds they offer to families with children (Kahvecioğlu & Topaloğlu, 2018).

Research Questions

Interactive playgrounds are areas that are specifically designed to provide a safe and fun play environment for children and adults. To integrate such areas into summer holidays, interactive playgrounds with wet floors are created using water and water jets. Generally, water-themed playground equipment is used in these areas. This equipment offers a variety of activities, such as slides where water is sprayed or flowed, water guns, and water fountain games. However, products used in traditional water areas usually have a fixed structure and are only capable of being splashed directly in front of them by users. These products cease to be interesting for children after a certain period since they do not allow any interaction other than static spraying of water.

Within the scope of this study, it will be ensured that the animations, figures, and water resources in the product tree, which we call splash products, can interact with children in children's playgrounds. The fact that water can rotate around its axis with the flow rate has attracted a lot of attention. While making the rotational movement, it will both carry its weight and prevent angles that may overflow out of the pool or wetting area. It is desired to create a leak-proof joint that will work with water-containing pool chemicals, as it will act as a plumbing part where this angle can be adjusted according to the area where it is installed.

Hypotheses of the Research

Polgün has changed the static structure of animation products in wet playgrounds with the articulated water gun he developed. Articulated water guns, unlike traditional water guns, have allowed users to direct water over a larger area and spray it from different angles. Articulated water guns provide greater maneuverability during water battles or water games and can help the water hit the target more effectively. In this way, it is a situation that we do not want to use as decorative products because the splash products used in playgrounds with wet floors are not subject to any activity. Thanks to this structure, decorative products are turned into interactive games. That is, with the use of a sealed knuckle water gun, animation products will be able to rotate on their own depending on the flow rate of the water. The sealed joint is resistant to pressure, temperature, or other external factors and is designed to prevent leakage, besides, the rotational movement will be quite easy due to the low friction force.

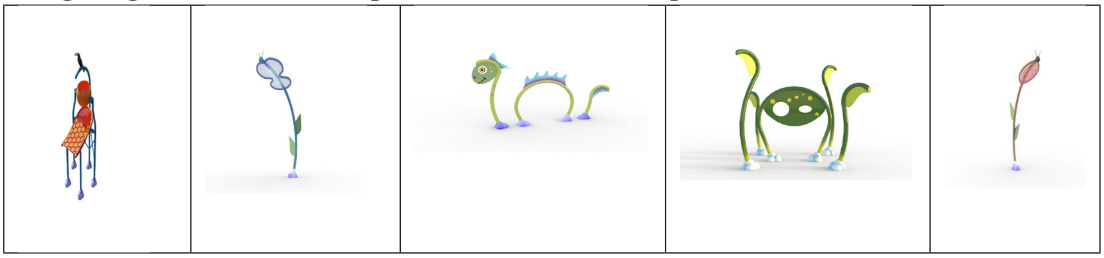
Interactive changes have contributed to the playgrounds providing visitors with a more fun and unique experience. Children and adults can interact with the animation products in the playgrounds with wet floors, and it offers more entertainment options to children as the users can direct them according to their wishes, apart from the rotation of the products themselves. Playgrounds established with this articulated structure offer the opportunity to teach simple engineering principles to the children who are users. By using this type of toy, children can understand how water is diverted and how such mechanisms work. This mechanism can be integrated into new and existing products, thanks to its structure, it is integrated into the animation products in the field. In this case, it has been ensured that the playgrounds established with traditional methods are made interactive.

Since water guns with an articulated structure can operate between 30-360 degrees according to needs, animation products used in interactive areas have made it a unique fastener because it is an element of hydromechanical installation and can adapt to environmental conditions. Creating a sealed joint that will work with water containing pool chemicals is a critical element for the health and safety of children. This joint protects the quality of the water by preventing water from spilling out of the children's playground and ensures that children can play safely. In addition, the use of such plumbing parts is also beneficial in the use of technology by providing children with a technology-compatible play experience.

As a result, interactive playgrounds and especially splash products in holiday resorts are an important game option that contributes to the development of children. These products have great potential in terms of improving emotional intelligence, social skills, physical activity, use of technology, and creativity, and at the same time, attention should be paid to safety measures.

Figure 1.

Design registered animation products used in water parks



Results of the Research

Families make choices based on some factors such as age-appropriateness, intelligence and strategy games, emotional intelligence development, social skills, physical activity, use of technology, and originality and creativity. In this context, juicy interactive children's playgrounds have become the preferred recreation areas. The interactive water playgrounds in this study are places where children can run and play in the water, pass under the water, and spend time with different water games.

In interactive playgrounds, special space is provided for modular sections that children can create according to their wishes (Unal, 2009). In the water areas, swinging, climbing, and interactive games are included (Ünal, 2009). These areas give children the advantage of gaining problem-solving ability; however, it takes time for designers to create these areas in the desired form (Unal, 2009). Flexible elements that can be rotated, moved, or changed by children are interesting for children (Unal, 2009). In addition, games in interactive playgrounds support children's creativity and independence (Unal, 2009). These areas include activities such as running, jumping, jumping, sliding, and climbing (Unal, 2009). These physical activities provide children with unique experiences and skills (Unal, 2009). One of the most important effects of these areas on children is that they support positive self-development (Unal, 2009).

Rather than the animation products used in the projects remaining static and creating only a visual feast, Polgün has turned each of the animation products into a game by including them in interactive playgrounds. In this way, it is designed as a track where children, who interact with the animated figures they use, can play with the spirit of competition by having adventures on wet ground. With the geometric shapes, warm-cold colors, and activities of different difficulty levels used throughout the track, it was aimed to improve the physical development of the children as well as their memory, repetition, sequencing, and mathematics knowledge through games. The reward system dropped water from above at each destination, allowing the child to experience feelings of achievement, and reward and enjoy the moment. From physical activities to climbing, jumping, synchronous walking, holding on, and balance games, the track has become an adventure.

These playgrounds have been indispensable for families as they encourage social interaction among children, improving emotional intelligence, social skills, physical activity, use of technology, and originality and creativity.

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CHAPTER 7

Children's Playground with Design by Customer Expectations and Environmentally Friendly Innovations

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Introduction

Tourism can be thought of as an experience chain based on human relations (Taner, 2018). The interactions between the people who have this experience, the quality of the services provided, and the memories left behind are factors in the next holiday choices (Taner, 2018).

Success in the holiday industry is possible not only by offering a beautiful place to stay but also by understanding the emotional and practical needs of holidaymakers and providing them with a special and unforgettable experience. The studies carried out in this direction will enable businesses to gain a competitive advantage and help them gain a solid place in the sector by increasing customer satisfaction. In today's intense competitive environment, businesses need to analyze customer profiles in detail and provide services that meet the wishes and needs of holidaymakers (Emir & Pekyaman, 2010). For example, considering the cultural differences of holidaymakers, and understanding the habits and holiday expectations of holidaymakers from different cultures can enable businesses to provide them with better service. At this point, businesses can train their staff to have a variety of cultures and language skills.

In addition, the presentation of the flavors of different cuisines gives holidaymakers an unforgettable experience. Another issue that businesses should consider is the various services they offer to families with children to make their holiday experience more enjoyable and comfortable. Children's playgrounds, children's clubs, spray parks, and businesses that provide educational activities are preferred because outdoor playgrounds support the development of children (Demir Öztürk, Atmaca & Kuru, 2020).

Another important issue for holidaymakers is the health and safety of the operators. How much attention is paid to hygiene standards and health measures, especially during the pandemic period, plays an important role in the preferences of holidaymakers. Investments in cleanliness and hygiene can enable holidaymakers to determine their accommodation preferences with confidence. Providing the most suitable services for these requests and needs, and ensuring customer satisfaction, causes businesses to stand out in the sector.

Aim and Problem of the Research

Children's Role in Families' Holiday Decisions and Choices

When families make holiday plans, they pay attention to the fact that the businesses they prefer are a suitable places for their children and then for them (Aymankuy & Ceylan, 2013). A consumer is psychological, such as family, personality, learning, lifestyle, attitude; age, income, gender, family size, occupation and educational status, and services provided to children (Emir & Pekyaman, 2010).

Table 1.
Decision-making stages in holiday selection (Emir & Pekyaman, 2010).

Step	Events and Decisions	Influences and Considerations
The need for a holiday	Perceived desire for a vacation Valuation of holiday needs Information collection and valuation	General holiday motivation Vacation time Time
Information gathering	Review of travel brochures and advertisements Consultation with friends and travel agents	Past holiday experiences Exposure to resort communications Holiday advertisements and promotions, Advice and suggestions from friends and agents
Decision	Deciding on the holiday destination, type of transportation, time, budget, intermediaries, tourist services to be received	Perceived image, touristic Destination promotions Previous Audit Potential Destination Image, Intermediaries
Preparing for travel	Location finalization, payment Hardware	Service advice, travel agencies Bank, credit card, health care

During childhood, children have fun, rest, and vacation with their families (Emir & Pekyaman, 2010). His family's choices currently are an incredible experience for them (Emir & Pekyaman, 2010). In addition, these choices affect children's lifelong holiday preferences (Emir & Pekyaman, 2010).

Families with children examine the services in the businesses they choose and turn to businesses that meet their expectations and needs. For example, when the research and surveys were examined, it was seen that the "no children's pool" of the hotels was the issue that affected the elections at the highest level (Emir & Pekyaman, 2010). This situation shows how much families care about the opportunities they can offer to their children in the purchasing process (Emir & Pekyaman, 2010). In addition, it is ensured that the operators are known as family facilities in the tourism market by adapting their products and services to the needs of families (Emir & Pekyaman, 2010). For this reason, children have a direct impact on families' holiday decisions. Families with children have special expectations from businesses about the services provided to children (Emir & Pekyaman, 2010).

The Impact of Holidays on Their Children

Families prefer hotels that can meet the needs and wishes of their children rather than their own needs and wishes (Emir & Pekyaman, 2010). Therefore, the child factor has become even more important in the tourism sector in the last decade (Emir & Pekyaman, 2010). Thus, businesses have started to provide additional services for children (Emir & Pekyaman, 2010). To obtain the title of a family hotel or child-friendly, it offers many criteria such as "children's pool and children's club" to its customers (Emir & Pekyaman, 2010). Thus, families prefer facilities where their children will be happier (Emir & Pekyaman, 2010). In this context, the study aims to develop an entertainment facility with new technologies for hotel operators (Emir & Pekyaman, 2010).

A compact playgroup has been designed that will attract the attention of children and ensure that families meet their children's needs and wishes and have a comfortable holiday during the decision process for choosing a hotel. This specially designed playgroup has been developed to enable families to make more informed and satisfied decisions when choosing a hotel. The playgroup, which will attract the attention of children and make their holidays more enjoyable, offers games, activities, and entertainment options to users in these areas with the ability to have both wet floors and pools. Families can enjoy a relaxing holiday by choosing this special playgroup to ensure that their children have a pleasant time during the holiday. Today, families do not prefer children's games that do not improve their academic skills. (Özyürek, 2019). They prefer games that improve children's physical, cognitive, and social skills (Yoleri & Tetik, 2020).

Our playgroup includes interactive games suitable for preschoolers. Specially designed playgrounds help children develop their creativity while also providing fun and educational experiences. It also gives holidaymakers the confidence to ensure that their children are playing in a safe environment. This private playgroup is aesthetically designed to blend in with the overall atmosphere of the hotel. Colorful and vibrant designs attract the attention of children while at the same time allowing the holiday to pass in a cheerful and pleasant atmosphere. While such entertainment facilities in the sector take up a very large area, it is not possible to use businesses with limited space. These factors have been minimized with the optimization studies carried out on the size of the playground to be established within the scope of the project and the amount of water used. Since it is an environmentally friendly work, it is important for businesses.

Research Questions

- Minimizing the areas of water park products,
- Wet playgrounds for customers who do not want to use a pool,
- High water consumption in water parks,
- The narrowness of the product range where preschool children can spend time with interactive play equipment,

Work has started on their feedback.

Figure 1.
Image of the Mini Splash project


Hypotheses of the Research

Based on the feedback from its customers about the water parks it produces, Polgün has identified some of the main problems and demands. Based on this feedback, he identified some key issues to consider during the design and development phase of the project. First, the fact that the products in the current sector cover a large area is a problem for operators with narrow areas. The feedback from these enterprises is the focus of our project, and studies have been carried out on the usability of the first one in narrow spaces.

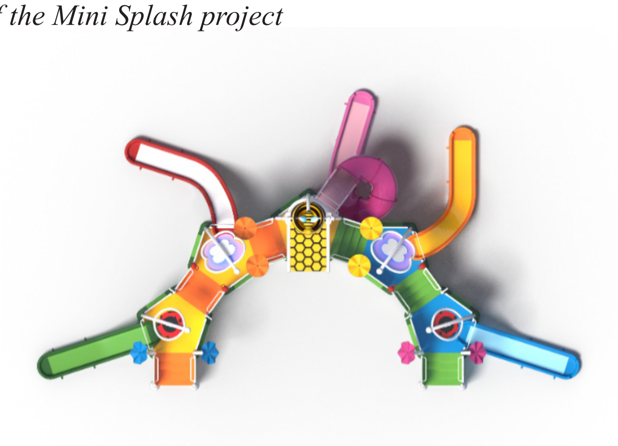
This will attract the attention of businesses with limited space and provide a competitive advantage. The second important issue in the incoming requests is that water-based activities have been developed in our project for businesses that do not want to build a pool. The successful design of the activities in the water parks without the pool has been shown within the scope of the project. In addition, the correct use of water in playgrounds designed without pools, and environmentally friendly and fun alternatives not only meet the expectations of your customers but also lead to the development of systems that optimize the use of environmentally conscious water.

Figure 2.
Mini Splash project for confined space

Apart from the benefits mentioned within the scope of the project, attention has been paid to carrying out studies related to them within the scope of the same project, considering the user demands. It is predicted that 60% of the playgrounds will be preschool children. The narrowness of interactive playgrounds and product range where preschool children can spend time indicates that you need to develop products suitable for children's entertainment and learning needs. Therefore, developing creative, educational, and interactive games in the established playgrounds increases the attractiveness of our project for children and families with children. Our project, which was developed by taking this feedback into account, is a solution to these problems. In addition, feedback from users is resolved quickly thanks to the modular structure of our project.

Results of the Research

Figure 3.
Front and top view of the Mini Splash project



In these areas, spray parking and water slides are combined. These areas also encourage businesses to be “environmentally friendly” by minimizing the water consumption used. Feedback from customers,

- Occupying a large space of the existing products in the sector,
- The customer does not want to build a pool,
- High water consumption in existing water parks,
- The narrowness of the product range where preschool children can spend time with interactive play equipment,

provided solutions to their feedback.

Modules were suitable for new trends that include interactive games, environmentally friendly due to low water consumption, flower and insect motifs that can be applied to both wet ground and low-depth pools, where children can have fun safely, parents can easily follow their children, and operating costs will be low for businesses. By examining the demands of our customers, optimization studies have been carried out to adapt the park with the smallest slide sections allowed by the EN-1069 standard to use narrow spaces efficiently.

Since the general purpose of the project is to use narrow spaces effectively and the structure is desired to have modules, it has been produced in line with this purpose in all details. The maximum height of the slide in the group is determined as 2.60 m. The slide falling from the 0.80 m platform was chosen as a straight and single model. The minimum dimensions allowed by the standard were used as the slide section. Two models, flat and helical, have been prepared for the slide, which will be located on the 1.40 m platform. A helical slide model has been prepared for an elevation of 2.00 m. The cross-sections of all these slides have been prepared with similar cross-sections so that they can use the same start, finish, and dry exit parts. For the 2.60 m platform, a section that can be used in both open section and tube form was designed in the section allowed by the standard, which will be used for the first time in the sector and was created by combining helical parts. The variety and number of interactive games to be used by children in children’s playgroups play an important role in the success of the playgroup. Due to this situation, a minimum of one interactive game is designed on each column.

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CHAPTER 8

Double Slit Nozzle Design and Production of Metal Powders by Gas Atomization

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Introduction

In this section, Grade AA1070 (Etial-7) pure aluminum metal was atomized using the gas atomization method. A dual-slit nozzle with both sonic and supersonic zones was designed to increase the gas atomization efficiency and to obtain a narrower powder distribution. Our original design of the dual-slit nozzle in this study was expected to solve three main problems. The first is to control the liquid metal viscosity of the gas released from the sonic zone with low pressure and speed, thereby facilitating its transfer to the atomization zone and assisting the formation of smaller spherical particles. The second one is to eliminate the solidification problem at the end of the metal flow tube, which is a major problem with close-coupling systems, and the formation of positive pressure. The third one is to prevent the shutting of the gas expansion zone, also called the closed transition zone, by keeping the pressure fixed using supersonic nozzle geometry. Using a dual-slit nozzle integrated into the gas atomization system, production parameters (gas pressure, fusion temperature, flow tube diameter, etc.) were optimized and aluminum metal powders with high added value were produced.

Next to steel, the second most commonly used material in the world is aluminum alloys (Gökçe et. al., 2017). The "Powder Metallurgy (PM)" method, an advanced procedure for manufacturing technological material, is a significant method regarding small-piece production and cost reduction. With technological developments, aluminum and its powders have enabled the production of high-durability parts thanks to its low density and corrosion resistance. Aluminum powders in particular find much use in defense, aviation, and automotive industries. Aluminum is used in various electronic circuit parts because it remains unaffected by magnetic field. The gas atomization technique was first used in the development of aluminum alloys around the mid-18th century (Akkaş et. al., 2019). Metal powders, being rather economical, are used in the production of parts that are difficult and costly to produce, particularly in machining. The necessity of fine grains in the field of industry has gradually increased; moreover, special requirements are present for the production of spherical fine powders (Urionabarrenetxea et. al., 2021). Today, close-coupling nozzle systems are used in atomization systems due to high production rate, powder quality, and production ratio. In the atomization of fused metals, atomized grains complete their solidification during their freefall inside the tower (Arkhipov 2016). High-pressure gas atomization systems are used to satisfy the need for spherical grains. Keeping the atomization conditions under control is critically important to attain a fine and spherical product with high performance (Liu et. al., 2018). The grain size of powders produced by the close-coupling gas atomization technique varies between 1µm and 1000µm (Zhang 2020). Among the gas atomization parameters, fusion temperature, nozzle geometry, gas pressure, and inner diameter of the flow tube greatly affect the particle size and distribution. Ünal et al. described gas atomization as the process of pulverizing a bundle of liquid metal using pressurized gas and claimed that grain size and distribution can be controlled by optimizing variables such as nozzle geometry, gas pressure and flow, and inner diameter of the flow tube and that the cooling speed of grains directly affects powder shape (Ünal et. al., 2008). Berndt et al. stated that the gas atomization technique is the most effective method of manufacturing fine and spherical metal powders (Berndt et. al., 2008). Sarı, on the other hand, describes gas atomization as the process of cutting and breaking metal drops into pieces by transferring kinetic energy from gas expanding at high speed to liquid metal (Sarı 2010). Tıng et al. claimed that liquid metal attains its spherical shape while freefalling inside the tower and cooling down after pulverization and that the resulting grains would range from 1µm to 1000µm in size; they concluded that the tower should be filled with a noble gas to protect the excessively-heated liquid metal from surface oxides during atomization (Ting et. al, 2002). Antipas stated that the properties of the gas and the liquid metal are the major factors in determining the powder shape (Antipas 2009). In their study, Miller et al. found that the gas exhausted from the nozzle at a higher speed yields smaller sizes (Miller et. al., 1997). German described the usability of nitrogen, argon, carbon dioxide, and helium as atomization gases German 2007). In a study, Yıldız emphasized the importance of using noble gases for metals with high oxygen affinity (Yıldız 2007). Literature includes several studies on the optimization of the atomization process. Mates et al. studied four different nozzles and reported that droplet pulverization is carried out by dynamic gas pressure and takes place at the tip of the nozzle. They have determined that using a supersonic nozzle and starting the atomization in the molten metal outlet, combined with increased dynamic gas pressure, can yield finer grains (Mates et. al., 2000). Mates and Settles reported high dynamic pressure and higher efficiency compared to close-coupling systems in their circular-slit supersonic nozzle design (Mates & Settles 2005). In their study, Aksoy and Ünal showed smaller grain sizes with increased atomization gas pressure. The gas/liquid mass ratio increases with shorter flow tube outlet length, and the decrease in molten metal flow rate is due to the effect of gas circulation area under constant pressure (Aksoy & Ünal 2023). In a study, Özbilen described sterilization as a structure formed by smaller grains with shorter cooling time sticking to larger grains with longer cooling time while grains of differing temperatures and sizes are drifting inside the tower. In addition, they suggested the possibility of the amount of oxygen and gas pressure in the environment controlling coarse grain formation when the optimized metal has high oxygen affinity, and the direct influence of a lack of homogeneity in the thickness of powder surface oxides on surface roughness (Özbilen 1999).

Despite the bulk of literature in the opposite direction, an original close-coupling dual-slit nozzle system design was used to produce AA 1070 (Etial-7) pure aluminum powder. In particular, the effects of parameters such as dual-slit nozzle performance, fused metal temperature, and gas pressure, and the inner diameter of the flow tube on grain shape and morphology were studied in the production process.

Material and Method

Using our original design of a dual-slit nozzle, Grade AA 1070 (Etial-7) pure aluminum metal was atomized via the gas atomization method. By using a dual-slit nozzle of an original design, parameters directly affecting grain size and distribution in powder production such as gas pressure, inner flow tube diameter, and molten metal temperature were modified to allow the production of pure aluminum powder with highly economical value, small size, and narrow size distribution. High-purity argon (Ar) gas was used in our studies. The gas pressure of 15 to 40 bars was used, and according to these gas pressure values, the fusion temperature was adjusted to remain between 810ºC and 830ºC and the inner diameter of the molten metal flow tube between 3mm and 5mm. All these specifications were combined to achieve optimal conditions, making it possible to reach the targeted powder size and distribution. About 80.82 percent of the metal used at the start of the atomization was turned into grains of spherical morphology. The loss is 10.18 percent, which is made of dust stuck on the inner walls of the tower and escaped the vacuum pump filter. Grains obtained by atomization were individually gathered from dust collectors and cyclone dust collectors and grain sizes were measured. Average grain size was measured as 25.4µm. Gathered grains were properly packed and stored. Analyses of grain size, XRD, SEM, and BET were conducted on the obtained samples and the results were shared at the end of the study.

Table 1.
Chemical composition of AA 1070 (Etial-7) pure aluminum

Elements	Al	Fe	Si	Ti	Mn	Zn	Cu	Mg
Ratio (%)	99,7	0,25	0,20	0,03	0,03	0,04	0,04	0,03

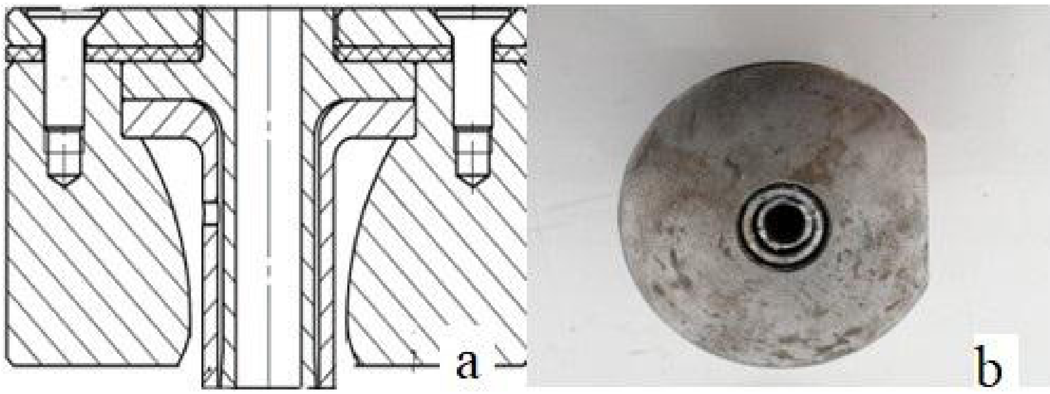
Grade AA 1070 (Etial-7E) pure aluminum used in this study was obtained from Eti Aluminum Inc., Foundry Management. Pure aluminum powder was produced by using a close-coupling gas atomization unit with a vertical design. Tables 1 and 2 illustrate the chemical composition and physical properties of Grade AA 1070 pure aluminum ingot.

Table 2.
Physical properties of AA 1070 (Etial-7) pure aluminum

Physical Properties	
State of matter	Solid
Density	2.7 g/cm^3
Fusion point	660 °C
Boiling point	2519 °C
Fusion heat	10.71 kJ/mol
Vaporization heat	294 kJ/mol
Heat conductivity	237w/mK
Brinell hardness	245

Our dual-slit nozzle of the original design is made of stainless steel. As seen in Figure 1, it has two areas for gas transfer and geometry. In this original work, we combine two different geometries, known in the literature as Laval and Mannesmann types. This nozzle can be installed and operated on both close-coupling and freefall systems. Situations that would interrupt the atomization process, such as solidification inside or at the end of the metal flow tube, positive pressure formation, or gas expansion zone closure, while the trials were conducted on our double-slit nozzle design. The nozzle was installed on the top center of the atomization tower. While atomization gas was connected and transferred, different values for influx pressure were studied and the optimal range was determined by using a manometer.

Figure 1.
Cross-section of the dual-slit nozzle (a) an image of dual-slit nozzle (b)



The outlet length of the flow tube was specified as 2.2mm by the nozzle design. This design choice allows the graphite to act like a flow tube and keep the system operational in case the flow tube breaks due to thermal shock. The flow tube and graphite pot are heated before each atomization process to eliminate thermal shock.

The grain size of the powders obtained from Grade AA 1070 pure aluminum was measured via Malvern Mastersizer 2000 in Eti Aluminum Inc., Q/C, and R&D Laboratory. Phase analyses of the powders obtained from Grade AA 1070 pure aluminum were carried out with an XRD device of GNR-EXPLORER brand in Eti Aluminum Inc., Q/C, and R&D Laboratory. This device has a θ/θ vertical goniometer design. The X-ray source is copper. Analysis of the pure aluminum powder product was carried out with a scanning angle of 5 to 70 degrees. Characterization of the powders produced via atomization for shape and morphology was conducted using a scanning electron microscope (SEM). Surface area inspections on the powders produced after optimal conditions were achieved were carried out using NOVA 4200e BET in Eti Aluminum Inc., Q/C, and R&D Laboratory. Powder samples went through a degasser at 105ºC before analysis.

Results and Discussion

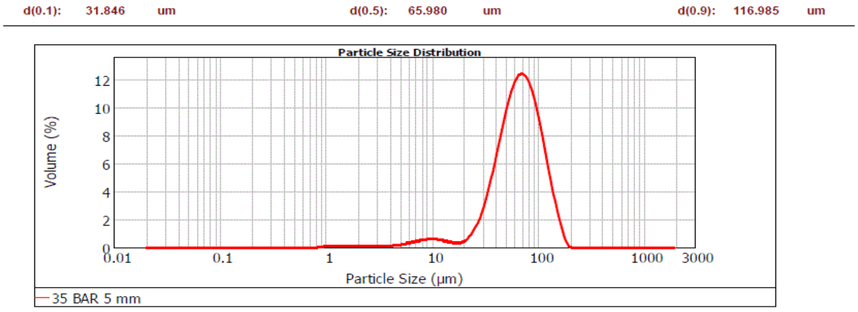
Grade AA 1070 pure aluminum was atomized using a dual-slit nozzle of our original design, and optimal conditions were determined. Raw material obtained as ingots was reduced to a size that fits in the furnace. Atomization parameters including gas pressure, inner flow tube diameter, and fusion temperature were optimized.

Table 3.
Powder production trials

Trial No.	Inner Flow Tube Diameter (mm)	Temperature (°C)	Gas Pressure (bar)	Average Grain Size (d50) (µm)
1	5	810	15	99.5
2	5	810	25	80.3
3	5	810	35	71.8
4	5	820	15	90.9
5	5	820	25	82.6
6	5	820	35	68.6
7	5	830	15	88.6
8	5	830	25	74.3
9	5	830	35	66.0
10	4	810	15	90.3
11	4	810	25	74.3
12	4	810	35	63.2
13	4	820	15	87.6
14	4	820	25	73
15	4	820	35	61.6
16	4	830	15	83.9
17	4	830	25	70.5
18	4	830	35	58.6
19	3	810	15	81.2
20	3	810	25	63.1
21	3	810	35	50.8
22	3	820	15	78.2
23	3	820	25	53.1
24	3	820	35	41.15
25	3	830	15	63.5
26	3	830	25	37
27	3	830	35	25.4

Optimized parameters are as follows: 35 bars for gas pressure, 3mm for inner flow tube diameter, and 830ºC for fusion temperature. Powder yield underwent sieve analysis at first. As seen in the trials shown in Table 3, the smallest grain size was 25.4µ, obtained with a temperature of 830ºC, gas pressure of 35 bars, and an inner flow tube diameter of 3mm. Grain collected from the tower and cyclones were mixed to homogeneity and grain size analysis was carried out (Figures 2-4). Figure 4 illustrates the device data. A smaller inner flow tube diameter as opposed to increased gas pressure and fusion temperature reduces grain size. Gas pressure of 40 bars and above is demonstrated to negatively affect powder morphology and grain size. The resulting powders have a leaflike appearance.

Figure 2.
Results of the grain size analysis for Trial 9.

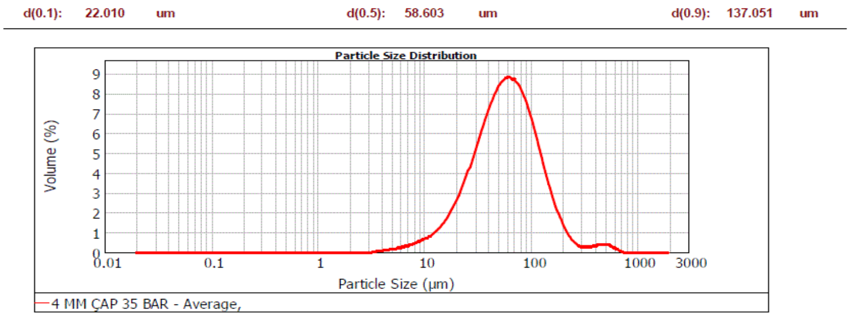


Size (μm)	Volume In %
0.010	
	5.41
20.000	
	16.50
44.000	

Size (μm)	Volume In %
44.000	
	37.41
74.000	
	38.41
149.000	

Size (μm)	Volume In %
149.000	
	2.28
2500.000	

Figure 3.
Results of the grain size analysis for Trial 18.

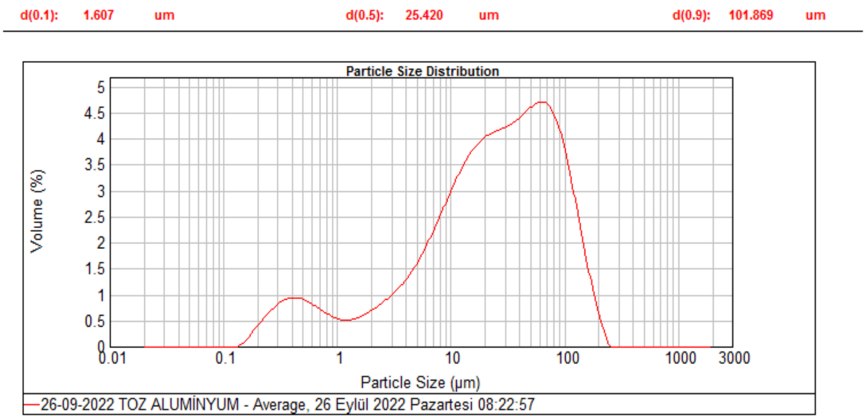


Size (μm)	Volume In %
0.010	
	8.25
20.000	
	26.10
44.000	

Size (μm)	Volume In %
44.000	
	28.97
74.000	
	28.74
149.000	

Size (μm)	Volume In %
149.000	
	7.94
2500.000	

Figure 4.
Results of the grain size analysis for Trial 27.



Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %
0.010	43.59	44.000	15.74	149.000	2.86
20.000	21.73	74.000	16.07	2500.000	
44.000		149.000			

Table 4.
Device data on grain size

Trial No	D_{10}	D_{50}	D_{90}
9	31.85	65.98	115.99
18	22.01	58.6	137.05
27	1.6	25.4	101.9

Results of the grain size analysis suggest smaller grain sizes with constant temperature and gas pressure and smaller inner flow tube diameter. Narrowing down the flow tube reduces the amount of liquid metal transferred to the atomization zone at a given time while increasing the kinetic energy transferred by the gas at the same rate, which results in smaller grains.

Powder samples pressed into the XRD sample tray under 20 kN of pressure were analyzed in the range 2θ = 5 – 70º. X-ray diffraction is a non-destructive testing technique that does not damage the crystalline structure and phases of the material. XRD analysis results for coarse and fine grains are shown in Figures 5 and 6.

Figure 5.
XRD chart for Trial 18.

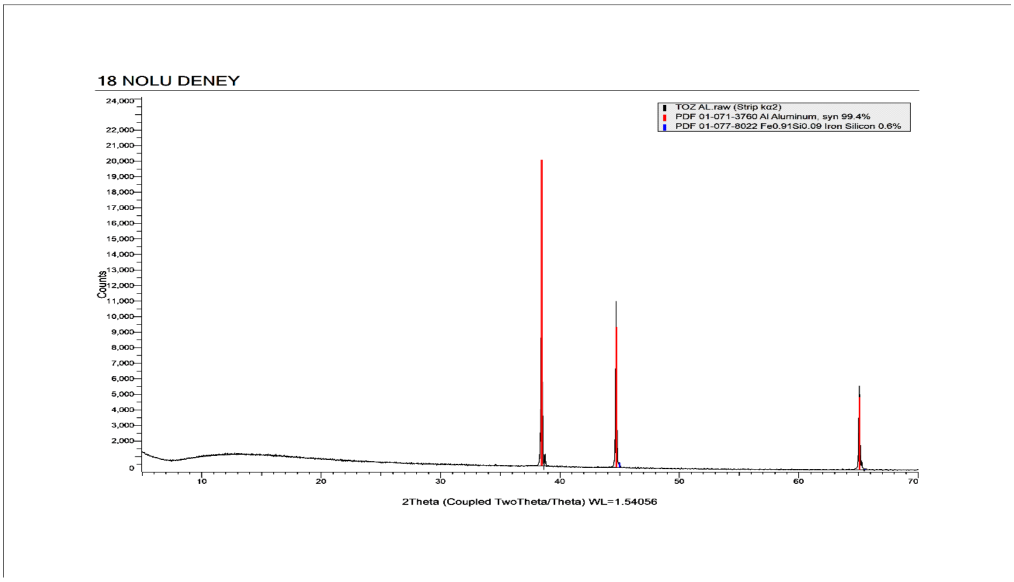
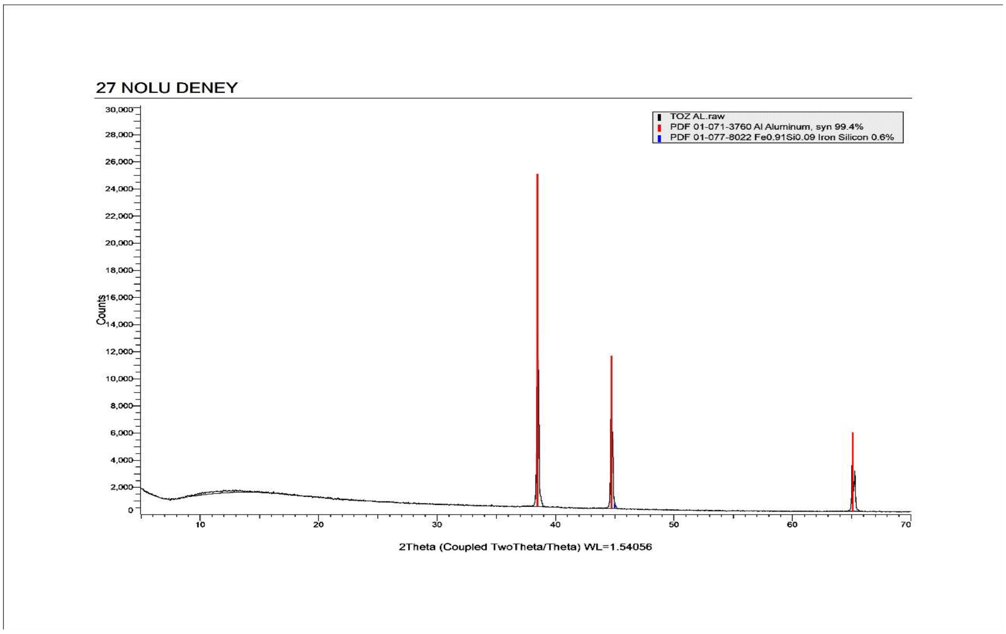
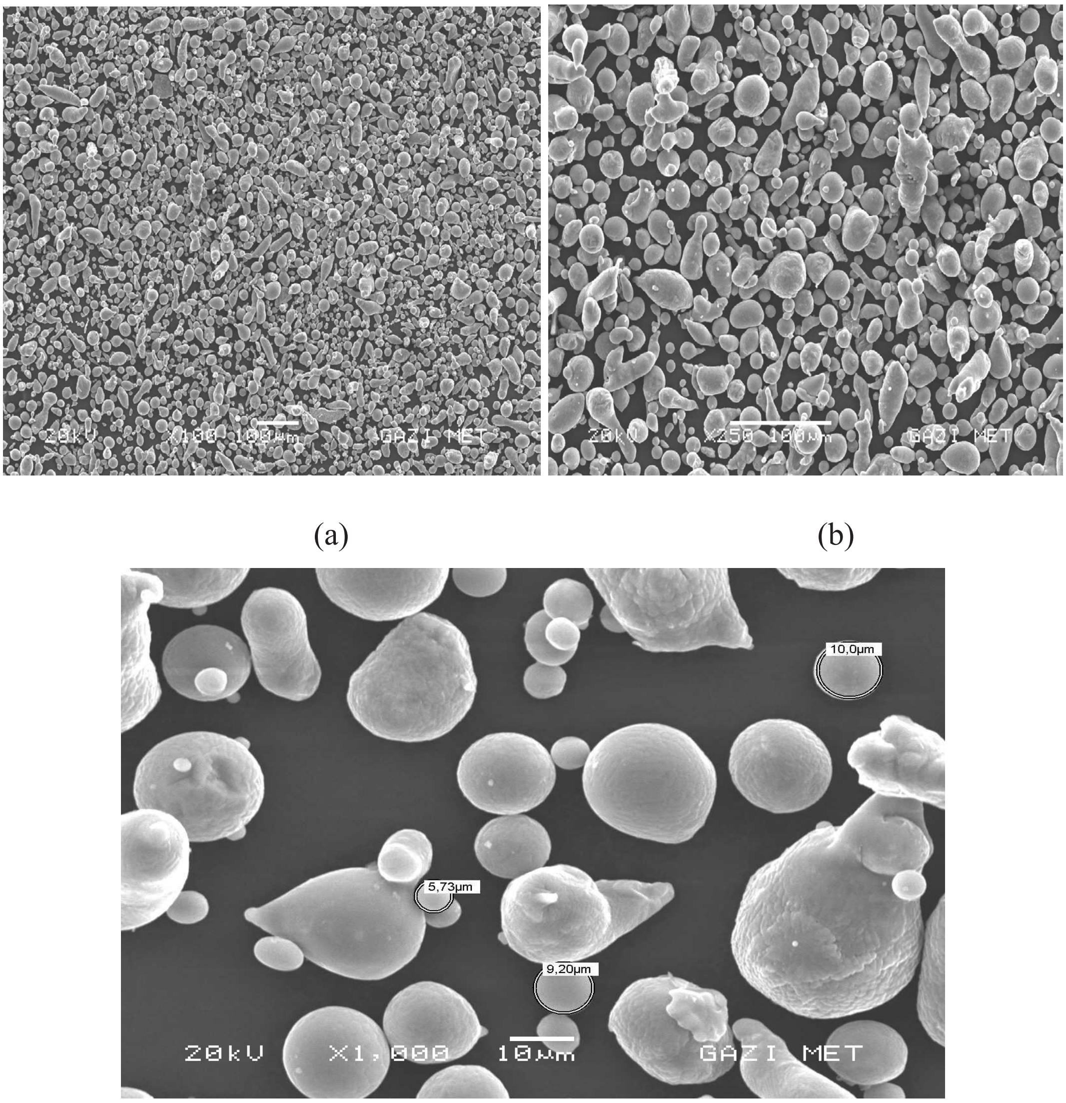


Figure 6.
XRD chart for Trial 6



Powders obtained in Trial 27 were pressed and analyzed in the XRD device in the range 2θ = 5 – 70º. Inspection of the diffractogram shows metallic aluminum as the main phase structure. Data from trials 9, 18, and 27 in particular were included in SEM analyses, and the device results are detailed below. Specifically, the effects of temperature, gas pressure, and inner flow tube diameter optimization in this study were verified by SEM images as well (Figure 7).

Figure 7.
SEM images for Trial 9

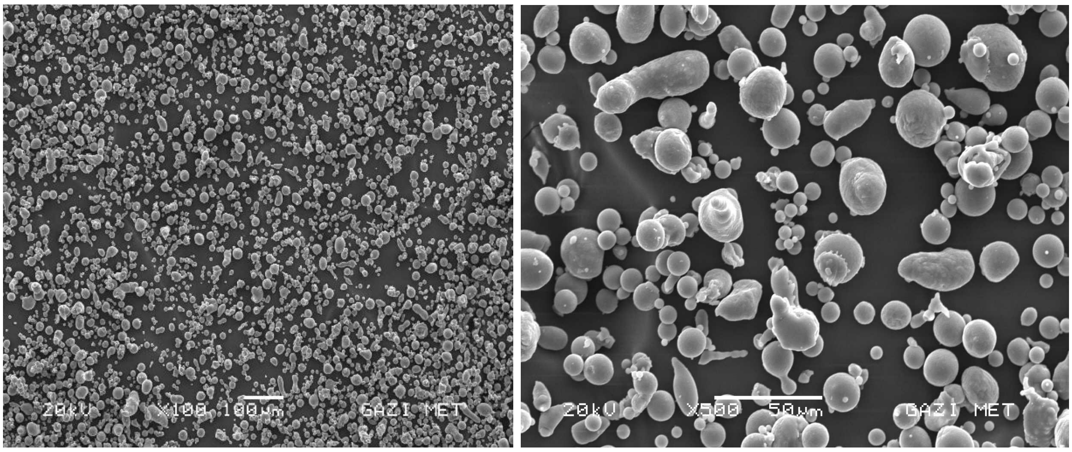


(a) (b)

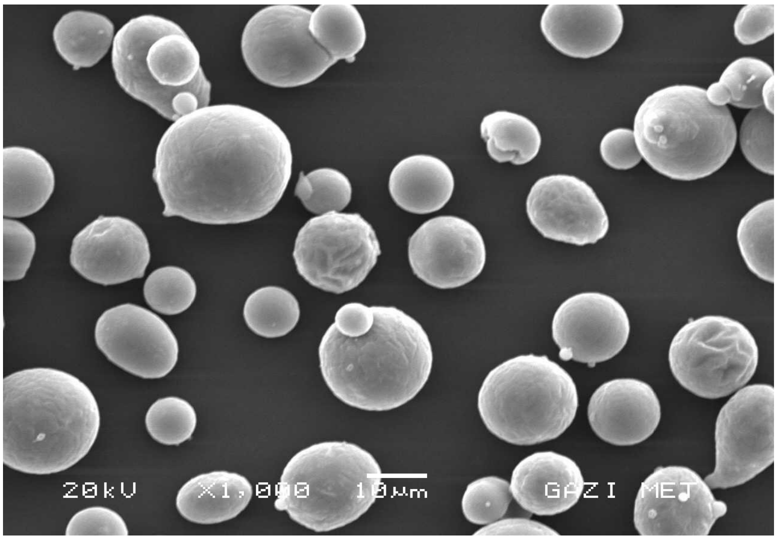
(c)

SEM images seen in Figure 7 (a), (b) and (c) show powders of d50 = 66µm from Trial 9, magnified by 100, 250, and 1000, respectively. Inspection of SEM images shows no regular morphology for the powder yield, with smaller grains being spherical and larger ones forming teardrops and other shapes. SEM images in Figure 8 (a), (b) and (c) show powders of d_{50} = 58.6µm from Trial 18, magnified by 100, 250, and 1000, respectively. More spherical formation and occasional satellization is observed compared to Trial 9.

Figure 8.
SEM images for Trial 18

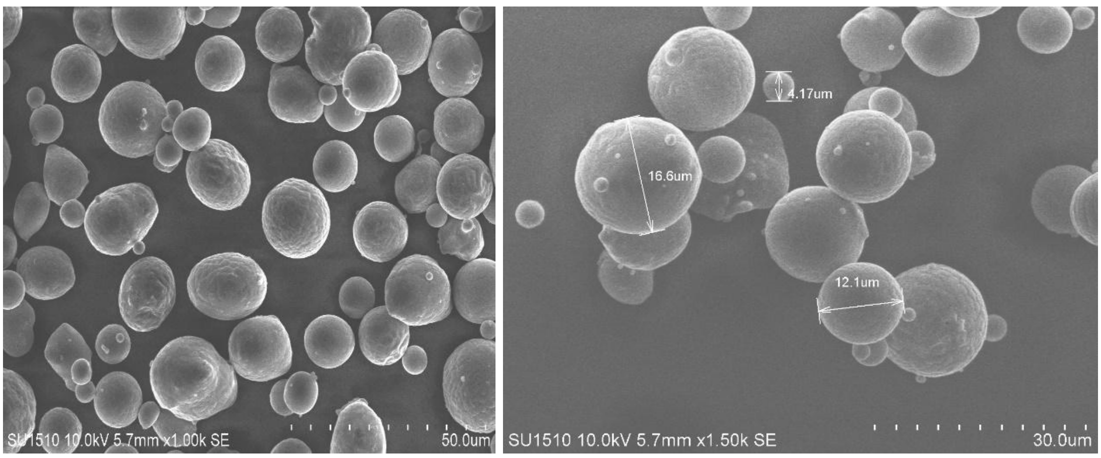


(a) (b)



(c)

Figure 9.
SEM images for Trial 27



Examination of the SEM images of the powders produced in the close-coupling gas atomization system with a dual-slitt nozzle of our original design demonstrated powder morphology including bar, teardrop, and sphere types, as also mentioned in the literature. Inspection of the SEM images from Trial 9 showed a general prevalence of bar and teardrop shapes. Low temperature and larger inner flow tube diameter compared to optimal conditions is found to result in a lower ratio of sphericity. Particularly, cases with a large inner flow tube diameter had lower gas/metal flow rates, which is the major factor influencing powder size and morphology. A reduced flow rate increased the amount of liquid metal transferred to the gas expansion zone, preventing the energy transferred to the liquid metal bundle from carrying out its task of pulverization effectively. Bar-shaped grains formed at the first stage turned into teardrops at the second stage of fission due to surface tension. Finer grains which solidify more quickly during the freefall inside the tower displayed an inclination for satellization, namely clinging to coarser grains. Inspection of SEM images for Trial 18 revealed an increased ratio of spherical grains compared to other forms. This is a result of a smaller inner flow tube size and increased fusion temperature. Almost all of the grains produced under optimal conditions in Trial 27 (Figure 9) are found to have a spherical form. Reduced grain size and a high ratio of spherical grains were observed with a higher liquid metal temperature and a narrower flow tube. Satellization was seen more clearly, especially in higher image enhancements. The satellization rate is found to be lower under optimal conditions compared to other trial conditions. Smaller grain size may be considered the major cause of this since smaller grains cool down and solidify faster than larger ones. BET analysis results for powders obtained in Trial 18 and optimal conditions are shared below.

The surface area of the powder produced under optimal conditions was measured to be 0.843 m2/gr, while the surface area of the larger powder produced in Trial 18 was 0.380 m2/gr (Figures 10 and 11). These results suggest that the surface area of the powder increases as its grain size decreases.

Figure 10.

BET analysis results for the powder produced in Trial 18

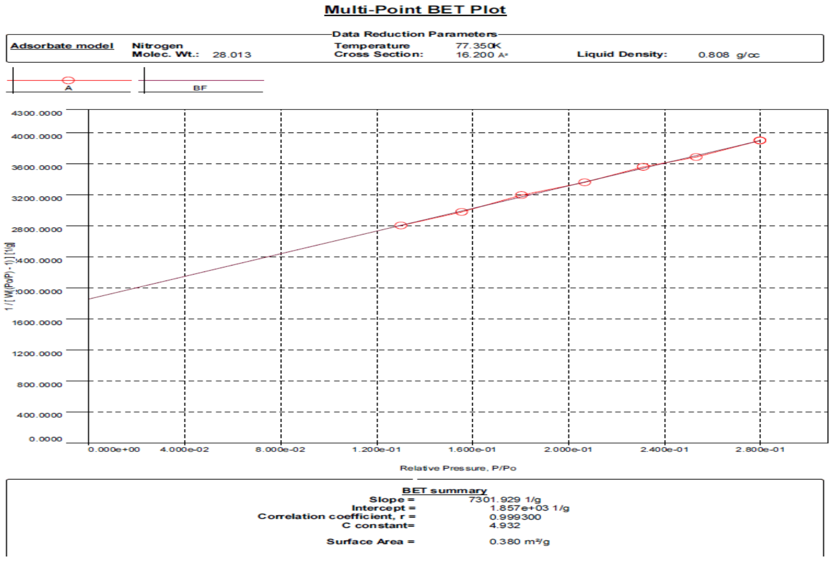
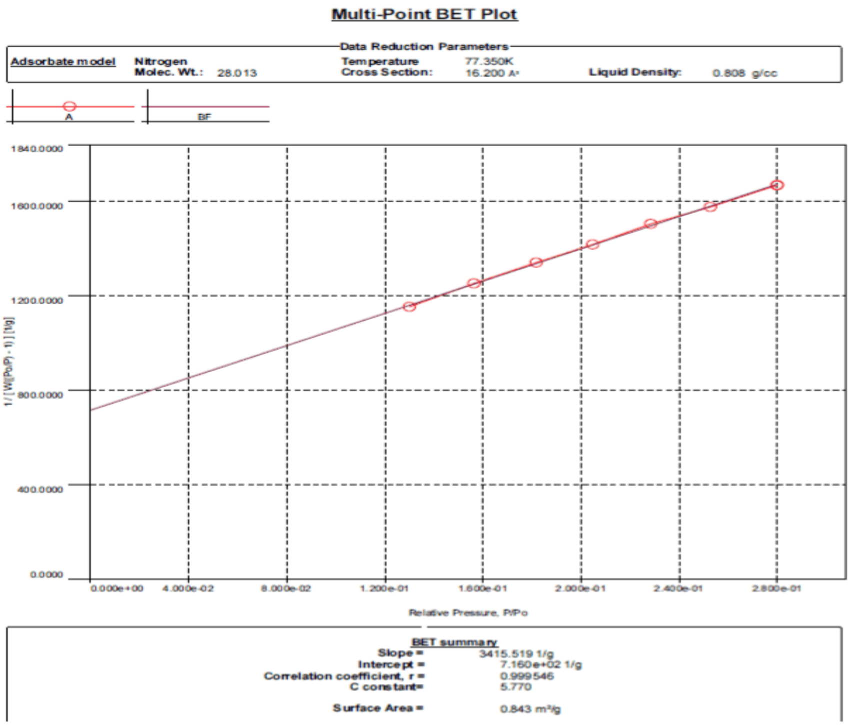


Figure 11

BET analysis results for the powder produced under optimal conditions (Trial 27)



Conclusion

The nozzle, which is a main parameter governing powder size and morphology in the gas atomization method, was constant in this study. Optimal conditions were achieved by altering gas pressure, fusion temperature, and flow tube diameter. They were identified as 35 bars for gas pressure, 3mm for inner flow tube diameter, and 830ºC for fusion temperature and taken as points of reference in all evaluations that followed. Grain size tests demonstrated that the finest grains and the narrowest range of grain distribution are obtained under optimal conditions. Rates of sphericity were found to increase as grain sizes decreased. Additionally, a narrower grain distribution resulted in reduced satellization. Database scanning via diffractogram during the XRD phase study verified metallic aluminum as the main phase. XRD results are semi-quantitative. The reference peak point of metallic aluminum has a face-centered cubic lattice structure. SEM studies demonstrated a direct influence of inner flow tube diameter and gas pressure over grain size. A narrower flow tube was shown to cause a lower rate of liquid metal drifting to the atomization zone, increasing the cutting power of the atomization gas. In this context, higher gas pressure was associated with increased gas cutting power, letting the transferred kinetic energy pulverize the liquid metal and creating a spherical product with a narrower grain distribution. Another result of increased gas pressure is reduced satellization. Increased gas pressure yields smaller grains which cool down and solidify more quickly, reducing the satellization rate. Analysis results for powders produced via the X-ray diffraction method identified metallic aluminum as the main phase. Separate analyses of coarse and fine grains demonstrated narrower peaks for coarse structures and wider peaks for fine grains. Peak width is associated with crystal size. XRD analysis displayed higher severity of finer samples (Trial 27) compared to coarser samples (Trial 18). Smaller grain size was shown to be associated with larger surface areas. Trial 18 yielded an average grain size of 59.8µm and surface area of 0.380 m^2/gr, whereas the values from Trial 27 were an average grain size of 25.4µm and surface area of 0.483 m^2/gr.

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CHAPTER 9

Telelactaction

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Introduction

Breast milk is a natural food that contains all the nutrients a newborn baby needs. The easiest way of breast milk intake is through breastfeeding (Boyraz & Erbil, 2023). The World Health Organization (WHO) recommends initiation of breastfeeding within the first hour after birth, exclusive breastfeeding for the first 6 months, continued breastfeeding until the age of two, and the provision of nutritionally adequate and safe supplementary foods (WHO, 2021).

Breastfeeding has long-term effects on both maternal and infant health. Perhaps no other health behavior has such significant effects. Studies have shown that breastfed infants are protected against infections, have a lower likelihood of becoming overweight or obese during childhood and adolescence, perform better on intelligence tests, and have higher rates of school attendance. For breastfeeding women, it has been observed that breastfeeding provides protection against breast cancer, improves birth spacing, and offers protection against ovarian cancer and Type 2 diabetes (Victora et al., 2016).

The WHO Global Breastfeeding 2025 targets state that the exclusive breastfeeding rate for the first 6 months should be increased to at least 50% (WHO, 2014). According to WHO data, globally, only 44% of infants aged 0-6 months are exclusively breastfed, and it's reported that three out of five infants do not receive breast milk within the first hour of life (WHO, 2022). UNICEF reported that between 2014 and 2019, 70% of infants in South Asia and 23% of infants in the Middle East and North Africa were breastfed until 20 to 23 months of age (UNICEF, 2020). According to the Turkey Demographic and Health Survey (TDHS) 2018 results, 71.3% of the most recently born children were breastfed within the first hour after birth, and 85.6% were breastfed within the first day after birth. As per the TDHS 2018 data, 40.7% of infants aged 0-5 months and 14.4% of infants aged 4-5 months were exclusively breastfed. The same report stated that while 65.6% of children were breastfed for one year, the rate for continued breastfeeding for two years was 33.5% (TDHS, 2018). These figures indicate that exclusive breastfeeding and continuation of breastfeeding for the desired duration remain below the desired levels both globally and in Turkey.

Although breastfeeding is an instinctive act, breastfeeding support is critical for breastfeeding success. Studies have shown that there is a strong positive correlation between prenatal and postnatal breastfeeding education breastfeeding support and breastfeeding duration (Özkara et al, 2016).

Telelactation

Although the utilization of technology in healthcare services dates back many years, significant developments in this field occurred in the 1990s with advancements in technology and innovations in healthcare services (Yıldız Çiltaş, 2023). According to WHO, telehealth is defined as "the provision of health services by health professionals using information and communication technologies to improve the health of individuals and their communities through the exchange of valid information for the diagnosis, treatment, and prevention of disease and injury, research and evaluation, where distance is a factor in service provision" (WHO, 2022). Telelactation refers to services that connect breastfeeding mothers with healthcare experts remotely using any real-time audio-visual technology. It is one of the most commonly used applications of telehealth (Demirci, 2019). Through telelactation, continuity in the assessment and support of breastfeeding is ensured while eliminating the barriers of time and distance (Ferraz dos Santos et al., 2019). This practice is significant, especially in situations where face-to-face counseling cannot be provided. When implemented appropriately, telelactation serves as an important tool in improving breastfeeding success and period (Uscher-Pines et al., 2019).

WHO views the support of breastfeeding through information technologies as an opportunity (WHO, 2021). Studies have shown that supporting breastfeeding through telehealth services increases the rate of exclusive breastfeeding during the first 6 months of life by 10% (Santos et al., 2020). It has been reported that women prefer telelactation services over traditional face-to-face education and that mothers who receive technology-assisted breastfeeding education have higher levels of knowledge about breastfeeding (Lewkowitz et al, 2019).

Commonly Used Telelactation Services

Telephone and Text Message Assisted Services

Telephone interventions as a part of telehealth in health services refers to the provision of health services through mobile communication technologies. Telephone support can be offered in two ways: passive and active. In passive support, support is provided only when requested, whereas active support is provided in the form of planned or unplanned calls. The medium of support can be voice calls or text messages (Lavender et al, 2013).

The use of the telephone to provide support in healthcare services emerged in 1897 when a doctor communicated via telephone to diagnose a child with croup. Within maternity care, it has been used as a means to assist pregnant women in quitting smoking, support women at risk of premature birth, and conduct birth triage (Lavender et al., 2013). In a systematic review conducted in 2018 examining studies on telephone support for pregnant and postpartum women, proactive telephone support was found to potentially prevent relapse into smoking, play a role in preventing low birth weight, increase breastfeeding duration, and aid in reducing postpartum depression symptoms (Dennis & Kingston, 2008).

Telephone-supported services related to breastfeeding are provided in the form of educational interventions, helplines, and counseling services (Sezer Yıldız & Özerdoğan, 2021). Educational interventions conducted via telephone to support breastfeeding primarily cover topics such as breastfeeding physiology, benefits of breastfeeding, common breastfeeding problems, breastfeeding techniques, assessment of breastfeeding behaviors, maternal emotional and physical health, extraction and storage of breast milk, and referral to healthcare services when needed (Oriá et al., 2018). In a study investigating the impact of telephone-based breastfeeding counseling in the postpartum period on exclusive breastfeeding during the first 6 months, it was found that the experimental group had a significantly higher rate of exclusive breastfeeding during the first 6 months compared to the control group (Moosazadeh et al., 2020).

Text messaging is the most common mobile phone activity used by all mobile phone users of all income levels as it does not require technologically advanced devices such as smartphones or tablets. In addition, text messaging is a familiar application for both adults and young people as it does not require activities such as using a new application or logging in, and a well-written text is likely to be read by people. It is also more advantageous than web-based technological support applications in rural areas and when internet access is limited (Mayberr & Jaser, 2018). Studies have found that breastfeeding support via text message contributes to ensuring continuity in counseling and positively affects breastfeeding behavior (Gölbaşı et al, 2019).

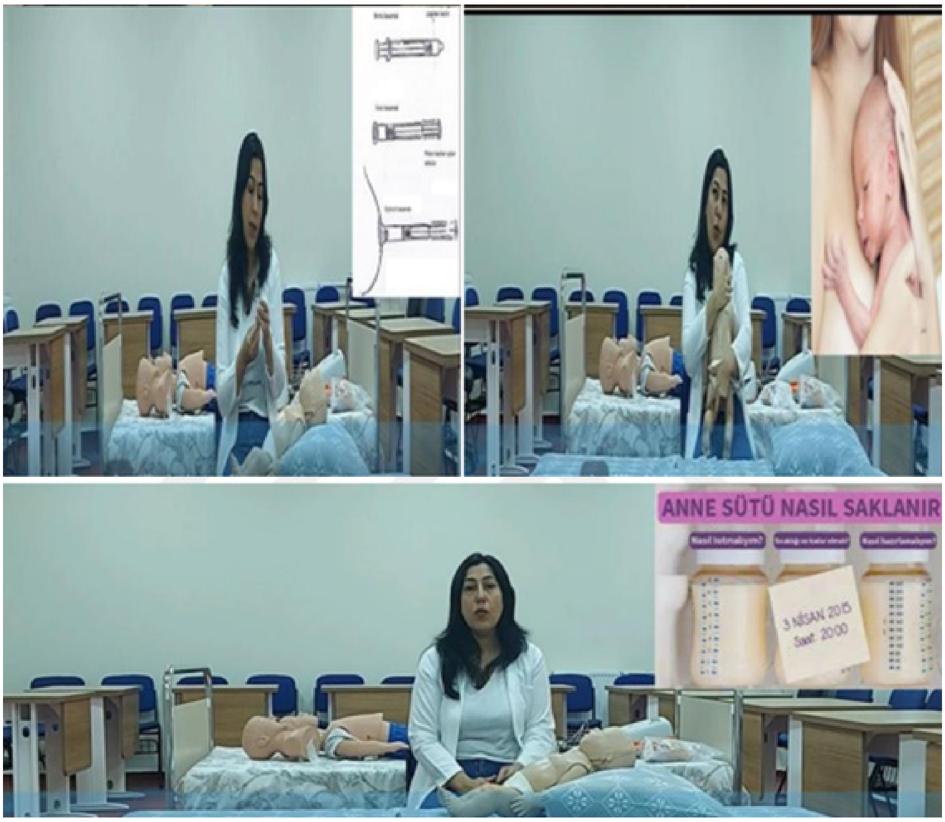
Video-Conferencing Assisted Mobile Health Applications

With the advancement of technology, smartphones have become an integral part of our daily lives. Applications that can be downloaded to smartphones and tablet computers are easily accessible tools for obtaining health-related information (Koçak & Ege, 2021). Mobile health applications are designed according to the needs of individuals. Individuals can easily overcome geographical, organizational, and attitudinal barriers between themselves and healthcare and access the information they need more quickly and at the desired level (Silva et al., 2015). While some mobile applications are available for free use, others are paid applications. In countries like the United States and the United Kingdom, numerous companies (such as Medela, American Well, Lansinoh, and Pacify Health, etc.) support breastfeeding mothers through video visits with certified lactation consultants via applications downloaded to individuals' phones (Demirci et al., 2019; Uscher-Pines et al., 2017).

Video-assisted education is widely used in health education, especially because it is more cost-effective than most other education models. Studies have shown that video-assisted breastfeeding education is more effective than face-to-face breastfeeding education (Adhisivam et al., 2017; Adam et al., 2019). These educations typically cover topics such as the benefits of breastfeeding, improving breastfeeding behavior, breastfeeding positions, initiation and continuation of breastfeeding, frequency, and duration of breastfeeding, extracting and storing breast milk, and skin-to-skin contact (Tetik Metin, 2023). In a study conducted in the United States, international lactation-certified consultants provided postpartum women with both video-based education and video calls until the fourth week after birth and the education increased breastfeeding success by 40% (Şensoy & Koçak, 2021).

Figure 1.

Images from Video Assisted Education (Tetik Metin, 2023)



In a scientific study examining breastfeeding-related videos published on social platforms in Turkey, it was observed that 63.2% of the videos included breastfeeding education, while 33.3% included correct breastfeeding techniques (Aydın & Ünlü, 2020).

In a study examining the experiences of community health workers using video education during home visits, participants expressed that health education videos were seen as an acceptable and feasible tool for women's participation in the community, leading to increased feelings of self-efficacy and self-confidence and reduced time spent in the field (Coetzee et al., 2018).

Online-Web-based counseling

The increase in personal internet usage, alongside technological advancements, has led to a greater desire to acquire health-related information online (İnci & Serçekuş, 2015). The freedom of individuals to access information anytime and anywhere has also increased the demand for counseling services provided on the web (Bulut & Gölbaşı, 2023). Studies have shown that the majority of women in the perinatal period can access the Internet using computers or mobile phones (Gao et al., 2013). When compared to face-to-face education, web-based health education is more advantageous due to its lower cost and greater accessibility to a larger number of people in a quicker manner (Şensoy and Koçak, 2021).

For web-based education to be successful, it should be designed in a user-friendly manner, meaning it should be easy to browse. To achieve this, the content should be compiled appropriately according to its purpose, with accurate and well-organized information presented effectively. Irregularly placed text and images can cause misunderstandings by making perception and communication difficult. Another criterion for the success of web-based education is readability. Readability refers to how easily the text can be understood by the reader. It is expected that educational materials prepared for the web should be understandable at the sixth-grade level or below (İnci and Serçekuş, 2015).

Advantages of Telelactation

Accessibility

Telelactation makes breastfeeding support accessible to a broader population. It is particularly valuable for those residing in rural areas or regions with limited access to personal lactation consultants. These services aid in meeting the needs of mothers living in rural areas (Kapinos et al., 2019). In a study evaluating the impact of telelactation services on breastfeeding duration among women in rural areas, the researchers found that women receiving telelactation services breastfed at higher rates (Kapinos et al., 2019).

Telelactation services can prevent the interruption of breastfeeding and the use of formula milk, especially during situations like pandemics or disasters (Uscher-Pines et al., 2017). During the COVID-19 pandemic, the postpartum discharge periods for women have shortened, leading to a reduction in the duration of breastfeeding support and counseling. Telelactation services have become advantageous during this period for assessing and supporting the continuity of breastfeeding (Serhatlıoğlu, 2022).

Cost

Telelactation services are less costly than face-to-face counseling services. Breastfeeding counseling through telelactation can reach a larger number of women at a lower cost. Likewise, the number and frequency of counseling sessions provided to an individual can be increased at a lower cost (Uscher-Pines et al., 2017)

Convenience

Another advantage of telelactation services is that individuals can receive assistance without leaving the comfort of their homes. They do not have to travel to a healthcare facility to receive the service. They can receive the service at their convenience, within the timeframes that suit them, without the necessity of adhering to a specific appointment time. This helps reduce the stress associated with trying to meet a scheduled appointment (Uscher-Pines et al., 2017).

Real-Time Evaluation

Telelactation services allow visual assessment of the breastfeeding process through video calls and live consultations, enabling healthcare professionals to provide instant guidance and address specific issues. Healthcare professionals can meet mothers' problem-solving needs within minutes or hours and potentially prevent the cessation of breastfeeding or the need for formula supplementation (Uscher-Pines et al., 2017).

Timely Support

Breastfeeding success is a multifaceted process. Therefore, the reasons affecting breastfeeding success need to be identified quickly and accurately and intervened promptly. Telelactation services provide a means for mothers to access support at any time, which is especially important for addressing urgent issues or concerns outside regular working hours (Uscher-Pines et al., 2017).

Privacy

Some mothers might feel more comfortable discussing challenges and difficulties related to breastfeeding in a private setting, and telelactation provides this level of privacy (Uscher-Pines et al., 2017). Studies indicate concerns regarding the lack of privacy in public breastfeeding spaces (Peksoy Kaya & Uludaşdemir, 2023).

Challenges and Considerations

While telelactation offers many advantages, it is not without its challenges. These include:

Technology Barriers

Mothers requiring telelactation services need to possess a technological device that enables communication with a healthcare consultant, is suitable for receiving the service, and they should be adept at its use, usually requiring a reliable Internet connection. Not all mothers have access to the necessary technology or a reliable internet connection, which can hinder their ability to benefit from telelactation services. This situation poses a challenge, especially for women residing in rural areas. Poor internet connection affecting women in rural areas may also decrease the likelihood of benefiting from telelactation services. This negatively impacts the reduction of inequalities, one of the objectives of telelactation services (Uscher-Pines et al., 2017). In addition to internet connectivity issues, some mothers, despite having access to proper technological devices and internet connections, may encounter difficulties in using them. This creates a disadvantage for them in utilizing telelactation services (Nandula & Hudak, 2021).

Cultural Sensitivity

Breastfeeding support should be culturally sensitive, and telelactation providers need to be aware of cultural differences and preferences in breastfeeding practices. In a study, some mothers expressed reluctance to engage in video calls with an unknown person (breastfeeding consultant) or preferred using community-based breastfeeding support systems (Demirci et al., 2019). Similarly, another study aimed to describe maternal responses to breastfeeding support via video conferencing, concluding that although mothers were comfortable with technology, they were hesitant to use the service provided through a technological device (Habibi et al, 2012).

Scope and Nature of Care

There may be limitations in the types of problems that can be effectively solved through telelactation. Complex medical concerns may still require personal assessment. Rojjanasrirat et al. (2012) evaluated the feasibility of telelactation as well as maternal satisfaction with videoconferencing support. Although mothers reported a positive attitude towards telelactation consultation, they reported problems such as not being able to evaluate the breast and the baby's latch, in addition to internet connectivity issues. A potential disadvantage of written and audio phone-based support compared to video-based support is the possibility of misinterpretation (Demirci et al., 2019).

An important criterion for the success of telehealth services is its readability. Educational materials prepared in online environments must be understandable by individuals. Studies examining the readability of breastfeeding education provided on the web have found that the readability level is often at a level that the reader can hardly understand. This presents an obstacle to achieving the service's goals (İnci & Serçekuş, 2014).

Conclusion

Telelactation is a valuable tool in bridging gaps in breastfeeding support. It offers accessibility, convenience, and real-time guidance to mothers experiencing breastfeeding issues. As technology continues to advance and telehealth becomes more integrated into healthcare systems, telelactation has the potential to play an increasingly important role in promoting successful breastfeeding experiences. Ensuring its effective and responsible use is crucial to supporting the health and well-being of both mothers and infants.

Especially with the Covid-19 pandemic, there has been a positive shift in the community towards telehealth services and the compliance level of individuals has increased. Telelactation services have been affected in the same way as other areas of telehealth. These positive effects have been evident among healthcare professionals as well. Telelactation services, which contribute positively to providing healthcare without the risk of transmitting infectious diseases and address any disruptions in service continuity, have become more accepted and utilized by healthcare personnel. Through telelactation services, the needs of breastfeeding women have continued to be met even during the pandemic.

Telelactation services should be made more accessible, and healthcare professionals' knowledge and experience in this area should be enhanced. Existing practices need to be updated or new application designs should be developed not only for mothers but also for other family members and fathers involved in infant care.

In this chapter, we examined the concept of telelactation, its advantages and challenges. Thanks to its ability to make breastfeeding support more accessible and convenient, telelactation is a promising solution to improve breastfeeding outcomes for mothers and their babies.

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CHAPTER 10

Rehabilitation Robotics

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Introduction

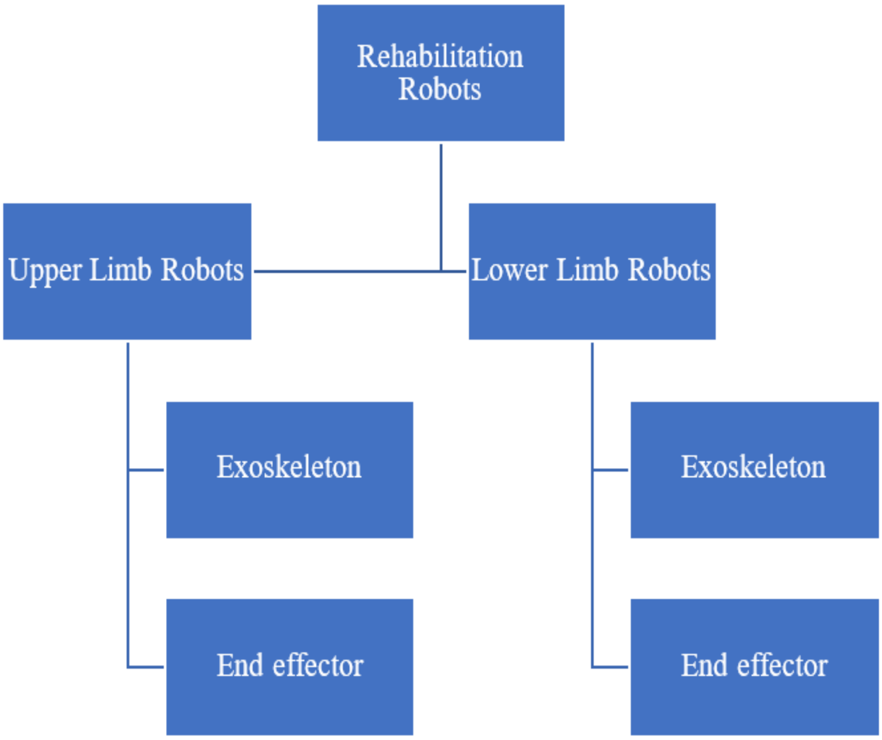
Mechatronics engineering is an engineering field that combines electrical-electronic, computer and mechanical engineering and is increasingly used in health applications. Thanks to the fields of mechatronics and biomechatronics engineering, the development of robotic devices, especially in the field of health and rehabilitation, is increasing the interest in this field (Demirbas, 2019). The ability of robotic devices to work intensively, repetitively and task-specifically has made them increasingly popular in neurorehabilitation, especially in the last two decades (Iosa et al., 2016). The main goal of neurorehabilitation is to develop a smooth movement pattern by providing muscle strength, coordination and sensory input, while facilitating neuroplasticity by reorganizing the representational areas of the cortex. Neuroplasticity, on the other hand, provides motor control and learning, making the movement permanent (Kilinc et al., 2019). Based on these principles, neurorehabilitation practices are used in the treatment of many neurological diseases such as stroke, spinal cord injury, brain trauma, Parkinson's, multiple sclerosis, and cerebral palsy (Calabrò et al., 2016).

The inadequacy in mobility that occurs in various forms and severities in neurological diseases is tried to be eliminated by applying motor learning principles in current rehabilitation methods. The most important factor in providing motor learning in rehabilitation is the repetitive performance of activities. In the development of the ability to fulfill the task, these repetitive activities should be applied variably with frequent repetition. In other words, motor learning can be realized if the activities and movements are repeated with different combinations and patterns (R. A. Schmidt & Lee, 2011). A rehabilitation program involving rehabilitation robots can provide a much higher number of activity repetitions compared to traditional neurorehabilitation applications.

Another benefit of robots in rehabilitation applications is that they provide continuous feedback to the patient and therapist. Robotic rehabilitation systems, especially integrated with virtual reality technology, provide visual and auditory feedback during the activity, providing information about the smoothness and coordination of the movement. In this way, the patient and therapist can monitor their performance instantly and continuously (Scheidt et al., 2005). In short, rehabilitation robots are technological devices that affect motor functions, can be adjusted at different speeds, provide continuous feedback by providing control in situations where the patient is inadequate, and provide personalized recovery (Conditt et al., 1997).

Today, the robots used in the field of rehabilitation are divided into two upper-extremity and lower-extremity robots specific to the body part, which is divided into two exoskeleton and end effector according to the way they work (Figure 1).

Figure 1.
Classification of Rehabilitation Robots



History of Rehabilitation Robots

In the field of rehabilitation, the robot called "Case Manipulator" was first used in the 1960s. The robot with four degrees of freedom was used to move the arm. Later, in Mexico, a seven-degree-of-freedom robot called "Rancho Los Amigos" was produced, which is the ancestor of today's exoskeleton robots (Hillman, 2004). In the 1970s, Roesler from Germany and Seamone and Schmeisser from the USA developed devices for robotic rehabilitation in 1974. In addition, robotic technologies continued to develop with the Spartacus and Master projects of France and the Manus project of the Netherlands. In 1978, Leifer and Van der Loos from Stanford University developed the first occupational assistant robot in their DeVAR project. In the mid-1980s, programmable, force-controlled, but single-axis devices such as BioDex began to be used in upper extremity rehabilitation. The first multi-axis project was designed by Khalili and Zomlefer. Later, robots began to use advanced force-based control, which required considerable computer power. However, in the early 1990s, the MIT-MANUS project by Hogan and Krebs and the Palo Alto VA MIME project at the University of California Berkeley by Lum et al. (Siciliano & Khatib, 2016).

In the 1980s, research and development in the field of rehabilitation robotics were led by the United States, the United Kingdom and Canada. After 1990, with the differentiation of rehabilitation robots into different types and extensive developments, research in this field has spread to industrial regions such as the USA, UK, Canada, Europe and Scandinavia-Japan (Li et al., 2017).

Features of Rehabilitation Robots

Today, robotic devices used in the field of rehabilitation can be considered assistive and controller devices that enable the user to move. They can operate in different modes as active, active assisted, passive, resistive, trajectory determining and corrective according to the needs of the patient during movement. It is designed in such a way that it can provide support or even resistance in cases where the patient can perform the movement or any stage of the movement, or it can help the patient in cases where the patient cannot perform the movement. Robotic rehabilitation devices have a working mechanism called degree of freedom according to the movement and joint level they support. The degree of freedom refers to the planes and axes in which the robot moves (Kilinc et al., 2019). For example, if the robot can only perform abduction-adduction movement to the hip joint, it has one degree of freedom, while if it can perform flexion-extension to the knee joint and dorsiflexion-plantar flexion to the ankle joint, it has three degrees of freedom. As the degree of freedom of the robotic device increases, its mobility and competence increases.

Robotic devices can also be integrated with virtual reality applications to provide visual and auditory feedback to the user and provide information about the smoothness of the movement. In this way, a rehabilitation program can be carried out according to motor learning principles with plenty of repetitive and purposeful activities (Kilinc et al., 2019).

Upper Extremity Rehabilitation Robots

Exoskeleton-type rehabilitation robots act directly on specific joints of the user (Figure 2). They can be adjusted for users of different sizes. They are more difficult to design because they are fixed to the limb from different areas. Exoskeletons designed for the upper limb are difficult to move because they are attached to different parts of the limb. This causes the patient to perform compensatory activities while moving (Lum et al., 1999, 2004, 2006). Exoskeletons can resist or assist the movement of limb segments. Each joint can move independently of the other joints. In this way, isolated or combined joint movements can be performed within anatomical and physiological movement limits. One of the most important benefits of exoskeleton robots is that they integrate daily life activities with virtual reality and video games to practice repetitive and intensive, purpose-oriented activities (Kilinc et al., 2019).

Upper limb end effector robots are utilized using a manipulandum, which is grasped by hand. The manipulandum is connected to a robotic arm that senses motion through motion sensors while providing force to the user when needed. Since the forces and measurements take place on a single interface, they can be easily adjusted for different users without major changes to the system (Colombo et al., 2005; Mehrholz & Pohl, 2012). Sensory and motor training using a robotic device is realized through video games controlled by the movement of the manipulandum. The user tries to perform tasks such as drawing shapes or moving along a plane by moving an icon on the screen with the manipulandum (Fasoli et al., 2003; Ferraro et al., 2003). In addition, in some robotic devices, the movements of the manipulandum are converted into kinematic data through sensors, allowing the user's motor functions to be evaluated (Krebs et al., 1998).

Upper Extremity Exoskeleton Robots

MIT Manus

The MIT Manus was designed by the Massachusetts Institute of Technology (MIT) in the early 1990s to improve arm function in stroke patients (Figure 2). The robot can assist or resist movement while enabling reaching movements in the horizontal plane. The device has two degrees of freedom allowing shoulder and elbow joint movements. It can be integrated with video games (Hidler et al., 2005).

Figure 2.
a. MIT Manus, b. MIME (Hidler et al., 2005)

Mirror-Image Motion Enabler (MIME)

MIME is a six-degree-of-freedom rehabilitation robot for the shoulder and elbow joint, produced in collaboration with the Veteran Administration Medical Center in Palo Alto and Stanford University (Figure 2). It is the first device that can operate bilateral upper extremities, as well as allowing the movements performed with the intact upper extremity to be mimicked with the affected side (Burgar et al., 2000; Lum et al., 2006).

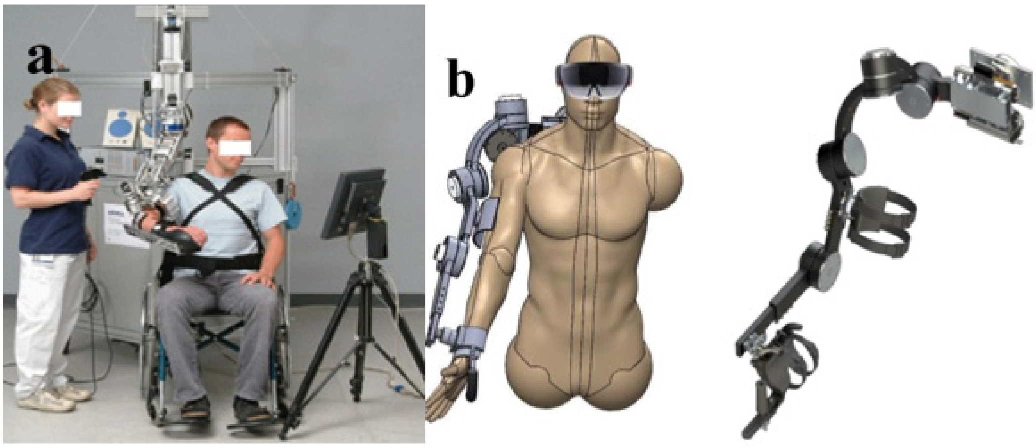
ARMin

ARMin is a rehabilitation robot with six degrees of freedom that allows movement in three planes: flexion, abduction and rotation of the shoulder, elbow, forearm and wrist (Figure 3). The device, which provides control in movements against gravity, enables to perform purposeful tasks that can provide video game integration (Nef et al., 2006).

CLEVERarm

The CLEVERarm rehabilitation robot has six degrees of freedom in the shoulder and elbow joints and two degrees of freedom in the wrist joint, which can passively perform flexion and extension and ulnar and radial deviation movements (Figure 3). It is a compact and lightweight device thanks to its carbon fiber material design. The device also supports virtual reality and augmented reality applications (Zeiaee et al., 2022).

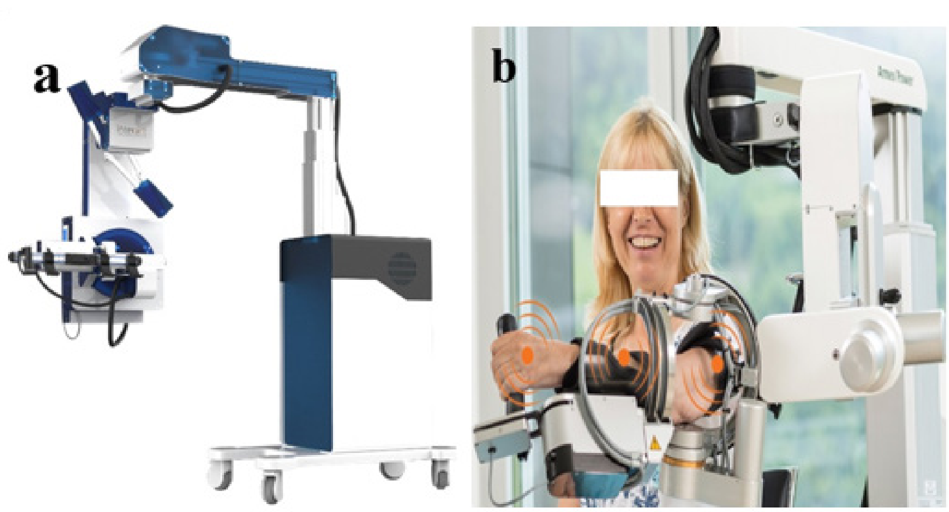
Figure 3.
a.ARMin (Nef et al., 2006), b. CLEVERarm (Soltani-Zarrin et al., 2017)



Asist On

Asist-On was developed by Patoglu et al. at Sabancı University in Turkey between 2006 and 2014 (Figure 4). In addition to supporting all upper extremity joints and performing all movement patterns, it also supports scapulohumeral rhythm. The device has seven degrees of freedom as it supports all upper extremity movement patterns. Made of lightweight material, the device is designed as a new-generation upper extremity rehabilitation robot with easy-to-wear features (Ergin & Patoglu, 2012).

Figure 4.
a.Asist On ('AssistOn-Arm', n.d.), b. Armeo Power ('Armeo®Power', n.d.)



Armeo Power

It is a rehabilitation robot device with six degrees of freedom by the Hocoma company. It can work as active, resistive or passive according to the patient's needs (Figure 4). The robot, which can be integrated with virtual reality technology and has additional materials for grasping functions, is one of the most advanced robotic devices. There are also different upper extremity robotic rehabilitation devices called Armeo Spring and Armeo Senso designed by Hocoma company (Grimm et al., 2021).

Upper Limb End Effector Robots

Arm Guide

The Arm Guide can allow four and six degrees of freedom controlling the shoulder, elbow and wrist (Figure 5). The device, manufactured at the Chicago Rehabilitation Center, is effective on tonus and muscle spasticity while controlling movements against gravity (Reinkensmeyer et al., 1999, 2000).

Figure 5.
a.Arm Guide (Hidler et al., 2005), b. InMotion Arm ('InMotion® ARM', n.d.)

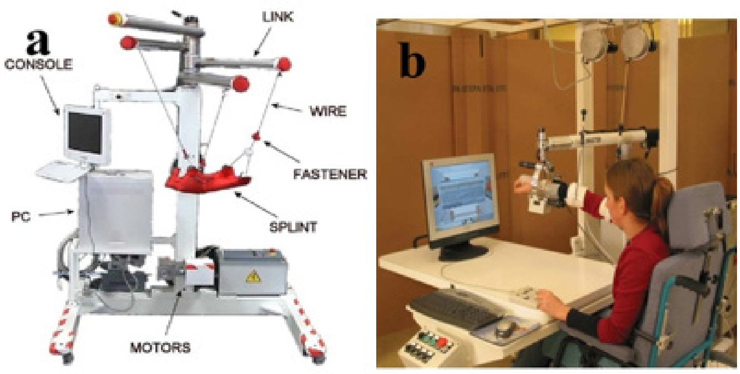
InMotion Arm

The InMotion Arm rehabilitation robot allows for practicing elbow and shoulder joint movements (Figure 5). The device, which is easy to wear and use, improves joint movement, coordination, strength and speed in activities. It can work together with virtual reality technology (Duret et al., 2019).

NeReBoT

NeReBoT is used as a rehabilitation robot with three degrees of freedom, allowing movement in the frontal and sagittal planes in the shoulder joint, while supporting rotation movement in the forearm (Figure 6). The device contributes to the patient's activity control and motivation with visual and auditory feedback during movements (Rosati et al., 2005).

Figure 6.
a.NeReBoT (Rosati et al., 2005), b. GENTLE/S Haptic Master (Harwin et al., 2006)



GENTLE/S Haptic Master

The GENTLE/S rehabilitation robot has three degrees of freedom, allowing movements in the shoulder, elbow and wrist joints (Figure 6). It is reported to improve upper extremity function in both chronic and acute neurological rehabilitation patients. It consists of a table, chair and computer and device-specific equipment (Hawkins et al., 2002).

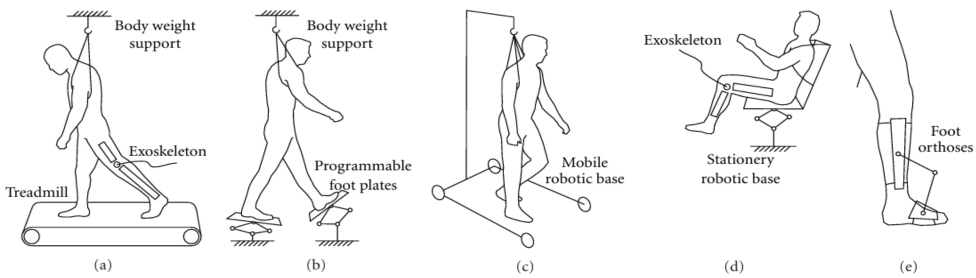
Lower Extremity Rehabilitation Robots

Exoskeletons used for lower extremities can have different degrees of freedom ranging from two to eight. They are mainly used for gait training, balance training and clinical evaluation. There are also body weight support systems in the devices used for lower extremities (Roy et al., 2007, 2013).

End effector robots used for lower extremity rehabilitation have force and torque sensors and are mostly used for walking and stair-climbing training (Low, 2015). In addition, data enabling the evaluation of gait performance can be obtained. It allows the physiotherapist to provide gait training safely and with minimum effort against the risk of falling, especially in neurological and geriatric individuals (Hesse et al., 2012; H. Schmidt et al., 2005).

Systems used in lower extremity robotic rehabilitation;
a) Treadmill-assisted rehabilitation device,
b) Programmable foot plane-assisted rehabilitation device,
c) Moving surface rehabilitation device,
d) Fixed surface walking device,
e) Foot orthoses,
are grouped as (Figure 7).

Figure 7.
Robotic system types for lower-limb rehabilitation: (a) treadmill gait trainers, (b) foot-plate-based gait trainers, (c) overground gait trainers, (d) stationary gait and ankle trainers, and (e) active foot orthoses. (Díaz et al., 2011)



Lower Extremity Ambulatory Robots

Ambulator robots are one of the technologies that can provide the patient with the opportunity to walk on a mobile floor by carrying body weight with a harness mechanism. They are robotic rehabilitation devices developed as an alternative to static walking training (Iyigun, 2018).

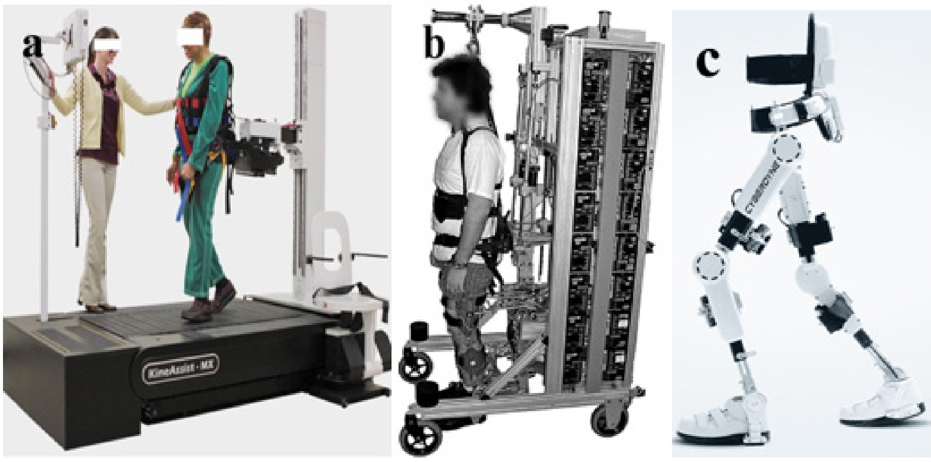
The KineAssist (Kinea Design LLC, USA) device has a movable floor and provides partial body support. The torso and pelvis mechanisms allow the patient's torso to move in all directions, with the ability to slow and stop the patient. In this way, the patient feels safe during walking.

WalkTrainer (Swortec SA, Switzerland) has six degrees of freedom. It has a robotic structure that controls the patient's pelvic movements. By design, the device prevents movement of the hip in the abduction direction.

The Hybrid Assistive Limb - HAL (Cyberdyne Inc, Japan) robot is available in different versions (full body, double leg and single leg). Since it has an exoskeleton structure driven by electric motors, it cannot provide adequate support for the trunk and pelvis. Therefore, it is not suitable for use in patients with severe impairment (Cao et al., 2014; Díaz et al., 2011; Iyigun, 2018; Pennycott et al., 2012).

Figure 8.

a. KineAssist (del-Ama et al., 2012), b. WalkTrainer ('KineAssist - Enabling Advanced Recovery', n.d.), c. Hybrid Assistive Limb – HAL (The World First Neurologically Controlled Wearable Cyborg - HAL Lower Limb, n.d.)



Lower Extremity Exoskeleton Robots

Lokomat

Lokomat is a robotic rehabilitation device developed by the Swiss company Hocoma (Figure 9). It consists of a walking belt, partial body weight support, and a robotic walking orthosis. The gait orthosis works in synchronization with the speed of the gait belt. The gait orthosis is controlled by motors connected to a computer that directs the movements of both hips and knees in the sagittal plane during walking. There are two types, LokomatPro and LokomatNano. The device can work by giving auditory and visual feedback with virtual reality integration (Kose, 2021).

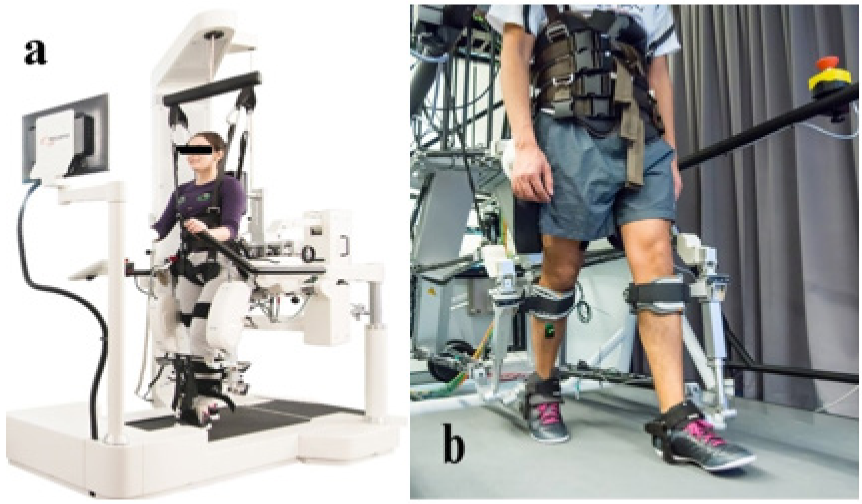
AutoAmbulator

The treadmill consists of partial body weight support, and robotic arms. Robotic arms placed on the patient's lower extremity guide the gait pattern. This system, like the Lokomat system, allows movement in a single plane (sagittal) and the patient has little influence on the gait trajectory (Cao et al., 2014).

Lower extremity powered exoskeleton (LOPES)

This rehabilitation robot, which is not yet commercially available, includes a gait belt and a robotic walking orthosis (Figure 9). This system allows translational movements of the pelvis and hip in both sagittal and frontal planes (Iyigun, 2018; Pennycott et al., 2012).

Figure 9.
a.Lokomat (Lokomat® - Hocoma, n.d.)*, b. Lower extremity-powered exoskeleton (LOPES) (Zhao et al., 2019)*



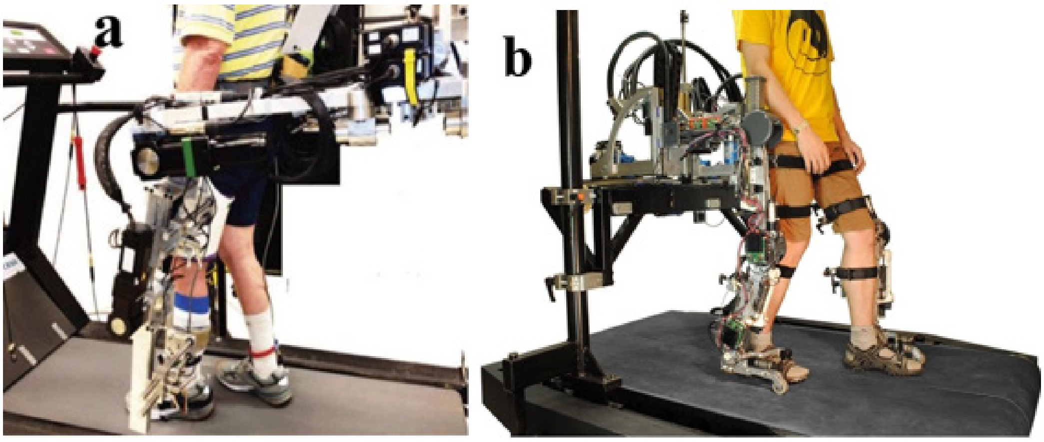
Active Leg exoskeleton (ALEX)

The ALEX, which is currently not in commercial use, includes a four-degree-of-freedom gait belt and robotic walking orthosis in the body (Figure 10). It allows movements in the sagittal and frontal planes of the hip, knee and ankle, but only actively controls sagittal plane movements (Díaz et al., 2011; Pennycott et al., 2012).

Actuated compliant robotic orthosis (ALTACRO)

The ALTACRO robotic rehabilitation device, which is currently not in commercial use, consists of a gait belt and a robotic walking orthosis (Figure 10). The device uses pneumatic artificial muscles to provide linear motion control, but only provides active assistance for knee movements (Cao et al., 2014; Iyigun, 2018).

Figure 10.
a.Active Leg exoskeleton (ALEX) (Srivastava et al., 2015), b. Actuated compliant robotic orthosis (ALTACRO) (Grosu et al., 2017)



Lower Extremity End Effector Robots

Gait Trainer (GT)

The device provides partial weight transfer during rehabilitation. Movement is provided by the individual capacity and speed of the patient (Figure 11). While the patient's balance is provided with the help of the harness system, walking is simulated with the help of foot connection plates. Gait trainer GT I produced by Reha - stim company was improved and Gait trainer GT II model was developed (Kose, 2021; Peurala et al., 2009; Surdilovic & Bernhardt, 2004).

G-EO Systems

The G-EO robotic rehabilitation device transfers movement from the sole to the patient. This device is used in combination with a harness mechanism that supports body weight (Figure 11). The gait system consists of a foot plane and a computer interface that can be programmed separately and independently for both feet. The hips and torso move freely according to the motion transmitted from the sole. The device also provides a different rehabilitation opportunity with a stair climbing program (Iyigun, 2018; Kose, 2021).

Figure 11.
a.Gait Trainer (GT) (Kose, 2021), GE-O System (GEO System, n.d.)

LokoHelp

The LokoHelp rehabilitation device includes a walking belt, partial body weight support, and foot pedals (Figure 12). The lower limb orthotic system is not moved by an external part but by the gait belt. With this system, the feet follow a specific trajectory, but no part guides the pelvis (Díaz et al., 2011; Iyigun, 2018).

Haptic Walker

The Haptic Walker robotic rehabilitation device provides partial body weight support (Figure 12). Programmable foot pedals accompany the movement. This system allows the simulation of walking on a slow and smooth trajectory (on flat ground and up and down stairs) as well as walking that requires a higher level of dynamics (on rough and slippery surfaces) (Díaz et al., 2011; Iyigun, 2018; Pennycott et al., 2012).

RoboGait

RoboGait, a device developed and manufactured by Bama technology company in Turkey, is a commercially available device (Figure 12). Structurally, it has the same features as other sliding floor-assisted robotic devices. Unlike its counterparts, there is no obligation to use separate units for adult and pediatric. Thanks to its adjustable structure, the same unit can be used in both adult and pediatric patients (Kose, 2021).

Figure 12.
a.LokoHelp (Díaz et al., 2011), b. Haptic Walker (H. Schmidt et al., 2007), c. RoboGait (Kose, 2021)

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CHAPTER 11

Web Based Sentiment Analysis Application with Deep Learning

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Introduction

Sentiment analysis, also known as Opinion Mining, is vital in the field of natural language processing and studies in this field. Emotion analysis, in its most basic definition, is a field of study that deals with certain emotional states and allows these emotional states to be analyzed from texts, photographs, or videos. There are many studies on sentiment analysis in the literature. It is used in areas such as sales forecasts, product ratings, opinion polls, voting result predictions, finance, media, and stockbroking (Tokcaer, 2021). Its increasing importance day by day enables the development of sentiment analysis applications in connection with many fields. In this direction, a web-based sentiment analysis application will be developed.

With its application, it will allow sentiment analysis to be used in areas where it is not effective or has little effect today. For example, with such an application, the emotional state of the students during the lesson can be detected, and analyses such as happy or unhappy can be made. Similarly, employee satisfaction analysis can be performed in the work environment.

Nowadays, sentiment analysis is carried out, especially on social media platforms. For example, product comments, likes, or dislikes on videos, etc. However, it may happen that these emotional expressions made on social media do not reflect reality. This project aims to design a system that everyone can easily access. Nowadays, many homes have internet, and access to the internet has become easier. In this regard, designing a system with a web application is quite simple in terms of user access. However, the main goal is to ensure that sentiment analysis is used not only on social media but also in daily life. With a well-trained system, the accuracy of the analyses can be brought to a successful level. Thanks to this system, for example, it can determine where or in which areas the unhappiness rate is high and enable regulation efforts.

There is a lot of research on sentiment analysis. This research: It was created by bringing together different techniques such as usage areas, research methods, and methods used.

In the article on face recognition and emotion analysis with deep learning, they implemented deep learning-based face recognition and facial expression recognition. Models developed with VGG-16, AlexNet, and ZFNet architectures were trained, and their success rates were compared. The most successful model was developed with the VGG-16 architecture as a reference, with a success rate of 92.03% (Safalı et al., 2021).

In the study of improving emotion classification performance using deep learning and down-sampling approaches, a data set consisting of 243 thousand user comments belonging to the Turkish e-commerce platform Hepsiburada company was used. In this unbalanced data set, deep learning algorithms were used to improve the classification performance, and an unbalanced data set approach was presented. With the presented approach, the false positive rate was improved from 69% to 90% and the accuracy value was improved from 95.5% to 99% (Santur, 2020).

In comparing different machine learning methods for sentiment analysis in Turkish texts, the classification results of different machine learning algorithms on the TREMO dataset were compared. Sentiment analysis was considered a text classification problem and four approaches were examined: ANN, SVM, RF, and KEYK algorithms. The categories provided by the data set, such as happiness, fear, anger, sadness, disgust, and surprise, were used as the emotion categories examined. According to the experimental study results, the ANN algorithm gave the best results. SVM, RF, and KEYK algorithms showed decreasing performance in this order (Toçoğlu et al., 2019).

In the article on sentiment analysis on Twitter, sentiment analysis was conducted on Twitter data, which is a popular social media site used by many users where users post their status updates in the form of "tweets". To perform this analysis, an intelligent model was created to classify tweets into positive and negative classes using machine learning methods such as Naïve Bayes and Support Vector Machine, and comparative results were given (İlhan et al., 2020).

Sentiment analysis was performed on Twitter datasets, which are widely used in the multi-population-based particle swarm optimization study for sentiment analysis. Emotions in the texts were classified as positive, negative, or ambiguous. Text mining preprocesses were applied to the datasets. In this study, a new optimization-based method was proposed for the classification process, and it was determined through experiments that the classification performance achieved with this method was more successful than the studies in the literature (Aydın et al., 2018).

In the sentiment analysis study using deep learning methods in Turkish texts, offensive language was detected on the OffensEval dataset. LSTM and BiLSTM networks were used as machine learning models in the study. The classification performances of these deep neural networks were evaluated as accuracy, sensitivity, precision, and F-score. The use of a large-sized corpus provided an improvement of over 40% in the F1 score (Yilmaz et al., 2021).

The sentiment analysis study of Twitter messages during the COVID-19 period, it was tried to measure the impact of the measures taken and the applications offered during the Coronavirus period on people using the sentiment analysis method. Important headlines about the coronavirus were published via Twitter. According to the sentiment analysis method, an overview was created by classifying positive and negative comments for the topics collected under 5 headings, and then it was analyzed whether there was a visible change in these topics in the weekly period. For approaches grouped as positive and negative on Twitter data, the logistic regression analysis method, which is accepted in the literature and can provide fast results, was used on approximately 2,000,000 tweets (Sarıman et al, 2020).

The above projects will be considered as examples of web-based sentiment analysis applications and these projects will be used as resources in some stages of the study.

In this study, there will be three different options for sentiment analysis. Analysis will be made through text, photos, and videos. In the video analysis option, analysis will be made by selecting a video recording. The same method will be valid for emotion analysis with photography. In analysis with text, analysis will be performed according to the entered text. Artificial neural network models will be used for all three cases. Which ANN models will be used will be explained in detail in the later stages of the project.

Python language will be used to train sentiment analysis models. Since the project will be written as web-based, the server of the application will be prepared with Flask. The interface of the project will be implemented with Vue.js.

Web-Based Sentiment Analysis Application

Visual Studio Code platform will be used for web-based sentiment analysis applications. In the project, the training of artificial intelligence models will be carried out with Python. The FER2013 dataset will be used together with the CNN (Convolutional Neural Networks) model, which is one of the ANN models, for video, photo, and emotion analysis. In text sentiment analysis, the LSTM model, which is also one of the ANN models, and the data set called store reviews, consisting of store comments, will be used. Vue.js will be used for the interface and vuetify will be used for interface design. Finally, a server will be created with Flask to display the analyses on the interface using the trained models, and the connection between this server and the interface will be provided by axios.

FER2013 dataset

Fer2013 is an open-source dataset created by Pierre-Luc Carrier and Aaron Courville for an ongoing project, later shared for a public Kaggle competition shortly before ICML 2013. This dataset consists of 35,887 grayscale, 48x48 face images. 7 emotional states are labeled. The data set consists of images belonging to the relevant emotional state: 4593 angry (0), 547 hate (1), 5121 fear (2), 8989 happy (3), 6077 sad (4), 4002 confused (5) and 6198 normal (6). It was created (Fer2013, 2023). Sample images of the Fer2013 dataset are shown in Figure 1.

Figure 1.
Fer2013 Sample Images, (Fer2013, 2023)

In the shared data set, each line contains the BGR color codes of the images converted into pixels. The first column of each row indicates the emotion tagged to that image. Figure 2 shows the content of the dataset named Fer2013.

Figure 2.
Fer2013 Content, (Fer2013, 2023)

1	emotion,pixels,Usage
2	0,70 80 82 72 58 58 60 63 54 58 60 48 89 115 121 119 115 110 98 91 84 84 90 99 110 126 143 153 158 171 169 172 169 165 129 110 113 107 95 79 66 62 56 57 61 52 43 41 65 61 58 57 56 69 75 70 65 56 54 105 146 154
3	0,151 150 147 155 148 133 111 140 170 174 182 154 153 164 173 178 185 185 189 187 186 193 194 185 183 186 180 173 166 161 147 133 172 151 114 161 161 146 131 104 95 132 163 123 119 129 140 120 151 149 14
4	2,231 212 156 164 174 138 161 173 182 200 106 38 39 74 138 161 164 179 190 201 210 216 220 224 222 218 216 213 217 220 220 218 217 212 174 160 162 160 139 135 137 131 94 56 36 44 27 16 229 175 148 173 154
5	4,24 32 36 30 32 23 19 20 30 41 21 22 32 34 21 19 43 52 13 26 40 59 65 12 20 63 99 98 98 111 75 62 41 73 118 140 192 186 187 188 190 190 187 182 176 173 172 173 25 34 29 35 29 26 20 23 19 31 22 21 20 31 26 17 34
6	6,4 0 0 0 0 0 0 0 0 0 0 0 3 15 23 28 48 50 58 84 115 127 137 142 151 156 155 149 153 152 157 160 162 159 145 121 83 58 48 38 21 17 7 5 25 27 24 25 1 0 0 0 0 0 0 0 0 0 0 6 18 26 37 50 62 83 115 134 138 144 147 150 16
7	2,55 55 55 55 55 54 60 68 54 85 151 163 170 179 181 185 188 188 191 196 189 194 198 197 195 194 190 193 195 184 175 172 161 159 158 159 147 136 137 136 146 120 86 93 114 116 99 74 55 55 55 55 55 52 71 86 79
8	4,20 17 19 21 25 38 42 42 46 54 56 62 63 66 82 108 118 130 139 134 132 126 113 97 126 148 157 161 155 154 154 164 189 204 194 168 180 188 214 214 214 216 208 220 205 187 176 162 22 17 17 25 29 32 44 47 46 54
9	3,77 78 79 79 78 75 60 55 47 48 58 73 77 79 57 50 37 44 56 70 80 82 87 91 86 80 73 66 54 57 68 69 68 68 49 46 75 71 69 70 70 72 72 71 72 74 77 76 83 84 82 81 81 69 60 60 46 57 74 71 70 67 36 40 45 54 65 71 78 77 78
10	3,85 84 90 121 101 102 133 153 153 169 177 189 195 199 205 207 209 216 221 225 221 220 218 222 223 217 220 217 211 196 188 173 170 133 117 131 121 88 73 73 50 27 34 32 34 40 46 63 78 76 101 131 116 117 149
11	2,255 254 255 254 254 179 122 107 95 124 149 150 169 178 179 179 181 181 184 190 191 191 193 190 190 195 194 192 193 196 193 192 188 182 173 162 152 144 129 116 113 106 184 255 252 254 255 255 255 254 25
12	0,30 24 21 23 25 25 49 67 84 103 120 125 130 139 140 139 148 171 178 175 176 174 180 180 178 178 182 185 183 186 186 178 180 172 175 171 155 152 141 136 132 137 131 96 46 37 44 37 31 22 21 22 24 28 44 67 86
13	6,39 75 78 58 58 45 49 48 103 156 81 45 41 38 49 56 60 49 32 31 28 52 83 81 78 75 62 31 18 19 19 20 17 20 16 15 12 10 11 10 23 36 65 59 9 3 5 7 93 69 86 90 84 75 51 129 133 63 46 45 41 41 42 38 33 30 29 29 27 29 39
14	6,219 213 206 202 209 217 216 215 219 218 223 230 227 227 233 235 234 236 237 238 234 226 219 212 208 201 190 183 176 161 74 15 24 22 22 22 21 19 19 20 20 23 7 89 255 252 255 255 215 215 206 205 209 214 21
15	6,148 144 130 129 119 122 129 131 139 153 140 128 139 144 146 143 132 133 134 130 140 142 150 152 150 134 128 149 142 138 156 155 140 136 143 143 139 144 160 170 154 181 185 183 193 193 224 247 149 140
16	3,4 2 13 41 56 62 67 87 95 62 65 70 80 107 127 149 153 150 165 168 177 187 176 167 152 128 130 149 149 146 130 139 139 143 134 105 78 56 36 50 69 82 64 35 10 11 13 105 4 4 21 42 53 67 61 70 58 86 107 115 132 1
17	5,107 107 109 109 109 109 110 101 123 140 144 144 149 153 160 161 161 167 168 169 172 172 173 175 176 171 170 166 165 162 162 157 150 149 145 140 136 132 128 111 98 111 109 107 107 107 107 107 107 107 10
18	3,14 14 18 28 27 22 21 30 42 61 77 86 88 95 100 99 101 99 98 99 99 96 101 102 96 95 94 88 78 72 65 55 40 25 20 20 42 64 74 129 133 125 144 151 153 154 154 155 16 14 24 28 27 25 31 43 65 84 97 96 96 101 102 109
19	2,255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255
20	6,134 124 167 180 197 194 203 210 204 203 209 204 206 211 211 216 219 224 228 230 230 226 222 220 217 217 210 207 213 210 199 191 190 188 177 172 148 142 90 46 81 132 116 81 45 84 162 207 154 107 137 182

Store reviews dataset

The data set was created by collecting user opinions from different online stores. Emotional states are divided into two labels: positive and negative. It contains 11622 pieces of data in total. Manual data entry was also done to diversify the data. A total of 27070 pieces of data were provided in the data set. Store review dataset content is shown in Figure 3.

Figure 3.
Store Comments Dataset Content, (Fer2013, 2023)

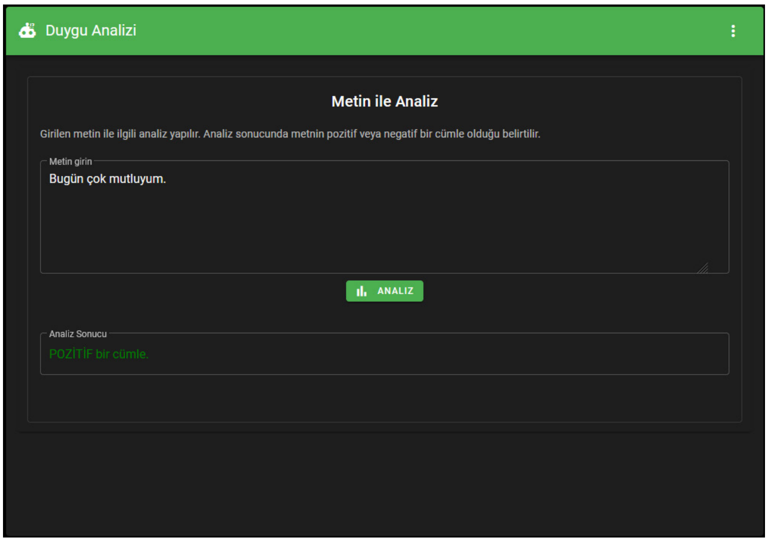
1	Metin	Duygu
2	Ürün gayet :) güzel boyutları dört kişilik aile için yeterli 7 günde teslim ettiler.	1
3	Ürünü kullandım gayet memnunum	1
4	Hızlı kargo	1
5	8 yıl önce lg 42 lm serisi almıştım ve tv den gayet memnundum ancak ekran kırılmasından dolayı bu tv yi aldım eski tv min görüntü özelliği ve teknolojisi bundan eski olmasına rağmen yeni tv ye göre görüntü kalitesi o	0
6	ürün fena değil ancak gövdenin plastik olması beni tedirgin etti. En azından ürün bilgilerine bu belirtilmeliymiş.	1
7	çok kötü hiç bir işe yaramıyor.	0
8	Çok geç ısıtıyor ekmeği kızartmıyor yani düşük performans ??????????.	0
9	good.	1
10	gayet güzel sadece kare tepsi kenarlara sürterek giriyor tam ayarını tutturmak zorluyor :) 2 tepsiyi aynı anda pişirmesi de cok iyi, yorumlardan acaba cizik gelir mi diye korkmustum ancak hiç bir sorunu olmadan geldi.	1
11	Fiyatına göre iyi gibi ama ince halıları kaldırıyor yerden gücünden dolayı. Süpürge olayı biraz zor oluyor. Parkelere yapışıp kalıyor. Fazla gücü olması çok da iyi değil demek ki.	0
12	İşi yapan Antalya Üçay mühendislik işi alana kadar sonrası adam yerine koymuyorlar defalarca aramama ramen dönmüyorlar Daıkın kombi için bilemiyorum.	0
13	Çok kötü. Hiç şarz yok. Kalitesiz. Kullanamadık.	0
14	Ürün ses deneyimi baslar tizler her konuda güzel.300 liraya en güzel 5+1 lerden. Kargolama sürecinde satıcı hepsiburada olmasına rağmen ürün kendi kutusunda kargolanmış ayrıca bir kutu içerisinde gelmedi. Kutusu	0
15	Kesinlikle rezalet bu kadar rezillik olmaz. İkinci el ürün geldi. Her şeyiyle ikinci el olduğu belli. Kablo orjinal değil ayna kısmı parmak izi dolu, gövdede yoğun çizikler var çok ayıp gerçekten.	0
16	Küçük ve ince kılları bile çok zor alıyor. Çin malı, seyyarda satılan traş makineleri bile daha iyi. 1,5 aydır kullanıyorum ve kullanışsız olduğuna emin oldum. Tavsiye etmiyorum.	0
17	Basketbol antrenmanlarımda sürekli olarak kulağımda gevşedi, tam anlamıyla rahat edemedim bu yüzden iade ettim. Her ne kadar böyle bir modelden yüksek bir kalitesi beklemiyor olsam da yine de ses kalitesi için	0
18	Tasarımı güzel ve kullanışlı. Benzer modellere göre oldukça hafif ve çekiş gücü yüksek. Kablosu biraz daha uzun olsa iyi olurdu.	1
19	Hocam canaksiz diyorsunuz wi-fi internet olmadan nasıl izliyoruz anlamadim.	0
20	Ev aletlerinde her zaman tefali tercih ediyorum bu üründe de aynı kaliteyi düşünerek aldım ve tabiki tefal beni şaşrtmadı çok memnun kaldım pratik ve güzel bi set. pudra rengi de beni bitirdi cidden mutfağıma aşırı	1
21	ücretsiz kurulum yapıldı güzel görünüyor.	1
22	gayet güzel bir ürün, denedim çok iyi utuluyor ancak kablosunda mi nedense ağır bir plastik kokusu var onu anlayamadim.	1
23	Kullanışlı sağlam bir ürün çok memnun kaldım aynı görseldeki gibi geldi paketlemeside güzeldi.	1
24	Gayet güzel bir ürün.	1
25	Güzel telefonumdan çok memnunum . Önerebilirim. Şarjı çok yavaş bitiyor ve bu durumdan çok memnunum . Rengi çok hoş , hiçbir çizik yada bir hasar yok . amazzon'a çok teşekkür ediyoruz .	1
26	Kaliteli Bi ürün.	1
27	GAYET GÜZEL VE UYGUN AYNI ZAMANDA HIZLI BİR TESLİMAT OLDU.	1
28	Mağazadakiyle aynı hem daha uygun.	1
29	ürün fiyatına göre çok iyi bence. kahvesi de gayet lezzetli oluyor. mağaza ürünü gayet güzel paketleyip kargolamış. Teşekkürler.	1
30	Mutfakta işimi kolaylaştırdı hep elimin altında kullanması, temizliğide pratik. Çook memnunum.	1

Results and Discussion

In the web-based sentiment analysis project, the data was primarily trained using relevant artificial intelligence models. The store reviews dataset trained with LSTM gave an accuracy rate of 98%, and the FER2013 dataset trained with CNN gave an accuracy rate of 68%. Then, the interface of the project was created using vue and vuetify. Requests were sent from Vue to the Flask API via axios. Flask is written in Python using trained models. When a text analysis is performed in the project interface, it takes up to two seconds for the analysis result to appear on the screen. In photo analysis, this time varies between three and four seconds. However, video analysis takes a little longer, reaching an average of fifteen seconds. My goal with these findings is to provide a basic understanding to evaluate and improve the performance of my sentiment analysis project.

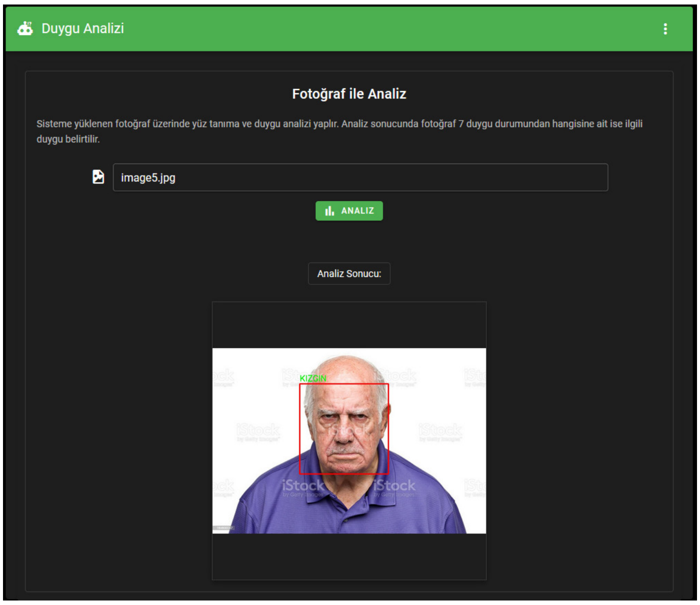
As a result of the findings, some important situations arise. While the data trained with LSTM gives a very successful percentage, it is seen that the data trained with CNN does not give such a successful percentage. In their study titled Comparison of different machine learning methods for sentiment analysis in Turkish texts, it is explained that different algorithms can also change the accuracy rates (Toçoğlu et al., 2019). The low success rate at CNN may be due to such a problem. Another situation is that the analysis result is quickly reflected on the interface in text data, but the speed decreases accordingly in photo and video analysis. This may be due to the structure and size of the data. These situations that I obtained because of my findings may be important discussion topics to further improve the success of the project. The screenshot of sentiment analysis with text is shown in Figure 4.

Figure 4.
Sentiment Analysis Example with Text



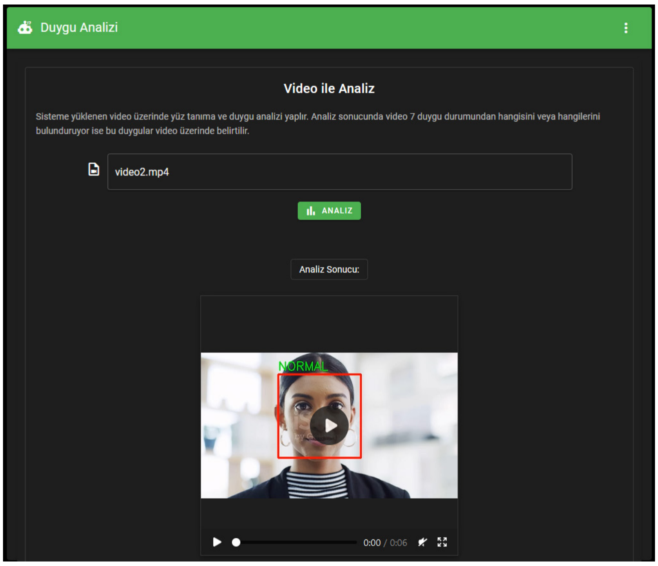
In the text and sentiment analysis section of the project, the text entered is analyzed. As a result of the analysis, if the text is a positive sentence, it is given a positive sentence; if it is a negative sentence, the analysis result is given as a negative sentence. The screenshot of the sentiment analysis with the image process is shown in Figure 5.

Figure 5.
Sentiment Analysis Example with Image



In the emotion analysis with photo section, face recognition, and emotion analysis are performed on the photo selected from the folder. The analyzed photograph is given as the analysis result. It is also saved as a new photo. The screenshot of the video sentiment analysis application is shown in Figure 6.

Figure 6.
Sentiment Analysis Example with Video



In the video emotion analysis section, face recognition and emotion analysis are performed on the video selected from the folder. The analyzed video is given as the analysis result. It is also saved as a new video.

Conclusions

In this study, it was aimed and carried out to perform sentiment analysis with the web interface. The results of the sentiment analysis in the project were largely successful in reflecting reality. In particular, text and photo analysis give better results than video analysis. This may be because the accuracy rate of the model trained with CNN is lower than the accuracy rate of the model trained with LSTM. The analysis result of the text entered from the interface is quickly obtained. The result of analysis with photographs is created in a short time. However, some time must be waited for the result of the video analysis. In emotional analysis with videos and photographs, happy, normal, angry, and sad expressions are easily perceived. In text analysis, an output of around 0.01 is produced for a negative sentence and around 0.991 for a positive sentence. These results reveal the success of the project. However, it shows that it can be taken further.

This study, like every other study, can be developed in line with different thoughts and opinions. However, performance is more important than design and is the main goal. When thought in this direction, the accuracy rate of data trained with CNN can be increased from 68% to around 90%. A different model or a different data set may be used. The data set can be diversified to make each statement easier to perceive. The number of trainings can be increased. Many other solutions are also applicable. For the same purpose, the waiting time for the result of video analysis can be reduced to five seconds. The data received from the user is processed on the flask side and waiting occurs in this part. However, this is due to the size of the data. Data processing time can be reduced with different methods. This study can be an important example of web-based sentiment analysis.

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CHAPTER 12

Use of Mixed Reality in Engineering Laboratory Applications: Flexural Strength Test

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Introduction

High-cost laboratory equipment and limited accessibility often result in undergraduate students being deprived of laboratory experiences. This problem is generally seen more frequently in newly established or rapidly developing educational institutions. Especially for engineering students, laboratory experiences are critically important for their professional lives. Students who graduate without laboratory experience start behind compared to their colleagues. Engineering students' completion of laboratory experiences greatly improves their jobs and professional careers. The practical knowledge and skills provided by laboratory experiences increase students' success. Additionally, laboratory experiences provide students with the opportunity to gain more in-depth knowledge and positively impact their engineering careers.

Considering the purchase of costly testing equipment and the cost of materials required for each experiment, the importance of laboratory experiences becomes clear. Additionally, material costs are incurred for each repeated experiment.

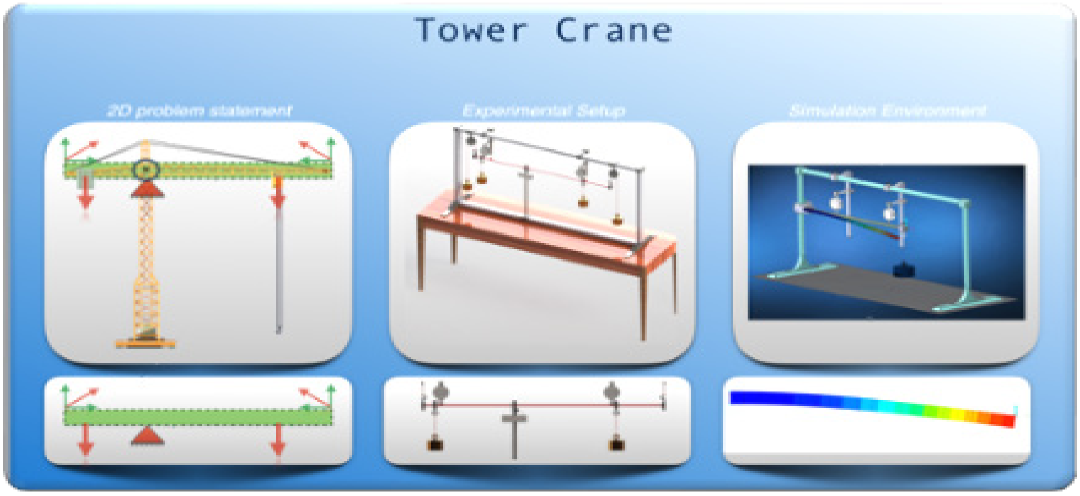
In today's rapidly developing digital world, augmented reality (AR) technology stands out by offering a unique interaction and learning experience with traditional knowledge. While AR provides users with a deeper understanding by combining the real world with virtual elements, it also has various applications in many fields, from education to virtual commerce. This technology has the potential to transform both the learning processes and the efficiency of the education world (Lyrath & et al. 2023; Alvarez & Velazquez, 20217; Chu, 2022.

In the studies conducted; Augmented Reality (AR) is seen to offer students a simple way to provide students with illustrative resources for learning, including videos and virtual 3D items from a first-person perspective (GUNT Inc., n.d.; Microsoft, n.d.; Fang, 2009).

Mechanical engineering is an application-based engineering field. Therefore, establishing a laboratory infrastructure for each of these applications creates very serious costs. To avoid costs, augmented reality applications have come to the fore by taking advantage of today's technology (Silva & et al., 2013; Kaplan & et al., 2021; Kaur & et al., 2021).

This study includes an augmented reality application performed with a flexural Strength test device used in the mechanical engineering mechanics laboratory. This application demonstrates the potential of augmented reality in the use of a flexural Strength testing machine and provides an example of real engineering applications and illustrative representation of the project is given in Figure 1.

Figure 1.
Illustrative Representation of the Project



1. Flexural Strength Test

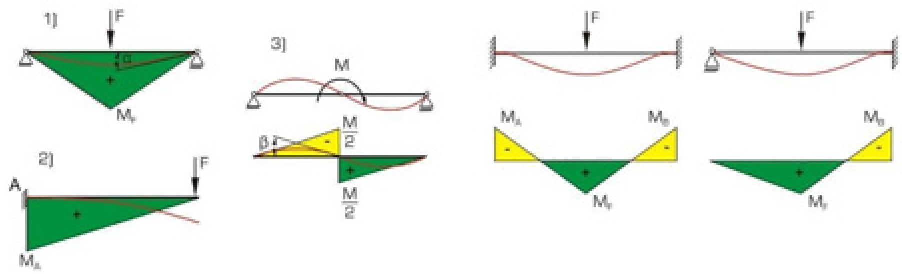
Beams play a pivotal role in both mechanical engineering and construction. These structural components, characterized by their elongated, bar-like shape with relatively small cross-sectional dimensions compared to their length, experience loads along and perpendicular to their longitudinal axis. Such perpendicular loading results in the bending or deformation of the beam. In terms of modeling, beams are typically treated as one-dimensional entities due to their characteristic size and behavior.

The field of strength of materials is concerned with understanding the stresses and strains that arise when forces are applied to structural components. A straight beam serves as an excellent practical example to illustrate fundamental principles in this field. The SE 110.47 experimental setup investigates a specific beam, exploring its behavior under different bearing methods. This beam can be supported in distinct ways, enabling the realization of statically determinate and indeterminate systems. The setup provides two supports with clamp fixings, equipped with dial gauges, which can also function as articulated supports. These dial gauges serve the purpose of determining the beam's angle of inclination at the support. Additionally, a third dial gauge is dedicated to recording the deflection of the beam at a chosen point.

The experimentation further incorporates a device designed to introduce a bending moment at an arbitrary location on the beam. A fourth dial gauge is employed to monitor the angle of inclination of this device. To apply loads to the beam, weights are used, including point loads and coupled forces to induce the bending moment. The clamping moment on the supports can be accurately determined by adjusting the weights.

This experiment delves into beam behavior, offering insights into different methods for determining the elastic line and the response of statically determinate and indeterminate beams under various support conditions. The setup comprises essential components, including supports with clamp fixing that can also function as articulated supports, an articulated support with a force gauge, a device for generating bending moments, dial gauges for measuring inclination angles and beam deformations, as well as weights for applying point loads and assessing clamping moments (Figure 2).

Figure 2.
The diagram shows the bending moment characteristics (green/yellow) and elastic line (red) for statically determinate beams, including a single-span beam with a mid-point load, a cantilever beam with a point load, and a single-span beam with a bending moment as the load, while referencing "MA" as the bending moment on support A, "MF" as the bending moment from force F, and "M" as the overall bending moment, along with "α" and "β" representing the angles of inclination. B) Bending moment characteristic (green/yellow) and elastic line (red) for statically indeterminate beams with centralized point load (Gunt Inc.n.d.).



2. Mixed Reality (MR) Technology

Mixed Reality (MR) is a wearable computing device that uses augmented reality (AR) technology. MR combines virtual objects and information with the real world while the user interacts with the real world. Its main features include holographic imaging, holographic audio, cameras, and sensors, as well as wireless connectivity. This technology is used in a few industries such as education, healthcare, industrial design, and military applications. For example, educational institutions use MR to provide students with visual and interactive learning experiences, while the healthcare industry uses this technology for surgical planning and patient care. It is also used in industrial design and military applications. MR combines the real and virtual worlds, giving users access to richer and more interactive experiences.

3. A Holographic Processing Unit: HoloLens

In this book chapter, we took a practical approach by deploying our application on the Microsoft HoloLens Developer Edition (1st Gen.), a device introduced by Microsoft in 2016. HoloLens is essentially a mobile holographic computer that lets you work with digital objects while staying aware of your surroundings. It uses laser-based cameras to map the space around you. You can control it using hand gestures and voice commands. HoloLens is designed to be wireless and offers a whole new way of computing with 3D holograms that interact with the real world. It relies on gaze tracking, gestures, and voice commands to understand what you want to do and uses features like spatial sound, various cameras, an inertial measurement unit (IMU), and microphones to adapt to your environment effectively Figure 3 (Microsoft, n.d.).

Figure 3.
This Figure Shows Lenses On The Visor Of Hololens (Microsoft, n.d.)

4. Flexural Testing Setup: Building a Digital Twin Simulation

The process of creating 3D models and assembling them using SolidWorks is straightforward and commonly employed in academic and industrial settings. This practical approach involves generating detailed 3D models of individual components. SolidWorks Pro, known for its precision, simplifies this task by enabling the creation of virtual replicas that accurately resemble real-world parts.

Once these individual 3D models are ready, they are assembled to form a complete digital representation of the flexure strength testing instrument. The assembly process carried out with SolidWorks Pro, aims to mimic physical assembly, ensuring a seamless fit between the components without the need for elaborate constraints and relationships.

After successful assembly, the next step involves converting the entire assembly into a usable file format, typically an STL file. This format is essential for various applications, such as 3D printing and simulations, facilitating practical testing and analysis.

In summary, the process of creating 3D models and assembling them using SolidWorks is a concrete and systematic approach, allowing for the development of a digital twin for a flexure strength testing instrument with precision and efficiency. SolidWorks Pro serves as a practical tool, essential for a wide range of applications, from academic research to practical design.

Figure 4.
3D Models of Experimental Set Up (Gunt Inc.n.d.)

2.4.1. Importing models into the UNITY 3D game engine and adding "textures"

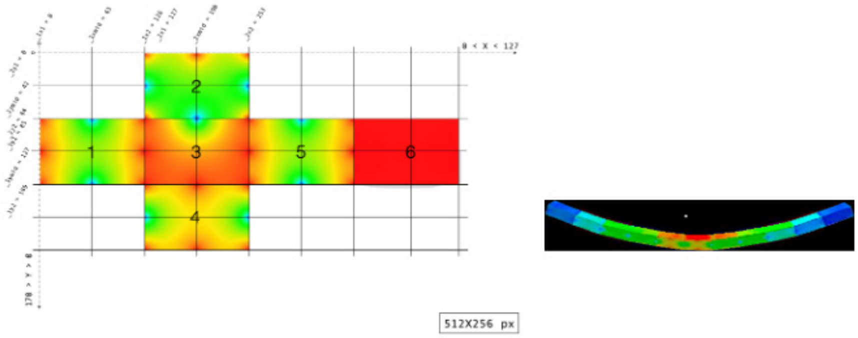
Following the assembly of the 3D models in SolidWorks, the next step involves importing the resulting STL files into the Unity3D game engine. Within Unity, constraints and textures can be added to enhance the visual and interactive aspects of the digital twin. Additionally, user interactions are programmed into the digital twin, allowing users to engage with the virtual representation of the flexure strength testing instrument. These interactions include features zooming, rotating, or manipulating different components, making the experience more engaging and informative.

2.4.2. Performing mathematical calculations

To simulate the flexure response of the chosen material, a solver is programmed within Unity3D. This solver calculates the material's instantaneous flexure response, providing valuable insights into how the instrument would perform under various conditions.

This comprehensive process, from 3D modeling and assembly in SolidWorks to the integration with Unity3D and the addition of user interactions and a flexure response solver, offers a practical and interactive approach to studying and analyzing the flexure strength testing instrument. In a virtual environment formulation (Figure 6).

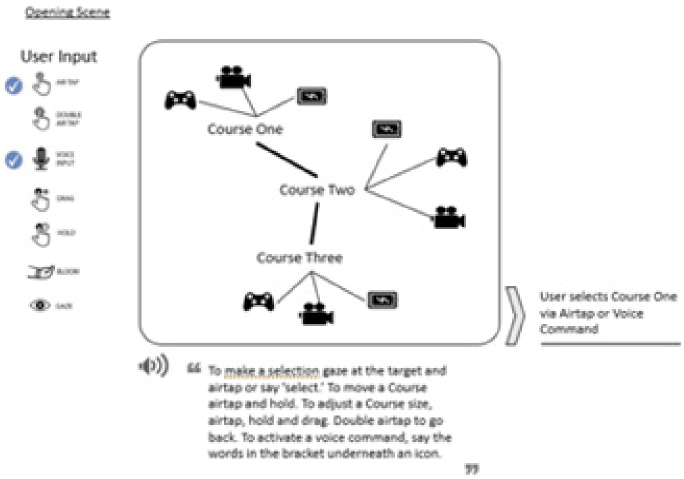
Figure 6.
Texture Creation Process in Unity 3D Results Data is Readily Available for Immersive Experience. (Gunt Inc.n.d.)



2.4.3. Creation of the user interface

Since Microsoft HoloLens is a headset that provides an augmented reality (AR) experience, the creation of the user interface is an important element that allows users to interact with virtual objects or information in the real world. Creating the user interface enables developers to integrate interactive and informative 3D visuals on the HoloLens device as shown in Fig.7. These interfaces enable users to interact using HoloLens' motion tracking, voice recognition, and gesture detection capabilities. The HoloLens Development Kit (HoloLens SDK), Microsoft's HoloLens development platform, is typically used to create a user interface. These development kits provide developers with the tools necessary to create customized holograms, menus, buttons, and other interaction elements on the HoloLens device. Developers can design unique user interfaces for HoloLens using game engines such as Unity or Unreal Engine and 3D modeling tools. In this way, users can interact seamlessly between the real world and the virtual world. Creating the user interface is a critical step in enriching the user experience of HoloLens apps.

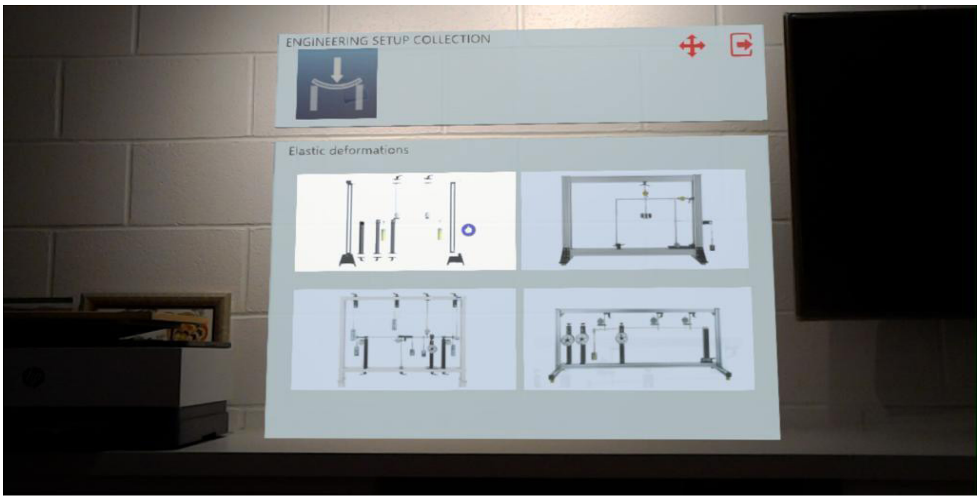
Figure 7.
User Interface



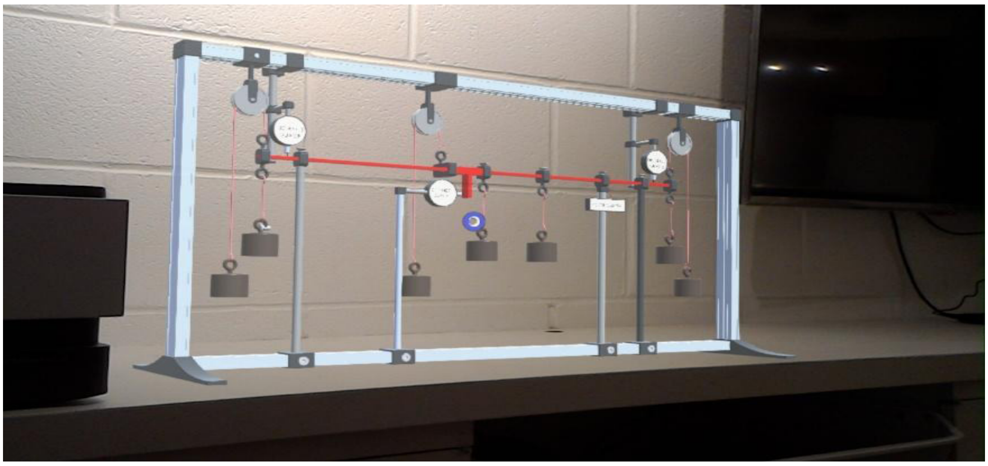
3. Demo application of flexural testing setup

A comprehensive demonstration of a flexure test setup, in which we will explore the practical aspects and procedures involved in performing flexure tests on various materials and forces, is given in Fig. 8a, b, c, d, e & f). This demo application aims to provide a hands-on understanding of how flexural testing works and its importance in assessing the mechanical properties of materials.

Figure 8.
a, b, c, d, & e *Comprehensive Demonstrations of a Flexure Test Setup In MR*



a)



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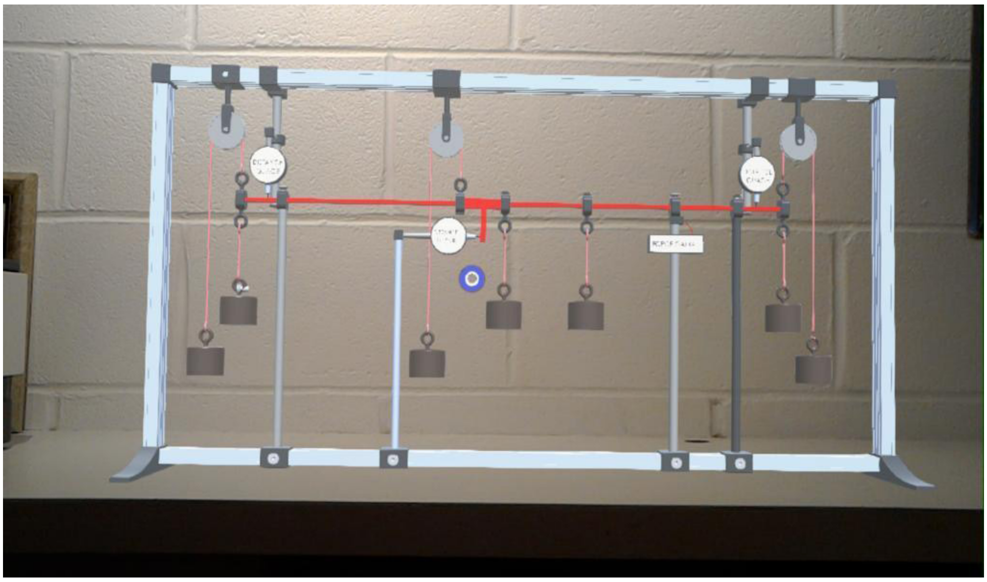

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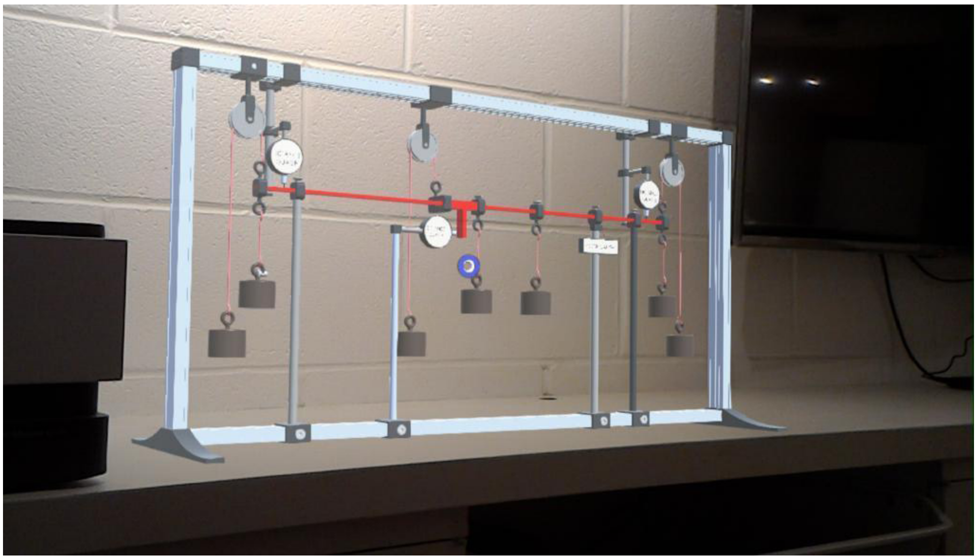

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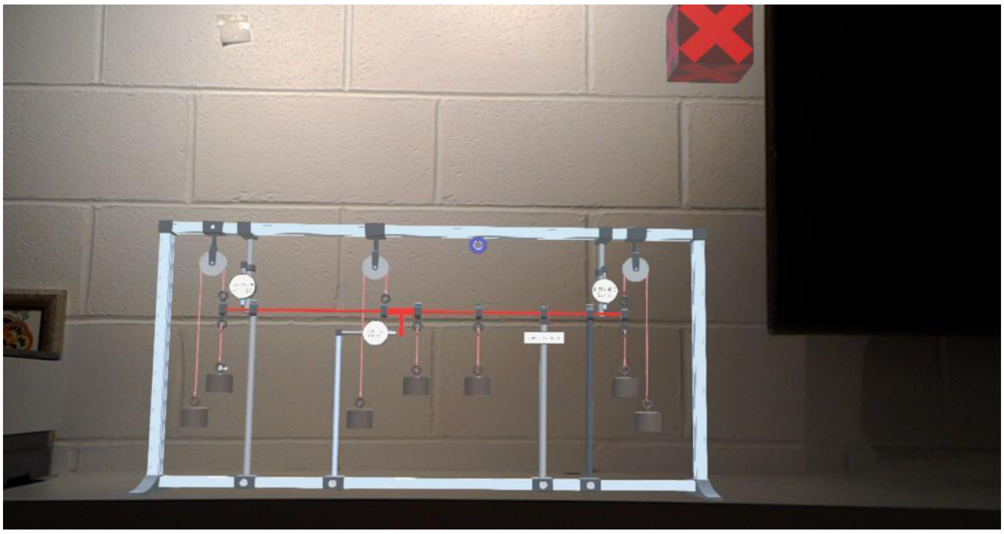

e)

In this section, we focused on the importance of engineering students' lab experiences on their job prospects and careers. Situations, where laboratory experiences are not available to some students due to costly equipment and access difficulties, are a problem faced by educational institutions. However, these experiences are critical for engineering students because they enhance student achievement by imparting practical knowledge and skills, positively impacting engineering careers.

Mixed Reality (MR) technology has the potential to transform learning processes and efficiency in the world of education. The ability to offer an interactive learning experience with traditional knowledge is one of the great advantages of MR in this field. In addition, as an example of the use of MR technology in engineering laboratory applications, the flexural strength test was examined.

MR applications for flexural strength testing provide students with better explanatory resources and can reduce the installation costs of laboratory infrastructure. The process of creating a 3D model and developing this digital twin using SolidWorks Pro provides a concrete and systematic approach to improving the precision and efficiency of flexure testers. In conclusion, MR technology has the potential to make engineering students' lab experiences more accessible and effective.

This technology offers a huge opportunity to make engineering education more efficient and effective.

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CHAPTER 13

Mechanical Design and Performance Analysis of Articulated Mechanical Hands: A Review

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Introduction

Since the development of the first industrial robots in the early 1960s, robotics has frequently replaced humans in many arduous and repetitive activities. The ambition of using robots in more versatile tasks began in the early 1980s, and led to equip them with multi-purpose capabilities robotic hands sparking the research into the development of the faculty of grasping. Hence, the ability to grasp and manipulate objects of diverse weights and shapes became a challenging issue central to the advancement of robots. Numerous robotic hands have been developed over the last four decades of research into dexterous manipulation (Birglen & Schlicht, 2018), (Zhang et al., 2020), (Hughes et al., 2020), (Samadikhoshkho et al., 2019), (Yoon & Choi, 2021). However, the improvement of such robotic hands remain a key challenge and far from human hand capabilities as grasp is very developed in the human being. The grasp may be soft or develop the necessary force to be firm (Yoon & Choi, 2021), (Chen et al., 2018). A robotic gripper, usually made of hard material, does not naturally possess this ability. The example of the handling of a fruit is demonstrative of such a dilemma.

The human-like dexterous manipulation is represented by the development of flexible multi-fingered grippers with both adaptive grasping and in-hand manipulation capabilities. The ability to grasp is generally seen as a set of kinematic strings connected to a base and closed on an object in areas of contact that should be modeled (C. Reboulet, 1988). There are essentially two types of grasps: (1) the power grasp also known as 'full-hand' that uses the principle of stability and safety, and (2) the delicate-gentle or precision grasp that may be performed by a child therefore needing dexterity.

Various traditional gripper designs that have been developed over the years have two or three rigid-material fingers that allow them to perform pick-and-place tasks but fail to accomplish activities requiring more complex actions (Bicchi & Kumar, 2000). Such complex manipulation activities are made possible when the thumb faces the remaining hand fingers (Seguna & Saiba, 2001).

The human hand acts as an articulated mechanical system similar to a complex kinematic chain with a tree structure (Osswald & Wörn, 2001). Indeed, its skeleton is formed by the complex assembly of the bones of the carpus, the metacarpus, and the phalanges. The articulations between these bones vary according to the number of DOF they possess. The long fingers represented by the forefinger, middle finger, ring finger, and little finger have the same structure while that of the thumb is more complex (Brown & Vardy, 1998). The design of the mechanical hands is often inspired by the morphology of the human hand. They have been developed to interact with the human environment.

In particular, the robotic capabilities of sensing and manipulating unfamiliar objects spawn more applications and enormous economic benefits. For instance, robots used in restaurants improve the efficiency of food delivery and reduce labor costs (Thanh et al., 2019). Moreover, the successful applications of domestic robots help people handle some housework to save people's time (Yamazaki et al., 2012), and robots in factories perform repetitive tasks quickly for a long time and reduce the loss caused by the worker's fatigue (Dogar et al., 2019).

Nowadays, the majority of these are made up of a mobile base equipped with one or two articulated anthropomorphic manipulator arms, the end of which is equipped with a gripper capable of capturing objects of various geometries.

The articulated mechanical hands of today have become analogous to human hands. They can capture objects of arbitrary shape and offered as equipment to the mobile manipulators with a versatile dexterity such as that achieved by a hand with multiple fingers capable of performing a variety of different entries thus enabling the reduction of the terminals.

The present paper provides a comprehensive review of mechanical and dextral hands. It presents eight of the more currently operated articulated mechanical hands, and includes those having three fingers as well as those integrating a thumb opposite to three or four fingers that can handle objects safely applying both arbitrary forces and movements to manipulate objects (Murray et al., 1994). It furthermore identifies their benefits and drawbacks and compares their respective designs to their diverse object-grasping capabilities and applications.

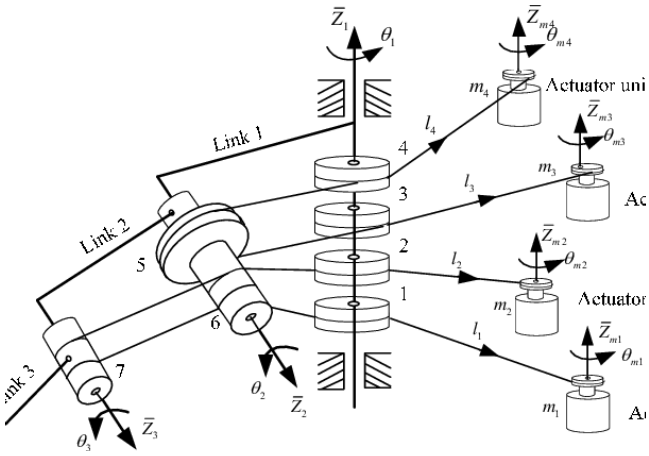
Articulated Mechanical Hands

Articulated mechanical hands are becoming more and more analogous to human hands. They are capable of grasping objects of arbitrary shape. They further offer solutions to equip mobile manipulators with versatile dexterity such as that achieved by a multi-fingered hand capable of performing a variety of different grips thus enabling the reduction of terminals.

The Hand of Stanford-JPL

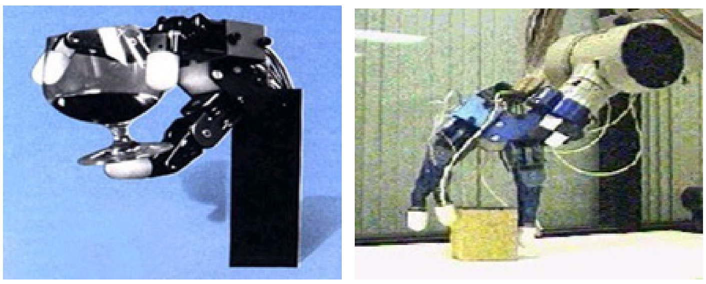
The Stanford hand illustrated in Figure 1 has not been initially designed to reproduce the human hand but rather to investigate the phenomena of handling along with the necessary conditions associated with it (Salisbury & Roth, 1983). The study led him to the conclusion that a minimum of three fingers are necessary for carrying out effective handling, a fourth finger would significantly increase its complexity (Loucks et al., 1987).

Figure 1.
Functional Representation of the Stanford/JPL Finger (Sang et al., 2016)



The Stanford hand comprises a mechanism articulated around three modular fingers, each one displaying three degrees of mobility. Both the first and second articulations show a 90° deflection while the third may be deflected through 135°. It uses a design of four tendons and offers three DOF. Its modular transmission system is made of four Teflon-coated steel cables protected by ducts. A direct current motor is used to actuate and control each joint (Pollard & Gilbert, 2002) while a cable tensioning mechanism located at the entrance of each finger controls the effort. This system positioning was dictated by the appearance of stresses that were exerted on the guide pulley. Incremental optical encoders located directly on the motors allow the obtaining of the positions and speeds of the hand joints. A sensor determines the location, amplitude, and direction of the force exerted at a distal phalanx contact point (Loucks et al., 1987). On this hand, the modularity of the fingers is realized to simplify the design while its dexterity is sacrificed because of the non-competition of the axes of the joints (Figure 3).

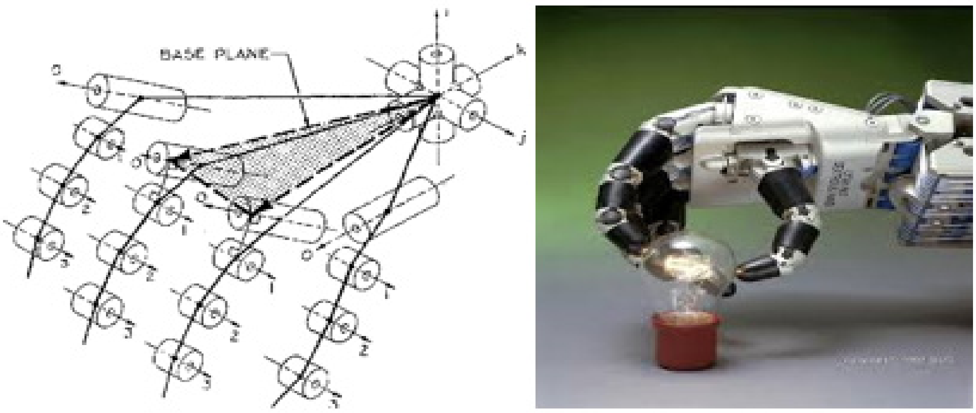
Figure 2.
The Stanford/JPL dexterous hand performing haptically-guided closed-loop grasp synthesis (Piater & Grupen, 2002)



The UTAH/MIT or Jacobsen Hand

The UTAH/MIT hand was developed at the 'Center of Engineering Innovation' of the University of Utah in collaboration with the 'Computer Science and Artificial Intelligence Laboratory' of the Massachusetts Institute of Technology (MIT). The aim was to make available a robotic terminal device for carrying out studies in the field of dexterity. This collaboration has brought out the most sophisticated hand on the market that possesses four modular fingers with a thumb-shaped opposing the three long fingers, the little finger having been considered unnecessary to facilitate the manipulation. Each of the four fingers had four DOF. Figure 3-a shows the kinematic pattern of Jocobson's hand which consists essentially of a motor block, an actuator, and an analog controller that acts on the joints. A tactile sensor system is integrated at the fingertips and in the palm. Figure 3-b shows the hand performing a guided closed-loop precision grasp.

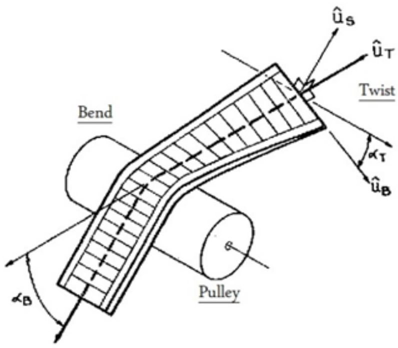
Figure 3.
The Utah/M.I.T Dexterous Hand. (a) Kinematics of the Hand (b) The Hand Performing a Haptically-Guided Closed-Loop Grasp Synthesis (Jacobsen et al., 1986), (Amirouche, 2004)



(a) (b)

The joints noted ‘0’ and ‘1’ of each finger are separated to allow for the conveyance of the tendons. The friction exerted on the tendons leads to a limited lifespan, they have been replaced by flat belts generating stress separated by axial torsions (Figure 4). The axis of the proximal joints ‘0’ is parallel to the palm plane with an inclination of 30° while for the human hand, the first joints of the fingers are perpendicular to it. This alteration allows the fingers to perform a movement in the lateral direction and therefore improves their mobility. When the fingers oppose the thumb, the joints noted ‘0’ show zero displacement while those indexed ‘1’ allow a displacement of 90°. The geometric adjustments incorporated into the design of the UTAH/MIT hand to grant it an anthropomorphic appearance also include the positioning of the thumb in the section of the palm between the first and second fingers. The wrist joints provide an additional space for the installation of 32 independent tendons as well as pneumatic actuators.

Figure 4.
Flat Belt of the Utah/M.I.T Dexterous Hand (Jacobsen et al., 1986)

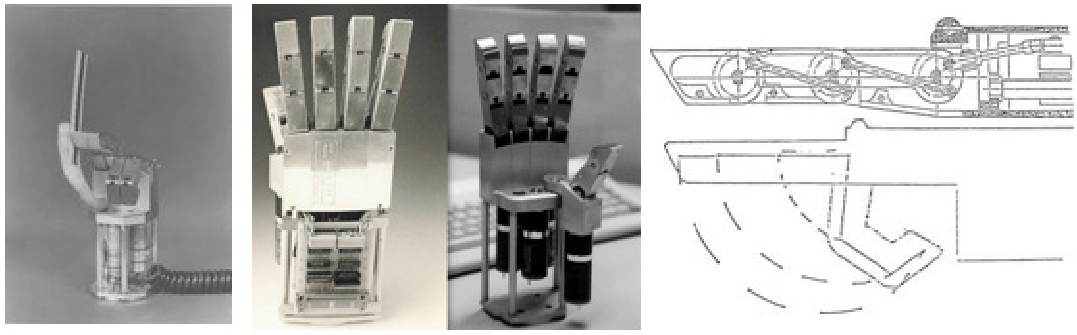


This hand is available in many American universities and is the subject of various research tasks, particularly in the field of remote operation (J.L. Banks, 2001). It resembles the Stanford model presented previously but differs in the number of fingers as well as in the design. While Salisbury and Roth were developing a non-anthropomorphic hand with some dexterity, the UTAH researchers in collaboration with MIT engineers were trying to replicate the human hand (Bekey et al., 1990).

The Belgrade/USC Hand

The first model of the Belgrade/USC hand was equipped with a rigid thumb and four articulated fingers (Figure 5-a), the motors being placed in the lower part of the wrist. The second model developed (Figure 5-b) has approximately the size of the human hand. It comprises five aluminum-made fingers. Its mechanical structure allows for the joints separation between the long fingers and the thumb. A control rods transmission system is used to ensure the movements of the fingers.

Figure 5.
The Belgrade/USC Hand. (a) Model-I, (b) Model-II, (c) Control Architecture for a Long Finger (Bekey et al., 1990)



(a) (b) (c)

The thumb is essentially constituted by two joints that rotate around an axis parallel to the wrist, allowing it to perform a movement of 120◦thus allowing an opposition movement with the four long fingers. The four fingers are identical in size having three joints each. All finger rotations are handled by miniature ball bearings powered by DC servo motors located in the structure of the wrist (Soto-Martell & Gini, 2007). The movement of the phalanges is ensured by the reduction mechanisms that allow direct transmission of the bending movement to the wrist using rods (Figure 5-c). Moreover, to imitate the movements of the human hand during a grasp, the motions of each finger phalanx are coupled using connecting rods. The trajectories of the phalanges during the phase of "bending" are shown in Figure 5-c. The design of the Belgrade/USC hand is different from that of both UTH/MIT and Stanford/JPL hands (Bekey et al., 1990).

The particularity of this hand lies in its mode of actuation. Four motors are placed in the wrist. Two operate the thumb while the two others operate the long fingers. Consequently, it seems to be more suitable for control grasp functions and lacks the dexterity needed for applications that require a large number of externally controllable DOF.

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The Multiple Actuator Hand (DLR)

The DLR-I hand (Deutshe Luft-Reederei) was developed at the German aerospace center and is a robotic hand articulated around four fingers (Butterfass et al., 1990). It has an anthropomorphic architecture and is represented in Figures 6-a and Figure 6-c. All the fingers are the same, possessing three phalanges made up of three joints.

Figure 6.

The DLR Hand. (a) DLR-I, (b) 2-dof Joint Unit With Actuator, (c) DLR-II (Butterfass et al., 1990)

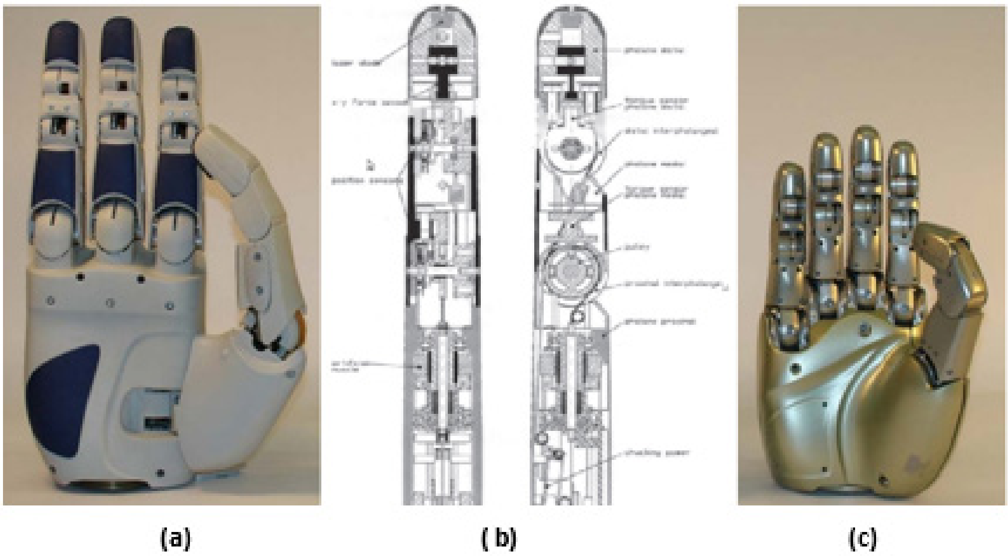


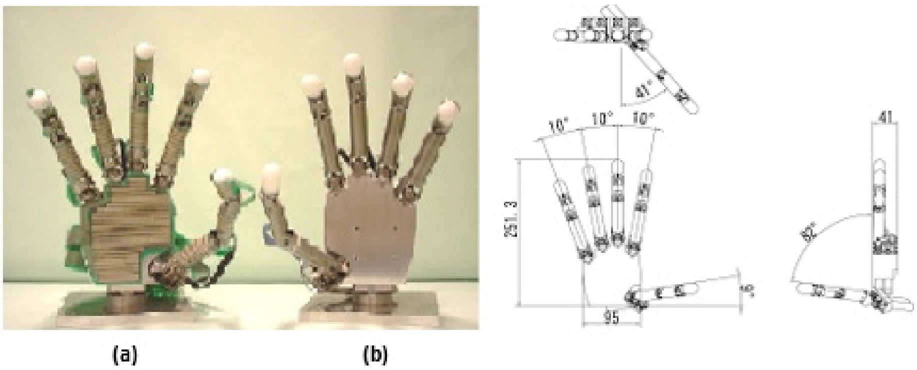
Figure 6-b shows a two-joint single-actuator finger unit. The first joint is situated between the proximal phalanx and the intermediate phalanx while the second lies between the middle phalanx and the distal phalanx. This last joint is coupled with the first one the same way it is accomplished within the kinematics of the human hand thus reducing this unit number of DOF to a single one. The transmission of the movement is ensured through cables and pulleys (Butterfass et al., 1990). The DRL hand has eighteen DOF, six of which refer to the movement of the wrist while three are independently controllable for each finger. This leads to an architecture that gives fingers modular design for of this hand.

Several versions of the DLR hand have been designed, all of them possessing four fingers except the one developed in collaboration with the Harbin Institute of Technology (HIT) which has five fingers (Figure 6-c). The development of a 5-fingered hand is very complex. To achieve a strength and size comparable to that of the human hand, the servomotors have been moved to the level of the forearm (Leblanc, 2011). The DLR-HIT collaboration enabled the development of a hand with 19 DOF using 'Dyneema' cords that are made of Ultra High Molecular Weight Polyethylene fibers. It integrates an independent palm and 5 identical modular fingers, the length and width of each having been altered by a proportion of two-thirds compared to previous versions. The use of a wire coupling mechanism achieved a unit ratio of transmission from the distal phalanx during all movements, and the type of conditioning used for the fingers and palm allowed the size of the hand to be reduced and made it anthropomorphic. Innovative force, torque, and position sensors have been integrated to increase its multi-sensory capacity (Shaowei et al., 1990). Each finger had 3 DOF and 4 joints. Electric actuators have been integrated in the body of the finger and also in the palm.

The Anthropomorphic Gifu Hand

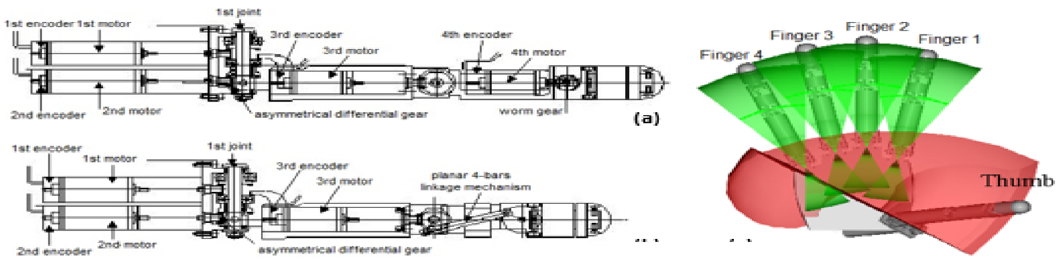
The GIFU hand versions I and II have been developed at GIFU University, Yanagido in Japan (Kawasaki et al., 2002). The GIFU hand comprises five fingers, has twenty joints with sixteen DOF, and is driven by built-in servo motors. The improved version of this hand has been called the "GIFU III" hand and has been designed to reduce the clearance that appeared in the gear transmission of the previous versions as a result of long operation time.

Figure 7.
The Anthropomorphic Gifu Hand-III. (a) Left and Right Hands, (b) Hand Structure (Cerruti, 2016)



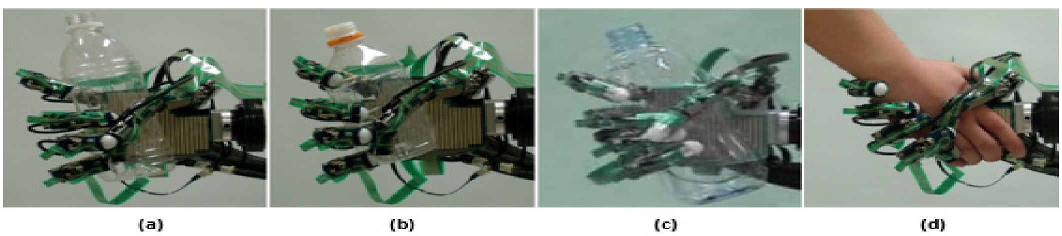
Both left and right hands have been designed symmetrically. They each have a thumb and four long fingers. Each long finger has 4 joints and 3 DOF while the thumb has 4 joints and 4 DOF. The movement of the first joint of both the thumb and the long fingers allows the adduction-abduction while the second and the fourth joint allow the ante-flexion and retro-flexion. Each servo motor has a magnetic encoder with 16 pulses per revolution. The thumb and long finger design mechanisms are shown in Figure 8-a and Figure 8-b respectively while the mobility space of the long fingers is represented in Figure 8-c (Mouri et al., 2002).

Figure 8.
Gifu Hand-III. (a) Mechanism of the Thumb, (b) Mechanism of the Long Fingers, (c) Opposability of the Thumb and Mobility Space of the Fingers (Mouri et al., 2002)



The improvement made on this hand lies in the use of a new tactile sensor having 859 detection points distributed over the hand (313 on the palm, 126 on the thumb, and 105 on each long finger). The motors are equipped with position sensors, and force sensors may be found at the fingertips (6 axes). A control device of the hand is coupled with an operating system in real-time called 'ART-Linux'. All this makes the Gifu III hand the artificial hand that may be considered as the closest to the human hand from the point of view of instrumentation. Several object seizures have been performed following a grasping strategy that imitates the human grasping reflex (Mouri et al., 2007).

Figure 9.
Figure 9. Grasping force of the Gifu Hand-III (a) Cylindrical object (b) Rectangular object, (c) Curved Object, (d) Human hand (Mouri et al., 2007)

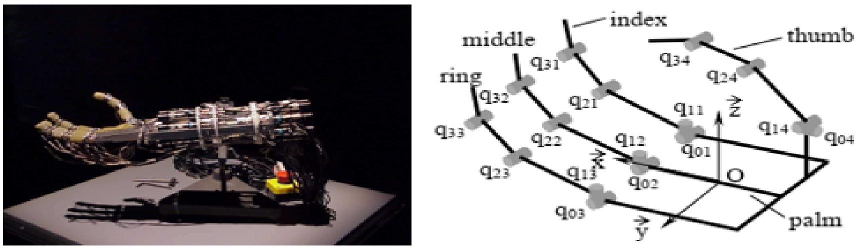


The L.M.S Four-Finger Articulated Mechanical Hand

The LMS hand, shown in Figure 10-a, has been developed within the 'Solid Mechanics Laboratory' of the University of Poitiers, France. It has three long fingers and a thumb in opposition. Each finger has four DOF. Three of the fingers enable the flexion-extension moves, while the fourth implements the abduction-adduction movements (J.P. Gazeau, 2000). For the long fingers, the axis of abduction-adduction movement is established by the connection to the proximal phalanx thus allowing it to maintain the amplitude of this operation regardless of the configuration of the finger. The range of the abduction-adduction movement is much greater in the thumb as it must allow the opposition arrangement of the thumb to the other fingers. Its axis is fixed relative to the palm.

Figure 10.

The LMS Mechanical Hand (a) LMS Hand, (b) Kinematics of LMS Exoskeleton *(Arsicault et al., 2007)*



(a) (b)

The LMS hand uses a design similar to that of the UTAH/MIT hand i.e. an architecture based on the use of 32 cables allowing the control of 16 joints. The drive pulleys allow an independent tension of the two cables controlling a joint. Other guide pulleys ensure the passage of the cables at the level of the joints. The transmission of the movements to the phalanges requires the use of a return pulley using cables. The material used for the mechanical structure is aluminum alloy, and the moving parts are mounted on Torlon bearings. The behavior of the hand, using the exoskeleton trajectories represented in Figure 10-b, was found satisfactory.

The Shadow Hand

Through the Shadow hand illustrated in Figure 11, the anthropomorphic concepts are adapted to robotic handling (Rothling et al., 2007). With its twenty DOF, the shadow hand offers unique analogies with the human hand. Developed by Shadow and the University of Pierre et Marie Curie (UPMC), it has been equipped with force sensors, position sensors as well as sensitive ultra-tactile sensors at the fingertips. Moreover, it uses industry standard interfaces leading it to be easily used as a tele-operation tool. It can also be easily mounted on a range of arms as part of a robotic system and perform various grasps. (Figure 7-b-c-d-e).

Figure 11.

The Shadow Hand (a) The Shadow Hand Representations, (b) Shadow Hand dimensions *(https://www.shadowrobot.com/)*

(a) (b)

The production of the Shadow hand constitutes a great achievement in the field of miniaturization, and its kinematics is very close to that of the human hand (Becket et al., 1990). With a total of 129 sensors (position sensors for each joint, force sensors for each actuator, contact sensors at fingertips, temperature sensors, and current loops on the motors) whose readings are processed via an 'EtherCaT' interface and a control board located in the palm, it can provide detailed telemetry that can be exploited to produce innovative manipulation control systems. This is particularly the case when wearing protective gloves needed for carrying out some specific tasks.

Figure 12.
Examples of Object Grasping by the Shadow Hand in the Simulator *(https://www.roscomponents.com/en/robotic-hands/117-shadow-dexterous-robotic-hand.html)*

The Shadow hand is fully accommodated to the Robot Operating System (ROS) that integrates various models of it along with its software. Moreover, its control along with its position command algorithms could be altered. For applications requiring detailed sensing capabilities, 'BioTac' touch sensors are available and can be added to each finger providing fine-tuned sensing of force, micro-vibrations, and temperature gradient.

Conclusions

Mechanical hands with four or five fingers facilitate the handling of objects as a result of the possibility of repositioning the fingers on the object. The mechanical design determines the fundamental dexterity of the hand i.e. the kind of handling that can be performed when grasping is performed. The size and arrangement of the fingers will drive the choice of approach. Anthropomorphic hands rely on the direct transfer of grasping strategies from the human hand while non-anthropomorphic hands consider the fingers to be identical and will therefore arrange them symmetrically.

The present review starts by introducing the anatomy of the human hand and the complex assembly of its bones, the joints that connect them, and the different movements achieved. This led the authors to present a range of mechanical hand structures made by the international scientific community as well as the latest developments in progress. Whatever structures are adopted, the goal of the designer is to obtain an artificial hand that exhibits dexterity as close as possible to that of the human hand with the concern of simplifying the design while choosing the appropriate control.

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CHAPTER 14

Social Network Analysis in Midwifery: Its Implications on Social Interaction and Healthcare Services

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Introduction

The rapid advancement of technology has made communication and information sharing accessible in today's world. Consequently, the midwifery profession has become significant when examined in the context of social networks, particularly in terms of public health, access to information, and health literacy. This is especially evident as technology continues to progress. The profession is crucial in addressing societal health, facilitating access to information, and promoting health literacy when viewed through social networks (Damar, 2022; Hinton et al., 2023; Vivilaki et al., 2023). Social network-based applications have experienced exponential growth in recent years, creating an efficient research area in various scientific disciplines, particularly when coupled with advanced computational techniques for extracting valuable information from the Web. This trend has provided a fertile ground for productive research across different fields (Camacho et al., 2020).

Midwifery is a crucial and critical profession that provides health services to women and their families throughout their lives, from birth to death (Jefford et al., 2019; Stevens & Alonso, 2020). In recent years, social networks have become an important tool supporting midwifery and enhancing information sharing in this field. They are a valuable tool for academic articles (Hinton et al., 2023; S. J. Nolan et al., 2021). Experiences, best practices, and up-to-date information about midwifery are shared through social media, leading to continuous improvements in the professional context (S. Nolan et al., 2018; S. J. Nolan et al., 2021). Social networks also play a critical role in information sharing and support for pregnant women and mothers who have given birth. Groups created for discussing pregnancy-related concerns and similar experiences enable women to exchange information, contributing to developing health literacy regarding pregnancy, breastfeeding, and infant care. This situation can assist them in receiving support both emotionally and sociologically and may help them find quicker solutions to their issues (Gleeson et al., 2019; Hinton et al., 2023; McDaniel et al., 2012; S. J. Nolan et al., 2021).

Empowering midwifery as a profession through social networks can enhance access to midwifery services and raise awareness. Simultaneously, it can contribute to professional solidarity and collaboration and strengthen social connections, thereby elevating the standards of midwifery practice. This, in turn, can improve public health (Damar, 2022; Hinton et al., 2023; Prosen, 2022). While the ease of using social networks brings convenience, it also introduces certain issues. These include patient privacy, information security, and ethical responsibilities. Midwives need to prioritize an approach that emphasizes ethical standards when adapting to this new communication method and leveraging social networks to meet the requirements of the modern age (Garcia-Mendez et al., 2022; Simbar et al., 2023).

Midwifery and social networks collaborate strongly to improve public health and facilitate information sharing. When used correctly and adhering to ethical codes, social networks can enrich midwifery practices, positively contributing to the community in areas such as pregnancy, childbirth, the postpartum period, newborn health, and breastfeeding experiences.

Definition and Fundamental Concepts of Social Network Analysis

With globalization and digitization, social networks have become integral to our lives today. Social network analysis has increasingly gained significance in recent years as a discipline to understand interpersonal communication and interaction and to decipher valuable information for solving societal dynamics. Social network analysis is a discipline that examines the connections between individuals, groups, or communities. This method studies interpersonal relationships, information flows, or resource sharing among individuals. The structures, strength, frequency, and effects of connections are evaluated, leading to the discovery of various information and syntheses (Serrat, 2017; Sosa, 2022; Tabassum et al., 2018). The scientific literature defines social network analysis as (1) examining services, applications, or specific domains (such as friendship, professional connections, common interests, etc.) that allow individuals to define a public (or semi-public) profile, (2) managing the list of other users with whom an individual (or organization) will share connections, and (3) viewing and navigating these lists, analyzing connections, and examining connections established by others within the social site. Although its roots extend to the Social Sciences, it has begun to enter the field of health and natural sciences in recent years. The concept of social network analysis was first introduced by British anthropologists Alfred Radcliffe-Brown and John Barnes (Barnes, 1954; Camacho et al., 2020; Radcliffe-Brown, 1930, 1940).

Table 1

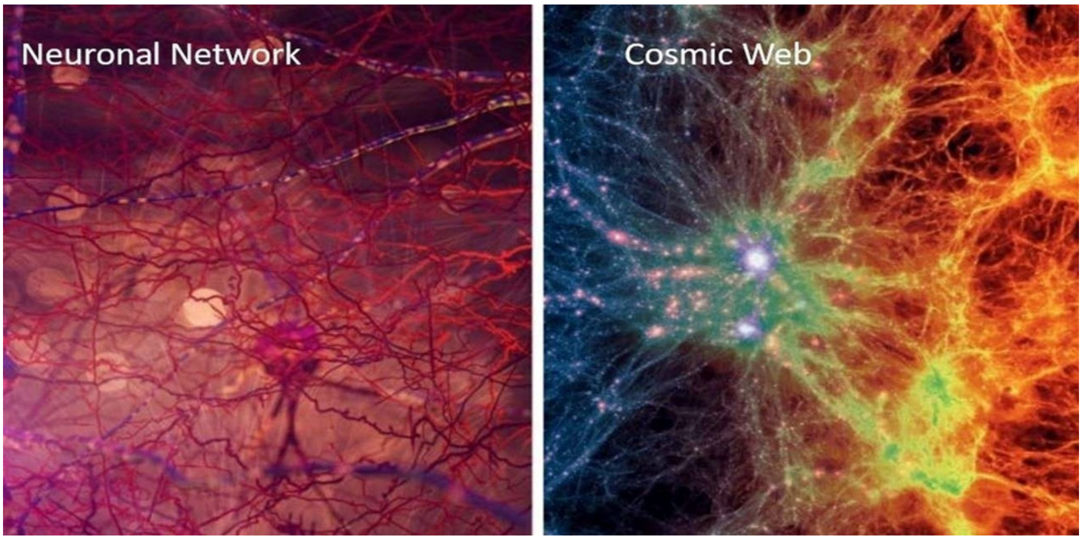
Some Examples of Social Networks (Tabassum et al., 2018)

Examples	Applications
Friendship networks	University/school students, organizations, or web (Facebook, MySpace, etc.)
Follower networks	Twitter, LinkedIn, Pinterest etc.
Preference similarity networks	Pinterest, Instagram, Twitter etc.
Interaction networks	Phone calls, Messages, Emails, WhatsApp, Snapchat, etc.
Collaborative authorship networks	DBLP, ScienceDirect, WikiBooks, other scientific databases, etc.
User-user citation networks	DBLP, ScienceDirect, WikiBooks, other scientific databases, etc.
Distributed networks	Epidemics, Information, Rumors, etc.
Supporting actor networks	IMDb, etc.

According to social network analysis, a network consists of living or non-living nodes (individuals, institutions, companies) and their connections. In an individual’s environment, there are numerous natural and artificial networks, whether visible or invisible. It is possible to talk about many networks, ranging from the structure of an atom to human cells and systems created by celestial bodies (Tabassum et al., 2018). Social networks are networks in which individuals are connected directly or indirectly. The nodes in any social network represent individuals, institutions, companies, etc., within the network, and the edges or links represent the relationships between these groups. For example, friendship connections among individuals, business relationships among institutions or companies, or interpersonal communication patterns can be considered. With social network analysis, features such as the distribution of resources, information flow, or the overall connectivity of the network can be revealed by analyzing the network structure and the characteristics of individuals within the network (Smith, 2013). Social network analysis aims to identify the most effective, significant, or central actors using statistical measurements, define central figures and authorities through connection analysis algorithms, discover communities, employ community detection techniques, and understand how information spreads in the network through algorithms. These analyses are highly effective in extracting information from networks and problem-solving processes. Due to the high potential opened up by such analyses, social network analysis is utilized as a current and popular approach in numerous fields, ranging from biology to business (Tabassum et al., 2018). Social network analysis is typically visualized as a network graph. This graph depicts individuals (nodes) and the connections between them (edges). This graph shows social organization, information transfer, interaction patterns, and power dynamics.

Consequently, scientific data can be obtained (Tabassum et al., 2018). Social Network Analysis is employed in a diverse range of fields. Initially perceived as impactful in the business realm, spanning from customer relationship management to collaborative projects, in recent years, it has also found application in the healthcare sector to comprehend relationships and interactions between patients and healthcare personnel or among the patients themselves. Furthermore, it serves as a potent tool for understanding educational sciences, political science, international relations, and societal interactions (Germani & Biller-Andorno, 2021; Olanrewaju et al., 2020). One significant feature of social network analysis is its capability to analyze real-time data, facilitated by access to big data through social media platforms and online environments, enabling swift and effective results (Serrat, 2017; Sosa, 2022; Toivonen et al., 2019).

Figure 1.
Quantitative Comparison Between Neural Network and Cosmic Network (Brown, 2021)



Social network analysis involves several fundamental concepts;
Centrality: Centrality is a fundamental concept that measures the importance of a node within a network. In a social network, various centrality metrics exist, each emphasizing different aspects of a node's position within the network. These various centrality metrics include degree centrality (the number of direct connections a node has), betweenness centrality (how many times a node acts as a bridge on the shortest path between two other nodes), and eigenvector centrality (the sum of centrality scores for all nodes connected

to a particular node) (Borgatti & Brass, 2019).
Density refers to the measure of the likely occurrence of connections within a network. The higher the density in a social network, the more it can be interpreted that participants in the network are interconnected to a significant degree (Faust, 2006).
Clusters or Communities: Compared to the rest of the network, these groups, which are more densely interconnected and form distinct nodes, are referred to (Gamsu & Donnelly, 2021; Wu et al., 2013).
Structural Holes and Brokerage: Structural Holes are a concept initially developed by Ronald Stuart Burt and utilized in social network research (Burt, 2004) They are the voids in a network where nodes can serve as bridges between two disconnected components of the network (Brass, 2022).

Software Tools Used in Social Network Analysis

There are various tools available for conducting Social Network Analysis (SNA). These range from open-source software to commercial offerings, each with strengths and weaknesses. Here are a few examples:
Gephi - The Open Graph Viz Platform**:** Gephi is an open-source, interactive visualization, and exploration platform for all types of networks and complex systems. User-friendly enables users to interactively manage network visualization, conduct network analysis, and export results in various formats.
UCINet – Analytic Technologies**:** UCINet is a comprehensive package designed for the analysis of not only social network data but also other 1-mode and 2-mode data. Widely utilized in social science research, it provides extensive capabilities for analyzing various types of data
NetDraw Software for Network Visualization**:** NetDraw, commonly used with UCINet, is a free tool for visualizing networks. It supports the visualization of large networks and offers various customization options.
Pajek**:** Pajek is a program designed to analyze and visualize large networks. It is a comprehensive tool offering various complex network metrics and is available for non-commercial use free of charge.
NodeXL: network analysis & insights as easy as pie charts**:** NodeXL is a free, open-source template for Microsoft Excel that allows users to visualize and analyze network graphs. Its integration with Excel makes it user-friendly, particularly for those familiar with Excel.
Cytoscape - Network Data Integration, Analysis, and Visualization in a Box**:** originally designed for biological research, Cytoscape has evolved into a popular open-source software platform for visualizing complex networks and integrating them with various types of qualitative data.
SocioViz - SocioViz is a free Social Network Analysis tool for Twitter**:** SocioViz is a social media analysis platform focusing on network analysis and visualization of Twitter data. It is a powerful tool for researchers interested in online social networks.
NetworkX — NetworkX documentation**:** NetworkX is a Python package designed for the creation, manipulation, and exploration of the structures, dynamics, and functions of complex networks. It integrates well with other scientific Python tools such as SciPy and Matplotlib.
igraph – Network analysis software**:** igraph is a library that can be utilized in R, Python, and C for creating, modifying, and analyzing networks. It is highly efficient and capable of handling large networks.
RSiena**:** RSiena is an R package dedicated to the statistical analysis of network data, specifically focusing on longitudinal social networks.

Methods of Social Network Analysis

Social network analysis is a research and analysis method employed to study individuals, groups, organizations, or societies, aiming to understand/unravel their connections and develop models. This analytical approach utilizes various techniques to visualize complex relationships in social networks and examine diverse network relationships and features (Knoke & Yang, 2020).

Network Visualization: Network visualization is a fundamental method used in social network analysis. Network visualization involves the graphical representation of individuals (nodes) and the connections between them (edges). The network graphs used in the visualization process serve as crucial tools for understanding and depicting the network structure. These graphs identify strong connections between nodes, subgroups, and interaction patterns within the network (Can & Alatas, 2019; Freeman, 2004; Knoke & Yang, 2020).

Centrality Measures: Centrality metrics are expressed as metrics that measure the centrality, or importance, of a node in a network. These metrics are utilized to evaluate the connections and interactions of a node with other nodes. Moreover, various centrality measures emphasize different aspects of a node's position in the network. Among these, degree centrality assesses the number of connections a node has, betweenness centrality measures how frequently a node appears on the shortest path between other nodes, closeness centrality evaluates how quickly a node can reach all other nodes in the network, and eigenvector centrality expresses the influence of a node in a network (Stroele et al., 2017).

Network Structure Analysis / Community Detection: This aims to identify clusters of nodes in a social network that are more closely connected than the rest of the network, also known as clustering. This process can assist in uncovering subgroups or communities within the network. Additionally, measurements such as "Connection Density," "Modularity," and "Transitivity" can be used to analyze communities, groups, and the overall structure of the network (Fumanal-Idocin et al., 2020; Nikolaev et al., 2015).

Social Network Mining: Social network mining involves the analysis of large datasets to uncover patterns, trends, and information within social networks. This process enables prediction, identification of trends, and understanding of societal dynamics using data obtained from social networks (Nasution, 2019).

Dynamic Network Analysis: Dynamic network analysis is a method used to understand the changes in a network over time. Examining a network's evolution is employed to comprehend how relationships develop, undergo alterations, and terminate. Thus, this method can assist in gaining insights into the dynamics occurring within the network over time (Lerner et al., 2021).

Structural Equivalence and Block Modeling: The measure of how two nodes in a network are similarly connected to the rest of the network is expressed as structural equivalence. Nodes demonstrating structural equivalence generally assume similar roles within the network. Through the block modeling technique, structurally equivalent nodes are grouped, simplifying the network (Butts, 2008).

Network Correlation and Regression: Correlation and regression are statistical techniques. In social network analysis, these techniques are employed to identify and test patterns within the network. For example, the statistical analysis of the connectivity patterns among nodes with certain characteristics within a network can be conducted using these techniques (Zhang et al., 2008).

Some notable examples of Social Network Analysis include:

Public Health – COVID-19 Pandemic: In China, Fang et al. (2023) utilized social network analysis to model the spread of the COVID-19 virus during the pandemic. Communication and interactions among individuals were mapped in a network format, identifying those contributing to faster virus transmission (super-spreaders). This information proved valuable for public health interventions related to COVID-19 (Fang et al., 2023).

Business – Google's "PageRank" Algorithm: Google's PageRank algorithm is a form of social network analysis. Web pages can be considered as nodes, and links as connections, determining the importance of each page based on the quantity and quality of links directed to it (Chen et al., 2007).

Sociology – Stanley Milgram's "Small World" Experiment: The renowned sociologist Stanley Milgram's most significant experiment and theory in the United States. This approach posits that in a given country, everyone can be connected through, at most, two intermediaries and, in many cases, this communication may occur through only one person in between (Milgram, 1967).
Online Social Networks – Facebook's "People You May Know" Feature: Facebook employs social network analysis to suggest new friends and help users discover potential connections. Essentially, the platform analyzes an individual's existing network, often revealing the likelihood of mutual acquaintance by displaying friends of friends or individuals who share common connections (Guy et al., 2009).
Criminal Network Analysis – Capture of Osama bin Laden: Social network analysis is a method also employed in criminal network analysis. It has been reported that social network analysis was utilized in the operation leading to the capture of Osama bin Laden following the Twin Towers incident in the United States. Intelligence agencies could pinpoint the location of the Al-Qaeda leader by mapping the social connections of known associates (Javed et al., 2022; Krebs, 2002).
Academic Research – Collaboration Networks: Social network analysis is employed in bibliometrics to analyze collaboration networks among researchers. Studies on co-authorship networks in scientific articles can reveal collaboration patterns among scientists working in different disciplines and unveil knowledge flows (Isfandyari-Moghaddam et al., 2023; Toral et al., 2011).

The Use of Social Network Analysis in Midwifery Applications and Research

The application of social network analysis in healthcare initially emerged in the field of public health, aiming to understand and examine the spread of infectious diseases, how networks reinforce social norms, and the organization of public health interventions (Pow et al., 2012). Furthermore, the significance of social network analysis has been highlighted in understanding the adoption or non-acceptance of contraception use and innovations in healthcare by society, emphasizing the impact of social norms in these dynamics (Gayen & Raeside, 2007, 2010b). Social network analysis has been employed in numerous studies, such as evaluating adolescents' utilization of sexual and reproductive health services, identifying support groups for coping with various disease groups, and characterizing dynamic groups or family members in the caregiving processes of mothers with their children (Gayen & Raeside, 2007, 2010b, 2010a; Hinton et al., 2023; Hirdes & Scott, 1998; Kawachi et al., 1996).

Applying social network analysis to midwifery provides a straightforward method to understand human interactions and how they may influence various health outcomes. Specifically, it can assist in identifying influential individuals as agents of change, forming social norms, examining their impact on communication, and determining the extent to which a group accepts new interventions and thought patterns. Therefore, collaborating with key individuals within a network is crucial for the success and sustainability of implemented health interventions. Additionally, social network analysis can aid in evaluating the effectiveness of such interventions in the midwifery profession from the perspectives of healthcare providers and recipients (Gleeson et al., 2019; Hinton et al., 2023; Pow et al., 2012; Prosen, 2022; Stevens & Alonso, 2020; Vivilaki et al., 2023).

Social network analysis can offer various advantages in numerous applications and research within midwifery. It can contribute to strengthening support networks among women, fostering collaboration and solidarity among colleagues, and enhancing the quality of midwifery services, among many other valuable topics. Additionally, it can provide advantages in utilizing midwifery practices, emphasizing the importance of employing certain methods in this context.
Analysis of Patient Support Groups: Social network analysis can be employed to examine support groups among expectant mothers during pregnancy. It can be used to understand interactions within these groups and identify connections between groups. Consequently, it can help identify robust support networks where experiences among

women are shared during pregnancy, childbirth, and postpartum periods, strengthening these networks (Groves et al., 2021; Wentzer & Bygholm, 2013).

Communication Analysis Among Midwifery Professionals: Social network analysis can assess communication and collaboration among midwifery professionals. This facilitates the sharing of best practices, the exchange of professional knowledge, and the global dissemination of accurate practices. Both professional solidarity and seamless exchange of information are crucial for the advancement of the midwifery profession, and in this context, social network analysis can contribute significantly (Gemperle et al., 2022; Ramesh et al., 2023).

Examination of Women's Information Exchange: Social media platforms and online forums serve as spaces where women exchange information and share information. By scrutinizing women's posts on various social media platforms and forum pages, social network analysis can reveal prominent topics, the prevalence of certain information, and the formation of support networks. This enables researchers to draw numerous insights from the data acquired by analyzing women's interactions in these online spaces (Xie et al., 2021; Zeavin, 2022).

Analysis of the Spread of Educational Materials: Social network analysis can also be employed to examine the dissemination of valuable information and educational materials. Particularly in midwifery, it can explore how educational materials spread across different communities, which networks predominantly use these materials, and through which networks the dissemination occurs. Additionally, insights can be gained into the characteristics of individuals accessing these materials. The findings derived from such analyses can contribute to the profession's advancement, providing midwifery professionals and students with more effective access to current data (Trivedi, 2021).

Determining Strong Connections for Public Health: In many applications related to public health, individuals can influence each other. Social network analysis can be employed to enhance the effectiveness of midwifery care and services for public health. Strong connections within the community, in particular, can assist in accessing and participating in health services. This approach can be utilized and researched in various public health applications, such as identifying risk factors within the community and developing early intervention strategies. Additionally, it can be valuable in applications related to maternal and newborn care (Muhidin et al., 2019).

- Identifying risk factors for pregnancy complications through social media analysis can facilitate early intervention and support for individuals at risk.
- Social network analysis in midwifery can be utilized to enhance public health awareness. Disseminating accurate information about pregnancy, childbirth, and postpartum baby care through social media can contribute to a more informed community on health matters.
- It can assist in identifying genetic risk factors and understanding how these factors spread among families. This information can contribute to the prediction and prevention of diseases by providing genetic counseling and recommendations.
- It is crucial for determining lifestyle and environmental factors within the community. Identifying these factors can improve public health by promoting healthy habits and reducing adverse environmental impacts.
- It can help us understand individuals' genetic predispositions and personal health histories. This information can be used to determine individuals' susceptibility to specific diseases and take preventive measures through early diagnosis.

In conclusion, social network analysis in midwifery can positively affect public health. It can increase information sharing, identify and develop prevention strategies for risk factors, and raise health awareness within the community. However, adhering to ethical standards and privacy regulations is essential when conducting such analyses (Assegaai & Schneider, 2019; McCullough et al., 2016; Simpson et al., 2021).

Future Research and Application Recommendations in Social Network Analysis within Midwifery

Social network analysis in midwifery holds significant potential for future research and application. Attention should be directed towards specific areas to advance the field and effectively leverage research in this domain. Further exploration and careful consideration are essential for progressing in the studies conducted in this field and extracting optimal benefits from such research endeavors.

Participation and User Experience: Future research in midwifery within social network analysis should concentrate on how users engage and experience the platform. Within this framework, strategies that enhance participation and strengthen user experience can be identified and integrated into applications (Sheridan et al., 2018).

Data Security and Privacy: One of the most crucial aspects is data security and privacy, a critical concern in social network analysis within midwifery applications. Future research should particularly focus on developing more effective and user-friendly security measures to eliminate users' concerns about data sharing (McCarthy et al., 2017).

Ethnic and Cultural Diversity: Future social network analysis applications in midwifery should focus on how they reflect ethnic and cultural diversity and reach different communities. This approach can contribute to effectively disseminating midwifery applications to a broader audience (Beake et al., 2013; Burton & Ariss, 2014).

Data Analysis and Artificial Intelligence: Future research endeavors may concentrate on more advanced data analysis methods and artificial intelligence applications in social network analysis. This approach can provide deeper insights and more effective predictions to strengthen midwifery applications (O'Connor et al., 2023).

Professional Collaboration and Education: Further research in social network analysis can be conducted to support collaboration and education among healthcare professionals. Specifically, social network analysis in midwifery applications can enhance the coordination of healthcare teams and facilitate the exchange of up-to-date and effective information (Ramesh et al., 2023).

Patient Education and Awareness: Data obtained from social network analysis research in midwifery should contribute to developing strategies to educate and raise awareness among women and the community regarding health issues better, with implications for behavioral change (Trivedi, 2021).

Developments in Mobile Applications: The increasing significance of mobile applications in recent years can also be leveraged in midwifery applications. Attention should be given to user-friendly interfaces, data security, accessibility, and user experience in mobile applications (Tripp et al., 2014).

Community Engagement and Feedback: Social network analysis in midwifery applications should focus on more community-centered initiatives to enhance community participation in health-related matters and make improvements based on feedback. Encouraging active user participation, soliciting feedback, and conducting assessments within this framework are essential (Simpson et al., 2021).

These recommendations can contribute to more effective and user-centric midwifery research in social network analysis. Thus, social network analysis has the potential to become a more powerful tool for strengthening midwifery applications and enhancing women's health experiences.

Conclusion

Social network analysis in the midwifery profession represents a significant realm of research and application for strengthening health services for both mothers and newborns and their families during pregnancy, childbirth, and postpartum periods. Through these analyses, interactions, information exchange, and emotional support systems between women and healthcare professionals can be comprehensively understood, fostering a holistic perspective. However, ethical standards and data privacy must be prioritized to achieve meaningful and extensive progress in this field, with solutions developed within this framework. The integration of future planned studies into the midwifery profession and the increasing importance of its effective use on a broad scale are anticipated. Additionally, focusing on enhancing user security and improving public health will enable a thorough evaluation of the full potential of this field. Social network analysis in midwifery should increasingly garner importance in future research and applications, serving as a critical tool to optimize healthcare services and support women's health experiences in this evolving landscape.

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CHAPTER 15

Methods Used to Determine the Fracture Toughness of Aggregate Filled Reinforced Polymer Composites

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Introduction

Reinforced polymer composites are materials formed by combining mineral aggregates and reinforcing materials with polyester resin. These materials are ideal for a variety of construction, rehabilitation, and repair applications due to their fast hardening and high-strength properties.

Polymer composites (PCs) are brittle materials, and their fracture behavior is affected by several factors such as the composition of the material, the type and geometry of the reinforcing material, the resin system, and environmental conditions. Different methods are used to characterize the fracture behavior of PCs. These methods aim to determine the stress intensity factor (K). K is an important parameter used to determine the rate of propagation of the crack and the fracture strength of the material.

In this chapter, the main methods used to characterize the fracture behavior of PCs will be discussed. The methods will be classified as the initial notch depth method, the compliance method, the J-integral method, and the critical opening (CMOD) method. The theoretical foundations of the methods and the advantages and disadvantages of their practical applications will be examined.

Reinforced polymer composite (PC) is formed by combining mineral aggregates and reinforcing materials with polyester resin. PCs with resin system; Due to its fast hardening and high strength properties, it is used in a variety of construction, rehabilitation, and repair applications such as bridges, pipelines, and other types of construction ((Hassani Niaki, 2023; Vipulanandan & Dharmarajan, 1987; Guerrini, 2000; Barnaby & Dikeou, 1984; Fowler, 1983).

At the same time, many studies have been carried out to characterize the fracture behavior in systems where cement is used as aggregate. (Avcı & et. al,2004,2005; Arikan & et. Al,2004; Samanci, 2012; Dharmarajan & Vipulanandan, 1988; Vipulanandan &

Dharmarajan, 1989).

Although PCs are brittle materials, the assumptions in the mechanics of direct elastic fracture and the mechanics of elastic-plastic fracture do not always give the correct result. Therefore; Characterizing the refractive behavior; to determine the stress intensity factor; Different methods such as the initial notch depth method, compliance method, J-integral method, and critical opening (CMOD) were used (Avcı & et. al,2004,2005; Arikan & et. Al,2004; Samanci, 2012; Dharmarajan & Vipulanandan, 1988; Vipulanandan & Dharmarajan, 1989).

1. Aggregate Filled Reinforced Polymer Composites

It is a type of composite material in which there are grains over millimeters in size in a matrix. For example, polymer concrete, which is a type of polymer composite, or cement-based concrete can be given.

As described above, the material obtained by holding various grains together by bonding them with a binder is called particle additive composite in general classification. If a thermosetting matrix is used as a binder, it is called a polymer composite. If the grains that form polymer composites are sand and resin is used as a binder, such polymer composites are also called polymer concrete. The polymer composite expression used in this study refers to polymer concrete.

Polymer composites have a single property depending on the formulation. These;

- Fast hardening at ambient temperature
- High tensile, flexural, and compressive strength
- Good adhesion to most surfaces
- A low permeability to corrosive properties or water, a good chemical resistance

Polymer composite components are briefly explained below.

- Hardeners for monomers: Hardener types for monomers are benzoyl peroxide (BPO), lauryl, and methyl ethyl ketone peroxide (MEK).
- Accelerators for monomers: These exist in the form of terthierdimethylaniline. They are slightly strawberry-colored liquids. They disperse quickly in monomers.

Sands: All sands used in connection with monomer systems should consist mainly of silicon, quartz, granite, limestone, and other high-quality materials. Sands should generally be dried. They must be cleaned of dirt, asphalt, and other organic materials. Moisture on sands reduces the bonding strength of most monomer systems and epoxy resins. Unless otherwise stated, sands should not have surface moisture. In some systems, the humidity content can be up to 3%. In certain cases, the humidity should be less than 1% (David, 1986).

Properties, Types and Uses of Polymer Composites

Polymer composites are preferred because they have higher strength compared to traditional concrete composites in applications where resistance to water and chemicals is required and they need to be lightweight. This material has a wide range of uses, for example, it has found a wide range of uses in building construction, stairs, pipelines, insulators, electrical and communication lines, cable lines, etc.

Polymer composite was first used in the construction of bench bodies. Later, it is produced from this material in applications such as high-speed milling and precision drilling machines.

Polymer composite is an artificial material with a high filling agent. While normal concrete composites are created with binder materials such as sand, water, and cement, polymer composites contain materials such as synthetic resin as a binding material, silicate-type materials as an additional material, and calcium carbonate as a filling material. The properties of polymer composites depend on the type and properties of the binder used, as well as the properties of the aggregates. The reason why aggregates such as sand are preferred is that they have less plastic deformation than other materials. Polyester resin, methacrylic resin, and epoxy resin are preferred as binding materials used in polymer composites. In practice, polymer composites with epoxy resins are used for mass production in applications such as bench bodies.

The strength of the polymer composite decreases significantly as the moisture content of the additional materials increases. The particles of these materials are dried by fire. When the plastic shaping process continues for a long time, the particle size increases. Polymer composite with small particles requires the use of more resin, which negatively affects the strength properties and hardness resistance of the polymer composite.

In addition to mechanical and thermal properties, plastic deformation and rest are important. In the experiments, it was observed that epoxy resin polymer composites had a higher shape change, while acrylic resin composites had less shape change. At the same time, epoxy resins show ductility at temperatures up to 50 °C. For the additional material to be thoroughly mixed, the synthetic resin must have a low viscosity. Table 1 gives the physical properties of polymer composite materials.

High-speed machine bodies made of polymer composites can operate at a higher frequency than bench bodies made of other materials. A particular advantage of polymer composite machine tools is the absence of critical resonances within the bench work area (Schulz 1984).

In the methacrylic resin composite formed with iron, an increase in friction strength was obtained compared to the construction from pure polymer composite, and an increase in absorption and rigidity compared to iron construction. The 3420 kg grinding machine uses 2100 kg of polymer composites, resulting in six times higher absorption and higher rigidity on the slide paths. The vibration of the polymer composite was reduced by 10 μm before filling and by 1 μm after filling. At the same time, natural frequencies increased from 115 Hz to 195 Hz and from 150 Hz to 232 Hz (Acherkan, 1973).

Tablo 1.
Physical Properties of Aggregate Filled Reinforced Polymer Composites

Physical Properties of the Material	Epoxy Composite	Polyester Composite
Density (kg/dm3)	2.02	1.98
Flexural Elasticity Modulus (GPa)	4-7	2.5-4.5
Flexural Strength (MPa)	12-25	5-15

2. Fracture Mechanics

Fracture mechanics and fracture toughness test methods constitute one of the main topics in the field of materials engineering, which is critical for studying the durability of materials, the propagation of cracks, and fracture behavior.

The most important aspect of fracture mechanics is that it examines fracture problems by considering the factors that increase crack and stress concentration in materials under stress. Mechanical cracks can occur during the production of materials used in machinery and construction. During the manufacture of materials, hairline cracks can be found for various reasons. Stress concentration occurs around these cracks and causes fracture. Cracks caused by stress concentration can also be at stresses lower than the yield stress of the material used. Materials whose structure contains capillary cracks and large cavities that undergo plastic deformation usually show brittle fracture (Kayalı & et al., 1983).

Theories and experiments have been developed that study the primarily brittle fracture character of metallic materials. These experiments are not sufficient for a construction engineer or researchers who are closely interested in fracture. With fracture mechanics analysis, both the cause of damage to the material can be understood and the formation of any cracks during manufacturing and use can be prevented.

In fracture mechanics, the parameters related to fracture are fracture toughness or stress strength factor (GCF). The stress intensity factor is expressed by the symbol "K". Stress intensity factor K is a parameter that determines the stress area around the crack, which depends on the geometric shape of the material, the loading shape, and the location and orientation of the crack.

The fracture toughness of a material can be defined as its capacity to carry loads when there are cracks in the material or its ability to deform plastically. Material toughness can be expressed by the critical stress intensity factor under plane stress conditions (KC) and plane deformation conditions (KIC). These behaviors are valid within the framework of Linear Elastic Fracture Mechanics (LEKM).

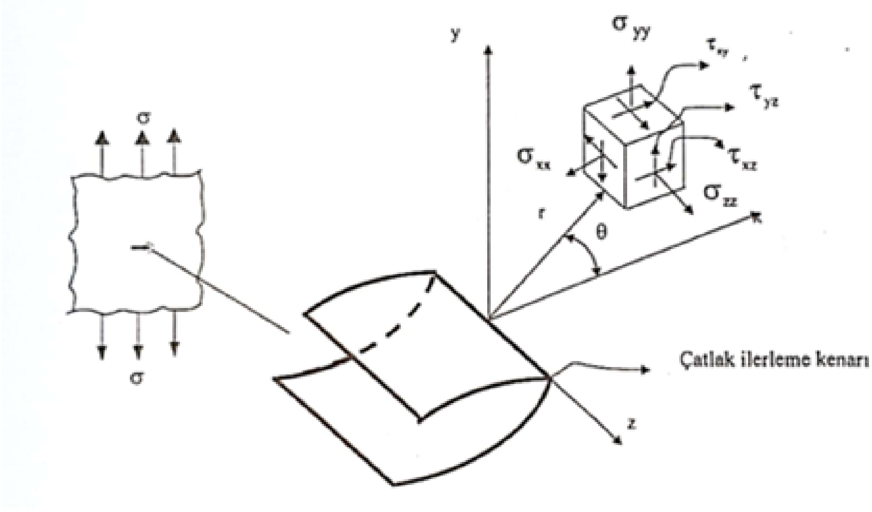
2.1 Linear Elastic Fracture Mechanics

To perform stress analysis of cracks in elastic objects, it is necessary to know the bound motion of the crack surface. Crack propagation behavior is seen in three types. This can include one, two, or all three of these three types.

Type I is the most common and more critical opening mode than the others. The two fracture surfaces are opened in opposite directions to each other and perpendicular to each other. In type II slip mode, the crack surfaces move in the opposite direction on the x-z plane. In Type III rupture mode, the crack proceeds inversely symmetrically concerning the x-y and x-z planes. The two fracture surfaces slide in a parallel direction with a line in front of the crack relative to each other. Stress deformations in isotropic materials near the crack tip were found by Irwin (Irwin, 1957). The intensity factors of crack tip strain are as follows for each mode. Here, K_I, K_{II}, and K_{III} are stress intensity factors for mode I, mode II, and mode III, respectively. The Mode I crack tip stress zone distribution and coordinate system representation are as shown in Figure 1.

Figure 1.

Mode I Crack Tip Stress Zone Distribution and Coordinate System



The stresses at the crack end are as follows;

$$\sigma_{xx} = \frac{K_I}{(2\pi r)^{1/2}} \mathbf{Cos}\frac{\theta}{2}(1 - \mathbf{Sin}\frac{\theta}{2}\mathbf{Sin}\frac{3\theta}{2})$$

$$\sigma_{yy} = \frac{K_I}{(2\pi r)^{1/2}} \mathbf{Cos}\frac{\theta}{2}(1 + \mathbf{Sin}\frac{\theta}{2}\mathbf{Sin}\frac{3\theta}{2})$$

$$\tau_{zz} = \frac{K_I}{(2\pi r)^{1/2}} \mathbf{Cos}\frac{\theta}{2}(\mathbf{Cos}\frac{\theta}{2}\mathbf{Cos}\frac{3\theta}{2}\mathbf{Sin}\frac{\theta}{2})$$

$$\sigma_{zz} = \frac{K_I}{(2\pi r)}(2v\mathbf{Cos}\frac{\theta}{2})$$

$$\tau_{yz} = \tau_{zx} = 0$$

As in Figure 2, the shape changes of the opened crack at the point at the distance r are as follows. where v: is Poisson's ratio, σ_{XX} : is the stress value on the x-axis, σ_{YY} : is the stress value on the y-axis, and σ_{ZZ} : is the stress value on the z-axis. K_I: is the stress intensity factor for mode I, E: is the modulus of elasticity, θ: is the angle r makes with the x-axis. U, V, W are the displacements on the x, y, z axes, respectively.

$$u = \frac{K_I}{E}(\frac{r}{2\pi})^{1/2}(1+v)\left[(2k-1)\mathbf{Cos}\frac{\theta}{2} - \mathbf{Cos}\frac{3\theta}{2}\right]$$

$$v = \frac{K_I}{E}(\frac{r}{2\pi})^{1/2}(1+v)\left[(2k+1)\mathbf{Sin}\frac{\theta}{2} - \mathbf{Sin}\frac{3\theta}{2}\right]$$

$$w = -v' \frac{K_I}{E} \quad (\textit{Düzlem gerilme hali için } 0'd \;)$$

$$v' = v,\; k = \frac{(3-v)}{(1+v)} \quad (\textit{Düzlem gerilme hali için})$$

$$v = 0,\; k = 3 - 4v \quad (\textit{Düzlem deformasyon hali için})$$

Stresses for the Mode II state;

$$\sigma_{xx} = \frac{K_{II}}{(2\pi r)^{1/2}} \mathbf{Sin}\frac{\theta}{2}(2 + \mathbf{Cos}\frac{\theta}{2}\mathbf{Cos}\frac{3\theta}{2})$$

$$\sigma_{yy} = \frac{K_{II}}{(2\pi r)^{1/2}} \mathbf{Sin}\frac{\theta}{2}\mathbf{Cos}\frac{\theta}{2}\mathbf{Cos}\frac{3\theta}{2})$$

$$\tau_{xy} = \frac{K_{II}}{(2\pi r)^{1/2}} \mathbf{Cos}\frac{\theta}{2}(1 - \mathbf{Sin}\frac{\theta}{2}\mathbf{Sin}\frac{3\theta}{2})$$

$$\sigma_{zz} = v(\sigma_{xx} + \sigma_{yy})$$

$$\tau_{yz} = \tau_{zx} = 0$$

The displacements equation is found as follows;

$$U_x = \frac{K_{II}}{E}(\frac{r}{2\pi})^{1/2}\mathbf{Sin}\frac{\theta}{2}\left[(2 - 2v\mathbf{Cos}^2\frac{\theta}{2}\right]$$

$$U_y = \frac{K_{II}}{E}(\frac{r}{2\pi})^{1/2}\mathbf{Cos}\frac{\theta}{2}\left[(-1 + 2v\mathbf{Sin}^2\frac{\theta}{2}\right]$$

$$w = 0$$

Stresses and displacements for Mode III state;

$$\tau_{xz} = \frac{K_{III}}{(2\pi r)^{1/2}}\mathbf{Sin}\frac{\theta}{2}$$

$$\tau_{yz} = \frac{K_{III}}{(2\pi r)^{1/2}}\mathbf{Cos}\frac{\theta}{2}$$

$$\sigma_{xx} = \sigma_{yy} = \sigma_{zz} = \tau_{xy} = 0$$

$$u = v = 0$$

$$w = \frac{K_{III}}{E}\left[\frac{2r}{\pi}\right]^{1/2}\mathbf{Sin}\frac{\theta}{2}$$

2.2. Elastic-Plastic Fracture Mechanics

In many materials, it is almost impossible to explain fracture behavior by linear elastic fracture mechanics and an alternative fracture model is required. Elastic-plastic fracture mechanics are applied for materials that exhibit nonlinear behavior (such as plastic deformation). One of the parameters that characterize elastic-plastic behavior is the crack tip displacement (CTOD) and the other is J-integral. The critical value of CTOD and J-integral establishes size-independent fracture toughness and gives a large amount of crack tip plastic behavior (Anderson,1991).

2.2.1. Crack Tip Opening Displacement (CTOD) Method

When Wells tried to determine the fracture toughness value in a steel structure, he found that these materials were too tough to be characterized by linear elastic fracture mechanics. Although high toughness is desirable, the theory of fracture mechanics could not be applied to such an important material. Wells, while examining the crack surface; He noticed that the crack was sharp at first, then it was closed by plastic deformation and the closure in the crack increased in proportion to the fracture toughness. This observation has led to the suggestion of the use of crack tip opening as a measure of fracture toughness. Today, this parameter is known as "crack tip displacement (CTOD)" and is used as a parameter of fracture (Anderson,1991).

A single edge notch bending (SENB) specimen is preferred to determine the CTOD value. As shown in Figure 2, the CTOD value is found by determining the amount of crack opening (CMOD) V_p. V_p is the amount of crack opening (CMOD). The amount of crack tip opening is expressed in δ. Figure 3 shows the measurement of V_p with clip-gage.

the connection between δ and clip-gage displacement;

$$\delta = \delta_{el} + \delta_{pl}$$

$$\delta = \frac{K^2(1-v^2)}{2\sigma_y E} + \frac{0.4(W-a)V_p}{0.4W + 0.6a + z}$$

It is found with expressions (ASTM E-1290 1993).

Here;

- K is the fracture toughness value found by the initial notch depth method.
- v is the Poisson ratio.
- W is the material width.
- A is the initial notch depth.
- V_p is the amount of crack opening (CMOD).

Basically, by measuring the critical value of the CTOD, the maximum allowable crack length for the plane stress state can be found. In the case of plane shape change, although some finite element solutions can be used, a complete analytical solution cannot be made.

Figure 2.
Representation of δ in a Single Edge Notched Bending (SENB) Specimen

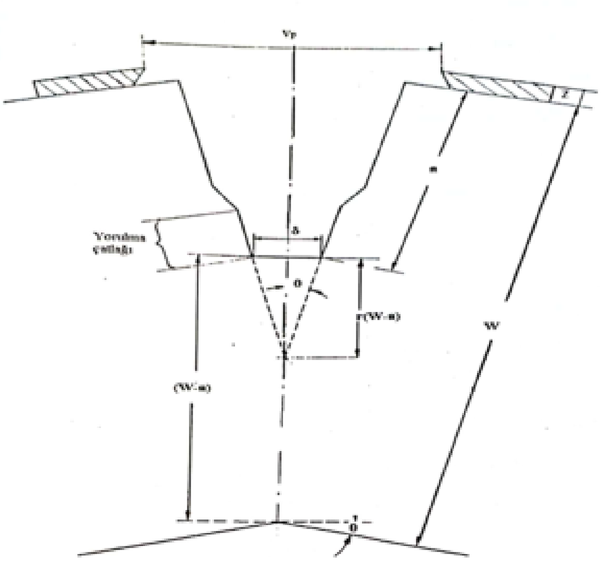
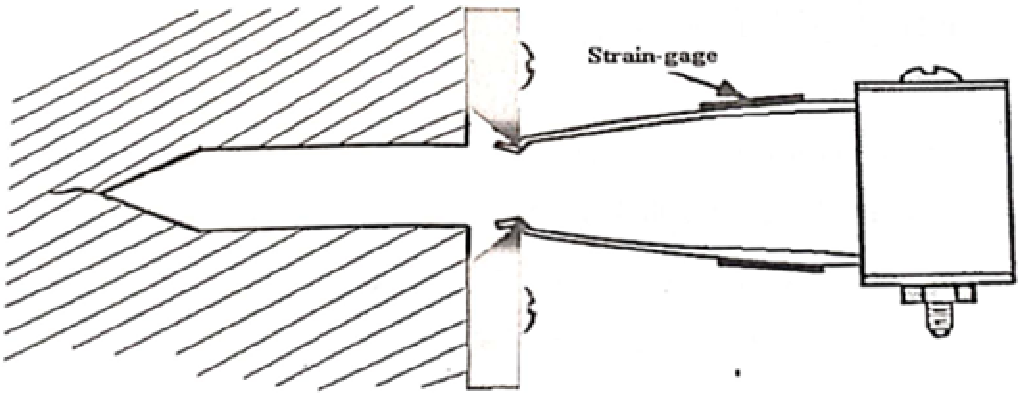


Figure 3.
Measurement of V_p Value with Clip-Gage



2.3. Fracture Toughness Test Methods

A fracture toughness test measures a material's resistance to crack growth. This test can determine both a single fracture toughness value and the resistance curve. These values are toughness parameters such as fracture toughness (K), J-integral (J), or crack tip opening displacement (CTOD) plotted against crack growth. A single toughness value is usually sufficient to describe a test that has undergone cleavage fracture. This fracture mechanism is typically unstable.

The ASTM E399 standard prescribes four sample formats. These are compact, single-edge notched bending (SENB), arc-shaped, and disc-shaped specimens. In bending specimens with a single edge notch, thickness is usually shown as B, width W. In samples with pre-cracks, the crack depth is expressed as a and the ratio of the crack to the sample width is expressed as a/W. Thus, a, B, and *a/W* values are considered in the sample design.

In most mechanical tests (fracture toughness and others); The healthy conduct of the experiment affects the experimenter as much as the procedure in the test standard, and invalid results can often be obtained due to these errors. If the plastic region at fracture is too large, it is impossible to obtain the valid K_{IC} value.

ASTM E-399 recommends an accurate approach to determining sample sizes due to very careful measurement requirements. Specimen sizes for K_{IC} testing are valid if they meet the following requirements.

$$B,(W-a) \geq 2,5\left[\frac{K_{IC}}{\sigma_{ys}}\right]^2$$

Here, to calculate the required sample sizes, the user must use the estimated K_{IC} value. While making this estimation, it can benefit from the K_{IC} values of similar samples.

According to ASTM E-399, the maximum value of the tensile intensity factor K_{max} in one cycle during the fatigue pre-crack should not be greater than 0.8 K_{IC}. When reaching the final size of the crack, the K_{max} should not be less than 0.6 K_{IC}. The fatigue value should always be less than the K_{IC}.

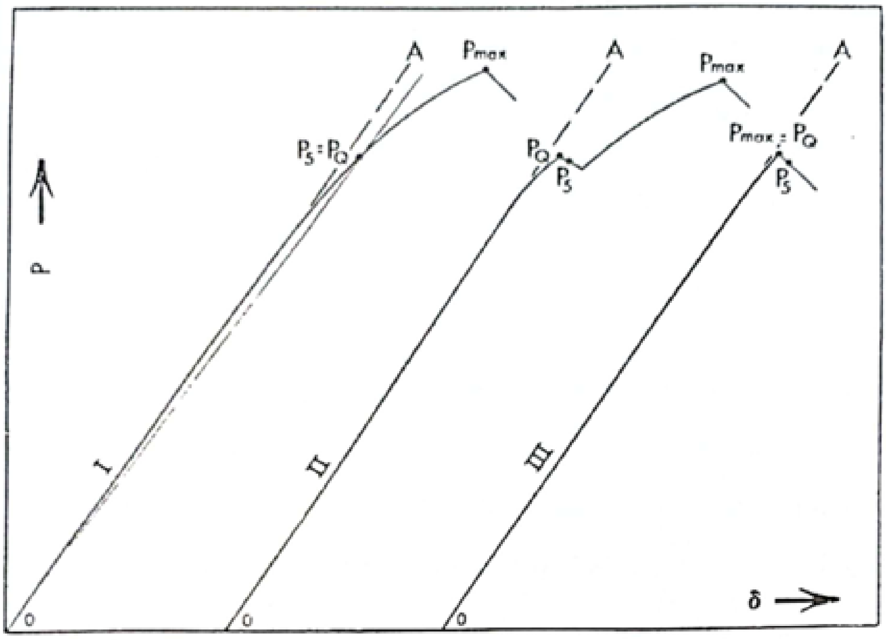
Load and displacement are observed when loading is performed to advance the crack on a pre-cracked test specimen. There are three types of load-displacement curves, as shown in Figure 4. Critical load P_Q is defined in several ways, depending on the type of curve.

- In Type I, a 5% secant curve must be drawn to obtain the P_5 charge. The critical load here is

  $P_Q = P_5$.
- In type II, there is unstable fissure progression. The critical load here is as shown in the figure.
- In Type III, the critical load is the same as the maximum load.

The crack length should be measured from the crack surface. First, the critical load and crack length are calculated, and the fracture toughness K_Q is calculated from the following relation.

Figure 4. *Typical Load-Displacement Graph*



$$K_Q = \frac{P_Q}{B\sqrt{W}} f(\frac{a}{b})$$

where $f(a/W)$ is a dimensional function of the notch ratio. It is given in the ASTM standard for the three-point bending test and S/W = 4 as follows. Here, S is the inter-support spacing, and W is the material width (Vipulanandan, & Dharmarajan, 1988).

$$f\left(\frac{a}{W}\right) = 1.93 - 3.07\left(\frac{a}{W}\right) + 14.53\left(\frac{a}{W}\right)^2 - 25.11\left(\frac{a}{W}\right)^3 + 25.80\left(\frac{a}{W}\right)^4$$

For other sample types, $f(a/W)$ values are also available in ASTM standards. Figure 5 shows a picture of a notched glass fiber-reinforced polymer composite specimen that has undergone a three-point bending test to determine fracture toughness.

Figure 5. *Notched Aggregate Filled Reinforced Polymer Composite Specimen (After Three-Point Bending Test)*

2.3.1. Initial Notch Depth Method

In linear elastic fracture mechanics, the amount of crack propagation cannot be clearly observed since the material is very brittle. For this reason, this method is used to determine the critical stress intensity factor of such a material and to examine the fracture behavior at different crack depths. According to the ASTM E-399 recommendation, the critical load for a valid K value is selected according to which of the charge-displacement curves given in Figure 4 is appropriate.

The graphs obtained in this study are generally like Type I. For this reason, P_5 should be taken as the critical load here, but since the K_{IC} value will be slightly higher if the maximum load is taken, the P_{max} value can be used (Brown, & Srawley, 1966). The stress intensity factor K_I concerning Mode I is expressed as follows.

$$K_I = \sigma \sqrt{a} f\left(\frac{a}{W}\right)$$

where σ is the net stress, a is the initial crack depth, $f(a/W)$ is the geometry factor and is given above. σ is expressed as follows for the three-point bending test.

$$\sigma = \frac{3PS}{2BW^2}$$

Here, P is the critical load, S is the distance between the bearings (for the three-point bending test), B is the material thickness, and W is the material width. The K_{IC} value is independent of the fracture thickness and the a/W value.

2.3.2. Compliyans Method

In materials with brittle fracture, the compliance technique can be used to evaluate the actual crack length and is an accurate method (13). Compliance (C) is the inverse of the slopes of a material's load-displacement or load-crack opening amount (CMOD) curves.

With this method, the complicity must be found first when finding the K_{IC} value. The compliance is found in the figure below using the load-CMOD graph (Duggan & et al., 1979).

$$C = \frac{d(CMOD)}{dP}$$

A crack size graph is created with the compliance values found from this formula. Using the slope of this graph, the KIC value is calculated from the following formula.

$$K_{IC} = \frac{PE}{2B(1-v^2)} \frac{dC}{d(a/W)}$$

2.3.3. J-integral Method

Fracture toughness is very difficult to measure due to the formation of large plastic regions at the crack tip. To overcome this problem, the J-integral method was developed (Aksoy,1984).

In an ideal brittle material with a 2a long crack inside, the amount of energy discharged if the crack grows in the face of strain;

$$G_{IC} = \frac{1}{C} \frac{d(-W + U_{el})}{d(2a)}$$

Here B is the material thickness, W is the elastic energy generated in the object due to the effect of the force P made by the force P forcing the object. The energy state within the J-integral curve developed by Rice (1968);

$$J = \int (Wdy - T)(\partial u / \partial x)dx$$

Here, T stands for the refraction vector. This equation holds true in both cases, whether linear elastic or elastic-plastic behavior.

If the material exhibits linear elastic behavior, the J-integral energy becomes equal to the amount of discharge.

In elastic-plastic behavior, the J-integral is expressed as follows;

$$G_{IC} = \frac{1}{B} \frac{dU}{d(2a)}$$

Here, U is the energy exchange. When the J-integral reaches a certain critical value (J_C and J_{IC}), unstable crack growth begins.

There are three methods for experimental determination of the J-integral.

- Different initial crack bottom sample technique (Bucci, 1971).
- Deep-fissured specimen technique (Begley, 1971).
- Cracked vs. non-cracked sample technique (Rice, 1973).

Mindess et al (1987) calculated the critical J-integral of the sample at maximum load using the third method, thinking that it works well in polymer composites.

When the crack begins to progress, there is potential change. Figure 6 shows the load-displacement graph of the notched and non-notched material. The following method is followed in the determination of the J-integral (Ziegeldorf,1983); The area (A_t) under the charge-displacement curve (P-δ) of the notched material is subtracted from the area (A_u) under the P-δ graph of the unnotched material charged with the same load. The value obtained from here is put into the formula below to find the critical J-integral (J_{IC}) value.

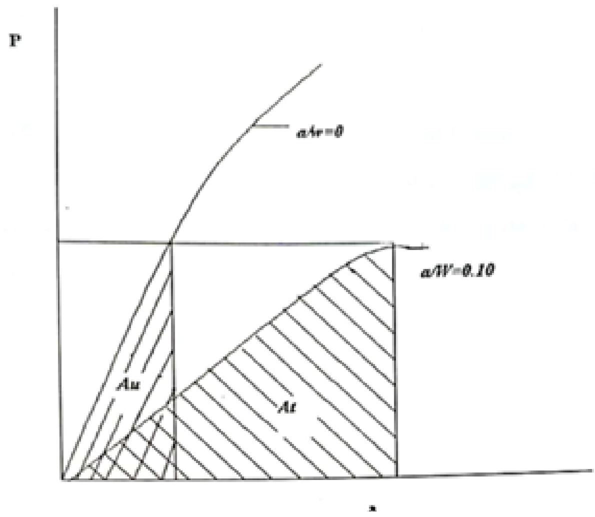
$$J_{IC} = \frac{2(A_t - A_u)}{d(b-a)}$$

Here, b is the width of the specimen.

The J_{IC} obtained from this is substituted below and the K_{IC} value is calculated (Vipulanandan, C., & Dharmarajan,1987).

$$K_{IC}^2 = \frac{EJ_{IC}}{1-v^2}$$

Figure 6. *Load-Displacement Graph of Notched and Non-notched Material*



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CHAPTER 16

Fundamental Differences Between Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM)

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Introduction

The word microscope is a combination of the two ancient Greek words μικρός (mikros), meaning "small", and σκοπεῖν (skopein), meaning "to see" (Liddell & Scott, 1996). Thus, the word microscope can be used to describe any instrument used to magnify small objects, regardless of whether it uses light or electrons. The first known microscope was invented in the late 16th century by Hans and Zacharias Janssen, two Dutch spectacle-makers. Their microscope was a simple compound microscope with two lenses, one objective lens and one ocular lens. It could magnify objects up to 9 times. Over the next century, microscopes were improved and refined by many different scientists. In 1665, Robert Hooke published his book Micrographia, which contained illustrations of many different objects as seen under a microscope. Hooke was the first person to observe and describe cells, and he is credited with coining the term "cell". In the 18th century, Antoni Philips van Leeuwenhoek built microscopes that could magnify objects up to 270 times. He was the first person to observe and describe bacteria, protozoa, and other microorganisms (Sanders et al. 2023).

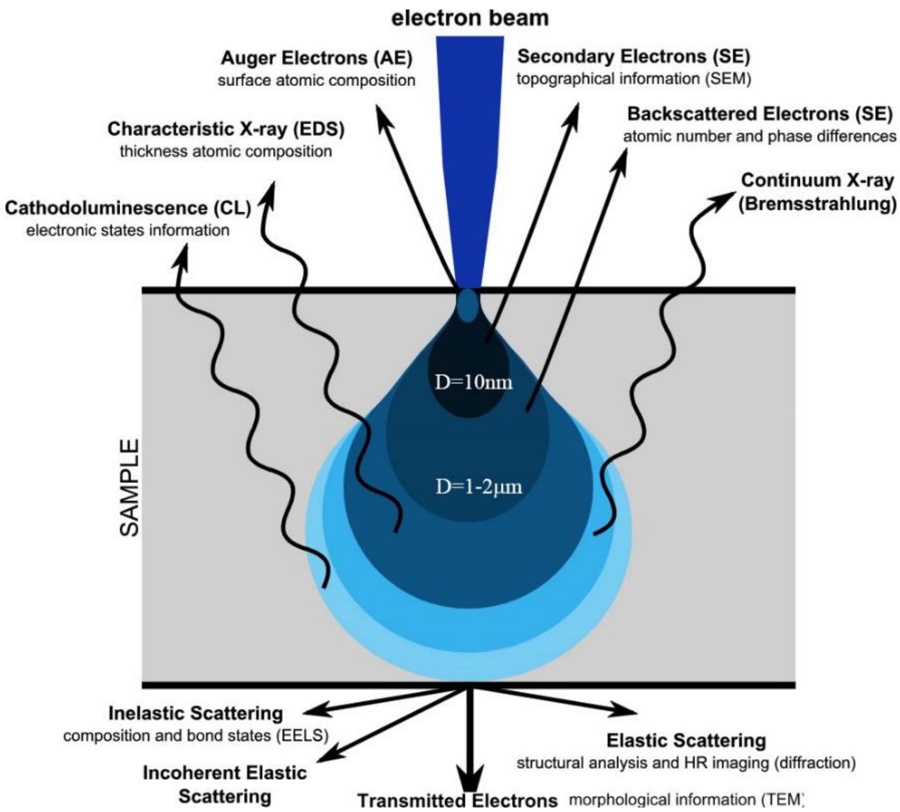
In the 19th century, many new types of microscopes were developed, including the phase contrast microscope, the interference microscope, and the electron microscope. The electron microscope was invented in the early 20th century by Ernst Ruska and Max Knoll (Knoll & Ruska, 1932). Electron microscopes (EM) use a beam of electrons instead of light to magnify objects. This allows them to achieve much higher magnifications than light microscopes, up to millions of times. Since the discovery of the electron, imaging techniques have reached an advanced level and have rapidly accelerated scientific progress. After the discovery of the wave-like nature of the electron, using electrons instead of light in microscopes significantly increased the resolving power, paving the way for higher magnifications. Thus, with the help of EM, the resolution increased from 1/1000 meters, visible, to 1 nanometer (nm). EM has revolutionized many fields of science, including biology, chemistry, and materials science. They allow us to see objects that are too small to be seen with the naked eye, such as individual atoms and molecules. Over the past hundred years, EM has become the most important window into the nanoworld for scientists and researchers. The development of image processing technology for advanced material production and characterization has driven the technology forward at an unprecedented rate. Evaluating a single atom now enables us to scale down the properties obtained at the macroscale to the nanoscale, enabling inventions that can be considered revolutionary for humanity. In general, electron microscopes can be divided into two categories: scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Both SEM and TEM microscopes provide the opportunity to examine samples with high precision by sending a focused electron beam through a vacuum chamber. However, SEM microscopes are designed to examine material surfaces, while TEM microscopes are designed to obtain information about the internal structure of samples. This study will discuss SEM and TEM, two imaging techniques that underpin advanced research, and reveal the fundamental differences between these two microscopes.

Scanning Electron Microscope (SEM)

SEM is an indispensable tool in scientific research and materials analysis due to its high-resolution imaging capabilities and ability to provide valuable information about the surface morphology and composition of various materials. Unlike optical microscopes, which cannot provide sufficient magnifications, SEM microscopes can be produced as compact desktop devices and are widely used around the world for advanced studies in research laboratories. Basically, a SEM image is created by a focused electron beam accelerated from the anode to the cathode and interacting with the surface of the material. The microscope column is placed under vacuum at approximately 10 to $1x10^{-4}$ Pa. The electron source may vary depending on the device's characteristics, such as a tungsten filament, single crystal lanthanum hexaboride (LaB_6), or field emission gun (FEG) (Paredes, 2014). SEMs typically have accelerating voltage from 200 V to 30 kV. The electron beam is collected by the condenser electromagnetic lens (condenser lens) focused by the objective lens and then scanned across the sample surface using an electromagnetic deflector or coils. Image formation in a SEM is based on the collection and analysis of signals resulting from the physical interactions of the electron beam with the surface of the sample under study (elastic and inelastic scattered electrons, among others) (Inkson, 2016; Fuller et al., 2013; Spence & Zuo, 1992). Another group of electrons that emerge from the interaction of the electron beam and the material on the surface of the sample under examination are backscattered electrons (these electrons are scattered at an angle of approximately 180 degrees from the incident electron beam). Backscattered electrons (BSE) are higher-energy electrons that come from deeper regions of the surface (down to about 300 nm). Because electrons at this energy of appearing photons have too high energy to be detected by a photomultiplier tube, they are usually detected with the help of quadrant photodetectors (i.e., solid-state detectors) (Mi et al., 2021). As you know, such detectors give output signals proportional to the intensity of the electric current induced by the electrons incident on them. As a brief reminder, the energy of an electron scattered from a high-atomic-number atom in the sample under examination is higher than that scattered from a low-atomic-number atom. As a result, backscattered electrons provide information about the composition of the sample under examination. Another interaction of the incoming electron beam with the examined sample surface (at a depth of approximately 1000 nm) is the emission of characteristic X-rays (whose energy is in the order of keV). When an electron hitting the sample knocks an electron out of the inner orbit of an atom in the sample, an electron in an upper orbit transitions to that level to balance the energy, and as it does, it emits an X-ray photon into the environment. This is called a characteristic X-ray. For example, a Si-Li detector (semiconductor detector) with a diameter of 10 mm^2 detects this X-ray. The resulting signal is sent to the amplifier, then to the multi-channel analyzer, and finally to the computer of the SEM system. The resulting characteristic X-ray, whose energy is specific to each atom, helps to qualitatively and quantitatively determine the elemental composition of the material examined in the SEM (Silva & Ferri, 2017; Egerton, 2011; Williams & Carter, 2009; Bell & Garratt-Reed, 2003). In addition, information about the content of the sample examined is obtained with the energy-dispersive X-ray spectrometer (EDS) integrated into the SEM. X-rays, in particular, are commonly used for examining materials, and they offer an image resolution of approximately 1 nm.

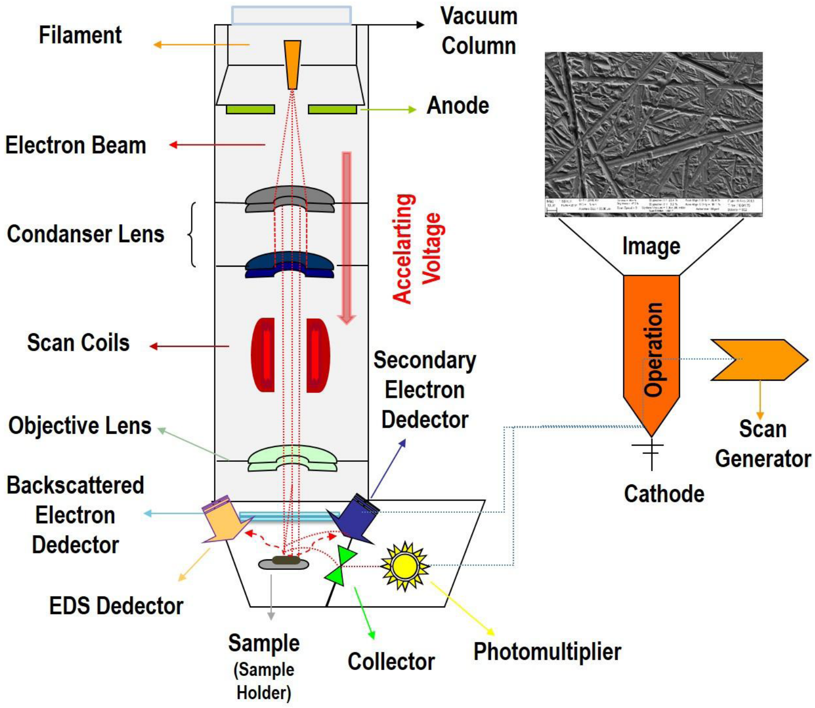
When electrons hit the sample, an interaction occurs between them. Figure 1 shows that the first electrons focused on the sample surface are called primary electrons, and secondary electrons are the electrons that result from the energy loss of primary electrons interacting with matter. Of these electron interactions, backscattered electrons (BSE), secondary electrons (SE), and X-rays undergo elastic scattering, whereas the others undergo inelastic scattering. Most secondary electrons are captured by detectors, called SE detectors or Everhart-Thornley (ET) detectors (Griffin, 2011).

Figure 1.
The Interaction Between Accelerated Electrons And Matter Is Illustrated Schematically (https://en.wikipedia.org/wiki/Electron_microscope)



Detectors that capture backscattered electrons are called BSED detectors, and detectors that capture backscattered X-rays are called EDS detectors (Goodhew et al., 2001; Inkson, 2016). Collecting backscattered electrons in the detector creates a contrast difference, which allows for the elemental discrimination of the atoms in the sample. Secondary electrons create the basic surface image, which helps to obtain a 3D image of the examined area. Additionally, collecting backscattered electrons in the detector creates a contrast difference, which allows for the elemental discrimination of the atoms in the sample. Figure 2 shows a schematic diagram of the colon structure of the SEM device. All the lenses mentioned here are magnetic and operate based on the Lorentz force principle [electromagnetic force equation is $\vec{F} = q(\vec{E} + \vec{\vartheta} \times \vec{B})\vec{F} = q(\vec{E} + \vec{\vartheta} \times \vec{B})$] (Jacson,1999). The charge q in this equation represents the electron. A dedicated EBSD detector collects the scattered BSEs over a large solid angle, which forms electron backscatter diffraction patterns made up of Kikuchi lines (Schwarzer et al., 2009).

Figure 2.
The Schematic Diagram Illustrates the Column Structure Of The SEM Device



Transmission Electron Microscope (TEM)

TEM is important because it allows us to see the internal structure of materials in unprecedented detail. This information is essential for understanding the properties of materials and for developing new materials with improved properties. TEM is also important for studying the fundamental physics and chemistry of materials, as well as the structure and function of biological cells and organelles (Spence, 2013; Williams & Carter, 2009; Reimer & Kohl, 2008; Smith, 2005; Goodhew et al., 2001). TEM provides information about the internal structure of the examined sample. The electron beam sent directly to the sample passes through it (at high vacuum). Operating voltage values for a TEM device typically range from 30 to 300 kV, but can be adjusted depending on the type of material being examined (Inkson, 2016; Kleebe et al. 2010). The filaments, electromagnetic lenses, condenser lenses, objective lenses, detectors, and surface scanning coils used in a SEM device are also used in a TEM device. When the high-speed electrons hit the sample, they interact with it. The microscope column is placed under vacuum at approximately $1x10^{-6}$ Pa levels to prevent electron scattering caused by atmospheric conditions. All of these lenses and coils are used to ensure that the electrons fall on the sample being examined. The number of accelerated electrons that leak into the sample depends on the number of electrons in the electron beam, the diameter of the electron beam, the energy of the electron (acceleration voltage), and the atomic number of the sample. Using a TEM device, magnifications from 20 x to 2,000,000 x can be obtained, as well as opposing lattice points. The objective lens is a particularly significant component in the TEM setup. This component is paramount, as its inherent aberrations directly impact the resolution capabilities of the microscope. Additionally, an electron diffraction pattern is generated in the back focal plane of the objective lens (Paredes, 2014). A removable aperture is strategically positioned in this plane to facilitate the selection of distinct electron beams, thereby enabling the formation of diverse images and the variation of image contrast. This precise control over electron beams and contrast is a fundamental feature of TEM analysis.

Electrons are emitted from an electron gun and accelerate them through an illumination system. The imaging system consists of magnetic (objective and projector lenses) lenses, and the resulting image is visualized and recorded. Within the TEM setup, the objective lens plays a crucial role in determining the resolution capabilities of the microscope. The back focal plane of the objective lens generates an electron diffraction pattern, and a removable aperture allows for the selection of distinct electron beams and the manipulation of image contrast. This level of control over electron beams and contrast is vital for TEM analysis. Overall, the objective lens in a TEM is crucial to determine the resolution and contrast of the microscope. By manipulating the size of the objective aperture, different electron beams can be selected, allowing for the visualization of various microstructural features in the specimen. The choice between classical diffraction contrast imaging and phase contrast lattice imaging depends on the desired level of resolution and contrast in the final image. Figure 3 shows a schematic diagram of the colon structure of the TEM device. When an accelerating voltage of 200 kV is applied to a TEM device, the wavelength of the electron will be approximately 0.025 Å (Angstroms). This value allows for interaction at the atomic scale, so the incoming wave will interact with the atoms of the material being examined. The electron wave interacts with the material through a wave function that undergoes Fourier transformations. Using this wave function operation, the system wave function can also be obtained as an inverse Fourier transform (Karlik, 2001). This results in a diffraction pattern on the fluorescent screen. The resulting diffraction pattern contains information about the crystal structure of the examined sample, and reciprocal lattice parameters can also be found using wave function transformations.

The basic design of the electron microscope has remained essentially unchanged since its inception in the 1930s. Despite this unwavering design, the resolution capability of TEMs has increased by over 1000-fold compared to its initial value. This remarkable progress began approximately 20 years ago with the development of electromagnets capable of correcting distortions in the electron beam. By the late 2000s, long-awaited aberration correctors had empowered advanced TEMs to achieve sub-angstrom resolution. Figure 4 shows the improvement in resolution dimensions of the TEM microscope over the years (Courtland, 2018).

Figure 3.

The Schematic Diagram Illustrates The Column Structure Of The TEM Device

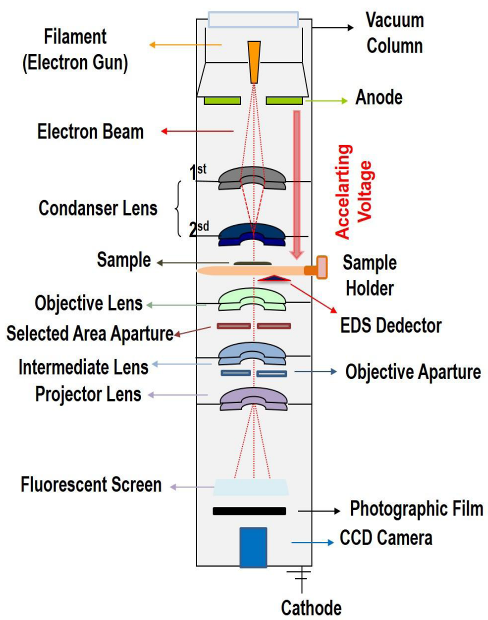
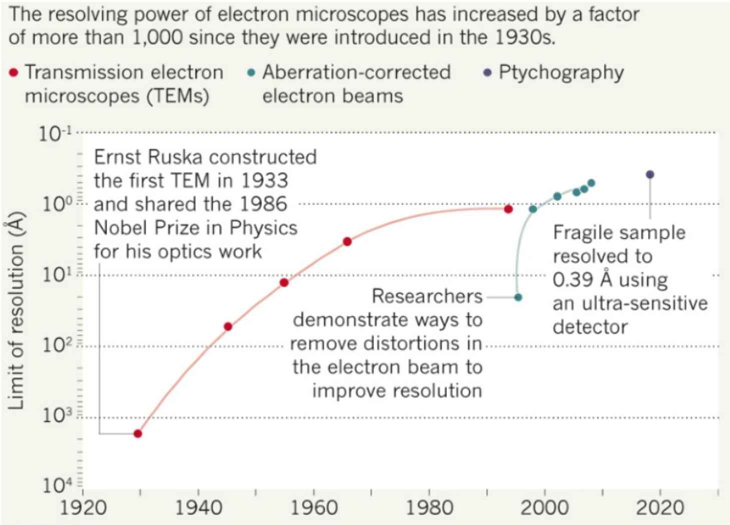


Figure 4.
Evolution Of TEM Microscope Resolution Dimensions (Courtland, 2018)



How to Choose the Right Microscopy Technique for Your Needs: SEM vs TEM

SEM and TEM are two widely used techniques in the field of electron microscopy, each specifically designed for different aspects of specimen analysis. These methodologies differ fundamentally in their imaging principles, applications, and the nature of the information they provide.

1. Imaging Principle:

SEM employs a focused beam of electrons that scans the surface of the specimen. The interaction between the beam and the sample generates signals, producing high-resolution three-dimensional surface images.

In contrast, TEM involves passing an electron beam through the specimen. This transmission allows for the visualization of internal structures in high resolution.

2. Depth of Field:

SEM provides a greater depth of field, enabling the examination of surface topography in three dimensions. This is particularly useful for studying surface features and morphological details.

TEM yields images with a shallow depth of field, limiting the three-dimensional details but facilitating the detailed examination of internal structures. This is ideal for studying the arrangement and organization of subcellular components, nanoparticles, and crystal lattices.

3. Sample Thickness:

SEM is suitable for studying thicker samples and material surfaces, as the electron beam can penetrate to a certain depth. This is advantageous for examining bulk materials and fracture surfaces.

TEM is ideal for ultra-thin sections and provides insights into the internal structures of specimens. Thin sections are required for optimal transmission of the electron beam, allowing for high-resolution imaging of internal features.

4. Resolution:

SEM offers slightly lower resolution compared to TEM but excels in producing detailed surface images. This is particularly useful for studying surface morphology and elemental distribution.

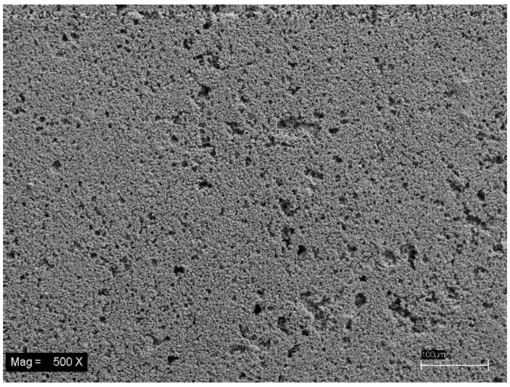
TEM provides exceptionally high resolution, allowing for the visualization of structures at the nanoscale. This is essential for studying the fine details of internal structures, such as the arrangement of molecules and the crystal structure of materials.

5. Applications:

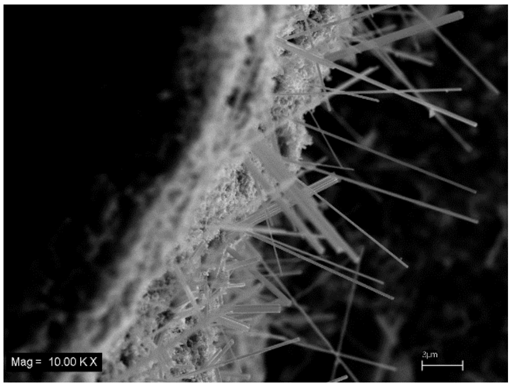
SEM is particularly advantageous for morphology studies, compositional analysis, and elemental mapping of surfaces. This is useful for characterizing the surface topography, chemical composition, and elemental distribution of materials.
TEM is indispensable for investigations requiring detailed information on internal structures, including organelles, nanoparticles, and crystal lattices. This is essential for studying the structure and function of cells, the properties of nanomaterials, and the arrangement of atoms in materials.
6. Operational Considerations:
SEM is well-suited for examining conductive or non-conductive specimens without the need for special sample preparation techniques. This makes SEM a versatile and widely applicable technique.
TEM often demands thin sample sections (or nanosize particles) and necessitates intricate specimen preparation, including the creation of ultra-thin slices for optimal transmission. This can be a time-consuming and challenging process, but it is essential for achieving high-resolution TEM images.
In conclusion, while SEM and TEM share a common basis in utilizing focused electron beams, their distinctive imaging principles and applications make them complementary tools in the realm of electron microscopy. Researchers strategically choose between SEM and TEM based on the specific aspects of the specimen they aim to investigate and the type of information required for their studies.

Sample Images Taken on a SEM Device to Illustrate Its Working Principle

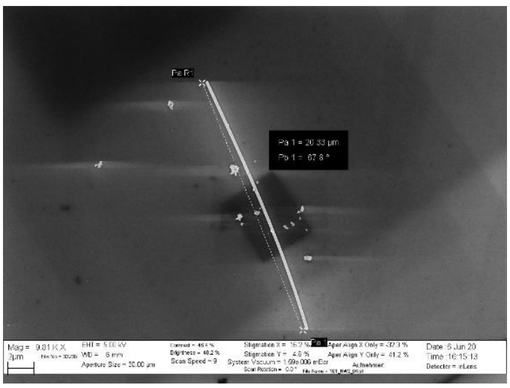
Figure 5.
(a, b, c, d, e, f, g, h, I, j ,k ,l) SEM Images Of Specially Prepared Materials



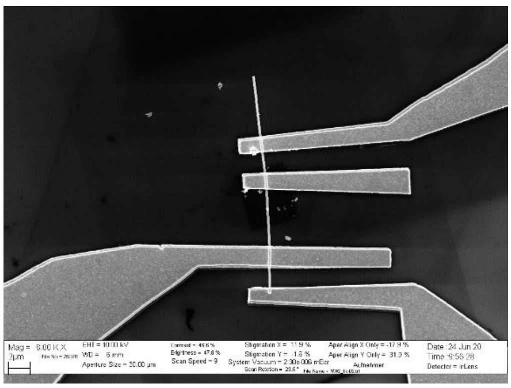
(a)



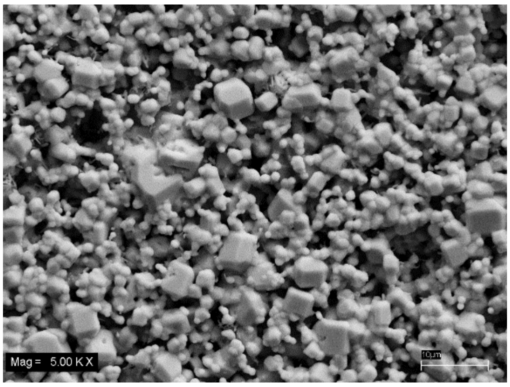
(b)



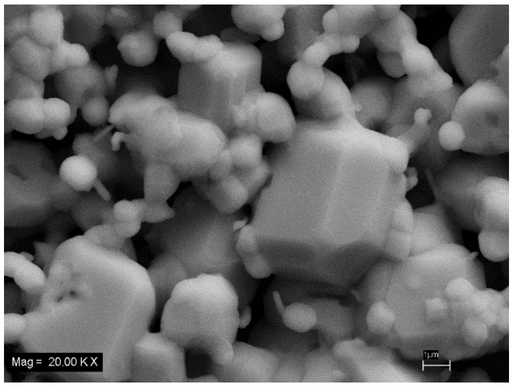
(c)



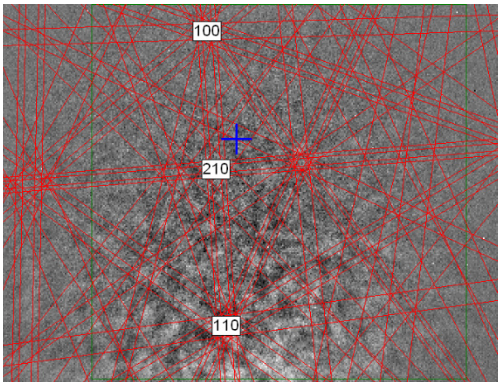
(d)


Mag = 5.00 K X

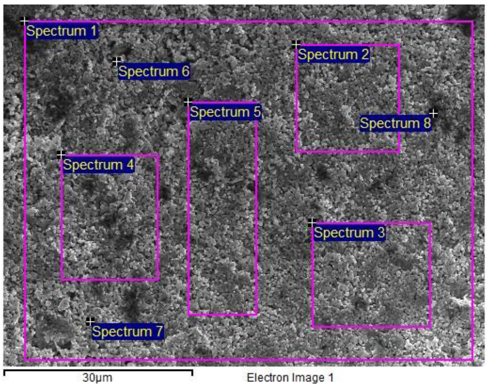
(e)


Mag = 20.00 K X

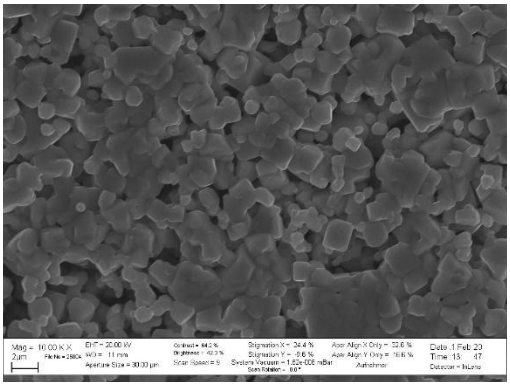
(f)


100
210
110

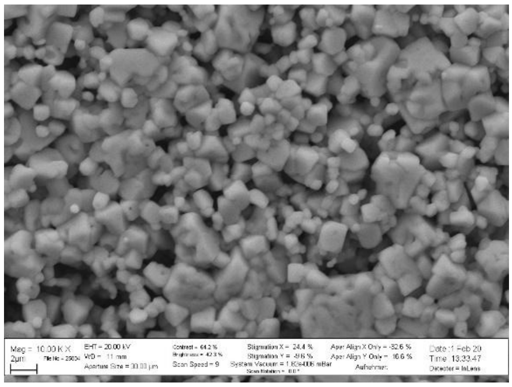
(g)


Spectrum 1
Spectrum 6
Spectrum 2
Spectrum 5
Spectrum 8
Spectrum 4
Spectrum 3
Spectrum 7
30μm
Electron Image 1

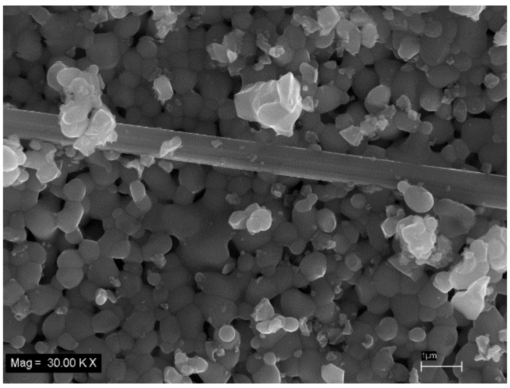
(h)



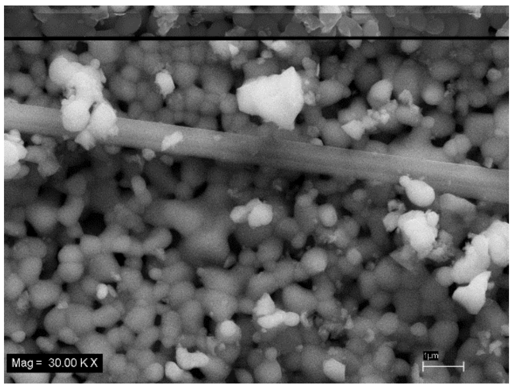
(i)



(j)


Mag = 30.00 K X

(k)


Mag = 30.00 K X

(l)

When examining the SEM images above, it becomes evident that each image possesses distinct visual properties. However, immediately identifying the exact material type and obtaining clear information about its composition is challenging.

Figure 5-a: The image captured at 500 x magnification reveals a spongy structure. This sample is actually an SEM image of a polycrystalline sample with a porous structure, obtained at the lowest magnification setting. In the image of this highly electrically conductive material, gaps can be observed in certain areas.

Figure 5-b: In the image captured at 10000 x magnification, two structurally distinct structures are clearly visible. The first consists of long, thin rod-like structures, while the second resembles a spherical shape. EDS analysis revealed that the rod-like structure is a mineral that formed independently of the underlying base material during its formation. Since understanding this situation at first glance is not possible, EDS detector signal analysis and backscattered electron (BSE) reflection analysis can be explained.

Figure 5-c: The SEM image captured at approximately 10kx magnification depicts a single-crystal material. This material is placed on a conductive substrate coated with a thin layer of conductive organic material. Upon examination in the SEM, the slightly darker rectangular-shaped region represents the area deformed by the electron beam. Utilizing the software integrated into the SEM, various paths are drawn by focusing the electron beam on these areas, and electronic circuits are designed.

Figure 5-d: The SEM image captured as a continuation of the previous image shows that Au (gold) was coated on the single crystal by evaporation, and contacts were placed on the paths drawn in the SEM. Now, a current or voltage difference can be applied to the obtained electronic circuit element. Simultaneously, with the help of the SEM device, a crucial step in scientific research or the production of new-generation nanoscale sensors can be achieved.

Figure 5-e: When focusing on the middle part of the image at 5kx magnification, as shown in figure 5-f, increasing the magnification of the same region to 20kx reveals that the grains within the structure vary in size, both large and small, and are tightly interconnected. The SEM image clearly illustrates that some grains within this tightly interlocking structure range between 1µm and 10 µm.

Figure 5-g: This image depicts a Kikuchi pattern obtained from the image at approximately 1kx magnification. In this image, the signals received by the electron backscatter diffraction (EBSD) detector from backscattered electrons are processed in the computer, and a diffraction pattern is formed by collecting the reflections of the crystal structure.

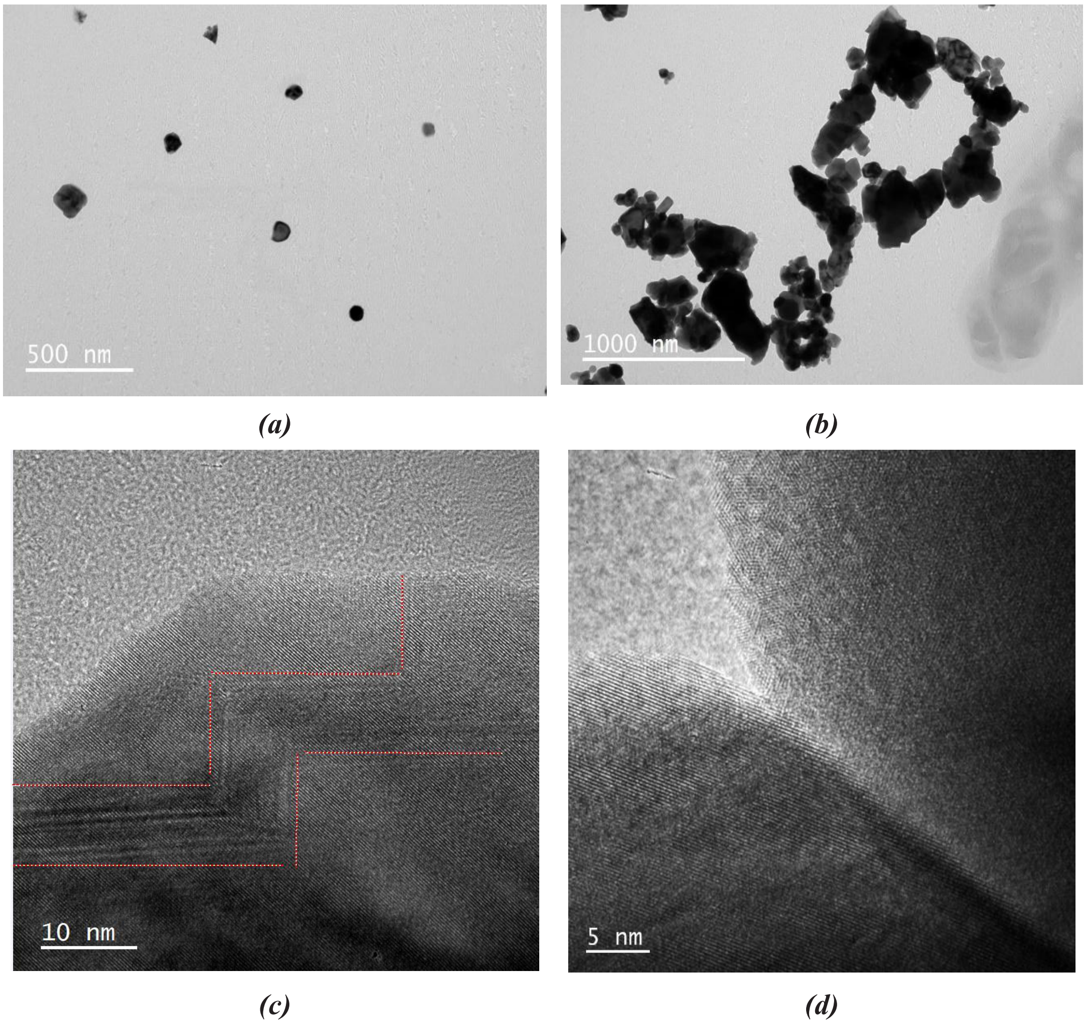
Figure 5-h: Information about the material's composition is obtained by collecting signals from point and area (spectrum) scans taken from the surface of the sample examined in the SEM image captured at the lowest magnification (Low Mag Mode) with the help of the EDS detector. As a result of analyzing the signals obtained by collecting characteristic X-rays, the elemental content of the sample is determined by obtaining the values of the elements in atomic percentage or weight ratios.

Figure 5-i shows that the surface image obtained by collecting secondary electrons (SE) scattered from the surface of a conductive polycrystalline material at 10kx magnification is given. To determine whether any impurities were present in the elemental analysis of this material, the image of the same area in the figure j shape at the same magnification was detected by commissioning the BSE detector. As can be seen from the SEM image, it is observed that the color tone is consistent throughout the image. The absence of different colored atoms anywhere indicates that the same atoms are present throughout the material, suggesting a compositionally stable material consisting of a single structure. If brightly colored regions or contrastingly different colors (grains) were observed in this image, it would indicate the formation of a separate phase, independent of the structure of these grains.

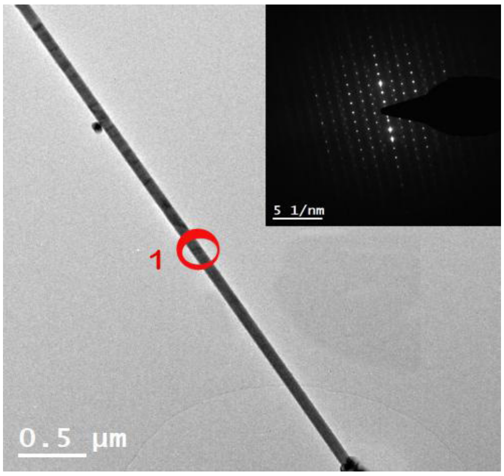
For instance, figures k and l demonstrate, with the help of BSE images, that three structures in different phases are formed on the surface of the material. The very light-colored particles represent one phase, the light-colored rods represent the second phase, and the interlocking structure at the bottom represents the third main phase. EDS analysis performed while examining this material may not provide clear elemental values for these three phases. This is because the incident electron beam passes through the top particle and descends to a certain depth; as a result, the detector will collect various reflections from the main phase at the bottom. The most suitable analysis method to determine the composition values of these three phases would be either X-ray diffraction pattern analysis or repeating the EDS analysis by separately collecting these three phases from the surface of the material with an extremely thin focused-ion beam (FIB) integrated another SEM device.

Sample Images Taken on a TEM Device to Illustrate Its Working Principle

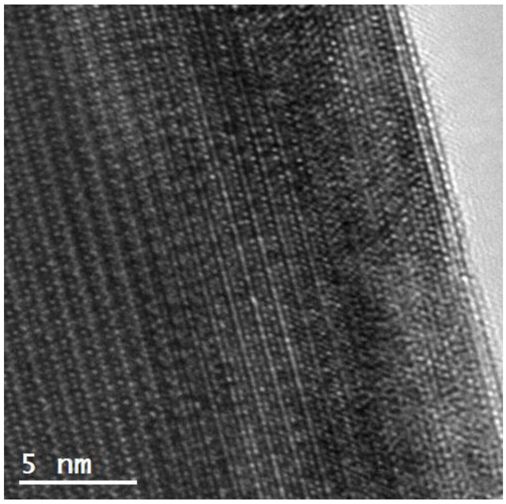
Figure 6.
TEM Images (a, b, c, d, e, f, g, h) Of Specially Prepared Materials



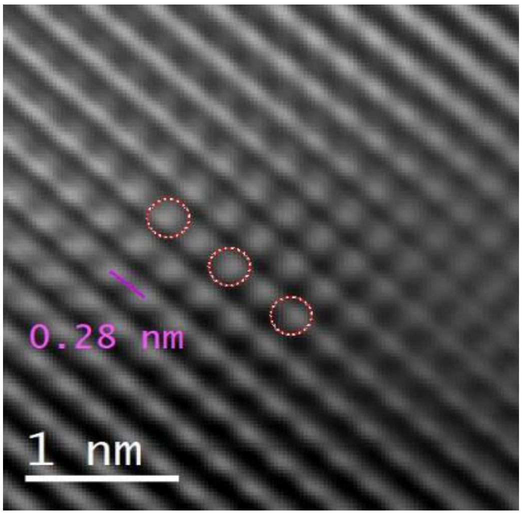
(a) *(b)*
(c) *(d)*



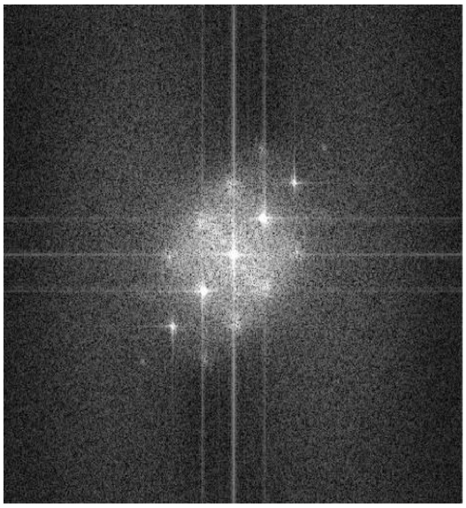
(e)



(f)



(g)



(h)

In the TEM images above, we see that there are different magnifications and different materials. In this section, we will briefly discuss what the images mean and their features. Figure 6-a: It can be seen that there are circular particles that stand out at first glance and that these particles are located on a 500 nm scale. This situation is also seen in the image in Figure 6-b. The 1000 nm scale image was taken with the help of a TEM device to obtain information about the initial general structure of the examined material. The difference between Figure 6-b and 6-a is that there is an obvious clustering. Since this clustering occurs mostly in magnetic materials, it reveals the necessity of distributing such nanosized particles evenly on the grid and performing the drying process properly while taking the TEM image. You can think of a grid as a very small sieve with certain properties. Alcohol etc., the sample to be examined is placed in liquid and dropped onto the TEM grid, and after drying, it is carefully placed in the vacuum system with the help of a sample holder. Since the electron beam passes directly through the sample, cooling is carried out with the help of liquefied nitrogen to prevent deformations in the sample holder part. As you may remember from the previous sections, electrons accelerated by applying very high voltage are used in TEM. (Figures 6-a and 6-b correspond to a magnification ratio in the corresponding SEM range of 50 kx-100 kx)
Figure 6-c: Here we see the atomic dislocations (a different atom entering the structure and disrupting the structure while the atoms are arranged in the crystal structure) obtained when examining a polycrystalline material. If you pay attention, the arrangements of the crystals at the atomic level are clearly understood with the 10nm scaling scale. When

we take a high-resolution (HR) image on the TEM device, the locations of the atoms and the arrangement in which these atoms are located can be determined.Figure 6-d: The grain boundaries of two nanosized particles are shown on the HR-TEM image. This image, which we cannot see at maximum magnification with macro-scale SEM analysis, provides clear information about the new material created. The HR-TEM image helps us make interpretations of how these grain boundaries affect the electron transition in the structure. Likewise, by determining the distance between atoms, information about the crystal structure of the produced material can be obtained.

Figure 6-e: A single nanorod stands out. After this nanorod was produced under special conditions, its diffraction pattern was taken on the TEM device (black image white dots) to obtain information about its crystal structure. Region 1 was selected for the diffraction pattern (with the help of the selected area aperture). Each of the points in the resulting image corresponds to a crystal plane in the diffraction pattern. That is, they are reciprocal lattice points. The real image of how the atoms are arranged for the same nanorod is shown by taking the HR-TEM image in Figure 6-f. What should be noted here is the formation of atomic planes and the symmetrical repetition of the dimensions of some planes. When the material is produced, the selected elements are bonded to each other to form a new composite, and atomic arrangements in the form of large atoms or small atoms can be distinguished due to the difference in the radius of the atoms. This allows us to perform nanoscale engineering at the scale we want. Figure 6-g: A high-resolution image taken on the TEM device is processed with the help of a computer program to create a Fast Fourier Transformation (FFT) image. Figure 6-h shows the masking process of this image. If you notice in this FFT image, the lengths of the interatomic planes and the distances between the atoms can be measured. Each atom depicted as a circle interacts with another atom, and the distance between atoms was determined to be approximately 0.28 nm. This information provides the most accurate understanding of the material's internal structure or crystal structure.

Conclusion

Microscopy is a powerful tool developed to perform analyses at a scale that the human eye cannot see (micro-nanometer level). Light microscopes are limited by the resolution of light, which is constrained by its wavelength. In pursuit of higher resolution, scientists turned to electrons, which could replace light rays and provide atomic-level resolution. By accelerating electrons under high vacuum, they achieved unprecedented resolution. The acceleration voltage of the electron beam varies depending on the applied voltage value, and the wavelength of the resulting electron beam also changes accordingly. While SEM can utilize acceleration voltages of 3-30 kV, TEM can employ voltages up to 200 kV. While SEM provides information about the surface of a material, TEM reveals its internal structure. Analyzes can be made with the help of many detectors in the SEM device. The most important condition for performing these analyses is that the material examined is conductive. The most important condition for conducting these analyses is that the material under examination is conductive. When examining an insulator material, the electron beam scanning the surface is discharged, making image acquisition extremely challenging. Therefore, if the materials to be examined exhibit insulating properties, they are rendered conductive by coating them with various conductive metals. In contrast, the TEM device allows for adjusting the particle size and acceleration voltage of the electron beam according to the type of material being examined, regardless of its conductivity or insulation.

The energy of the electron beam is crucial for both microscopes. When tungsten filament is chosen as the electron source, a stable electron beam is formed, but its lifespan is short (about 3 months). Additionally, it provides low brightness (contrast value) and low resolution (maximum magnification of 80kx). If a single crystalline LaB_6 filament is selected for the electron source, it offers a long working time (3-4 years working interval) along with a stable electron beam. It also delivers high contrast value and high resolution. In microscopes utilizing FEG filaments, a more stable electron beam is produced. This enhanced stability is particularly beneficial for examining specific proteins in TEM devices, enabling the analysis of single particles and the acquisition of 3D and tomographic images. As you are aware, higher-energy electrons are more likely to damage the sample. Therefore, when examining biological samples in both SEM and TEM devices, it is essential to employ FEG to achieve a more stable electron beam at lower energies.

Humankind's insatiable curiosity, fueling the path to innovation, drives the continuous creation of groundbreaking inventions and novel devices. This unwavering quest has led to the creation of ever-more useful tools, devices, and electronic structures, highlighting the importance of microscopy in various fields, from healthcare and food production to textile manufacturing and mineral processing. Technology, empowered by microscopy, has permeated every aspect of our lives, facilitating progress and enhancing our understanding of the world around us. Detector technologies, developed to elucidate the interactions between electrons and matter, play an integral role in our daily lives, from mobile devices to automotive engineering and logistics. This innate human desire to explore first turned its gaze towards the heavens, leading to the invention of the first telescope, which brought distant celestial objects within our reach. Similarly, the advent of microscopes marked the beginning of an extraordinary journey of exploration into the microcosm, igniting a profound curiosity about the wonders that lay hidden within the realm of the infinitely small. As we strive to unravel the intricacies of the world at the atomic level, to validate theoretical calculations against empirical observations, and to decipher the mechanisms that govern the natural world in its intricate detail, our reliance on microscopy will continue to grow. With each advancement in resolution, the universe unveils an ever-expanding tapestry of scientific knowledge, beckoning us to delve deeper into its boundless mysteries.

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CHAPTER 17

Various Uses Of Natural Language Processing

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Introduction

The goal of the artificial intelligence (AI) branch of natural language processing (NLP) is to create models and algorithms that let computers comprehend, interpret, and produce human language. The first computer scientists started investigating the idea of utilizing machines to comprehend and interpret natural language in the 1950s, which is when natural language processing (NLP) first emerged (Katar et al., 2023).
In recent years, machine learning, a type of artificial intelligence, has emerged as a crucial NLP method. Large datasets are used to train algorithms so they can recognize patterns and correlations in the data and provide outputs or predictions.
NLP made tremendous strides in the 2000s thanks to the advent of neural networks, especially deep learning models. These models can perform a broad range of tasks, such as text categorization, sentiment analysis, and machine translation, since they can handle enormous volumes of text data and understand intricate linguistic patterns. In general, the history of natural language processing (NLP) and machine learning is marked by gradual advancements and innovations in computational and algorithmic methods. These days, a wide range of sectors and applications, from chatbots and virtual assistants to healthcare and finance, use NLP and machine learning.

Suicide ranks as the 13th most common cause of death worldwide, contributing to 5–6% of all fatalities (Lozano et al., 2013). Suicidal conduct is complex, and no one explanation applies to all situations. Information retrieval, text categorization, document summarization, text clustering, and topic modelling are some of the text mining techniques now in use. Conversely, these methods focus on extracting valuable information from text texts using various techniques as sentiment analysis, topic modelling, keyword extraction, and categorization (Munot & Govilkar, 2014). Unlike natural language processing (NLP), these methods have a narrower emphasis and don't usually centre on understanding textual meaning. NLP, on the other hand, is able to understand the mood and emotion that underlie texts, phrases, and sentences in addition to the meaning and context of individual words. This gives it an advantage over traditional text mining techniques in that it can comprehend complex texts more efficiently and extract more pertinent insights (Khurana et al., 2023).

Cancer is one of the major public health issues. The World Health Organisation (WHO) reported in 2019 that the primary cause of mortality globally is this illness. By 2030, it is estimated that there would be about 13 million cancer-related deaths worldwide (Allemani et al., 2018). Researchers employ a variety of techniques to battle cancer since the illness is becoming more prevalent. One technique that has been utilised to diagnose cancer (Acs et al., 2020; Afolayan et al., 2022), as well as forecast its risk (Izci et al., 2020), likelihood of recurrence (Yang et al., 2020), and symptoms (Kourou et al., 2015; Yang et al., 2020), is artificial intelligence (AI). AI can offer a quick, easy, and safe method of treating many illnesses.

The Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) (Ely et al., 2001) and the Intensive Care Delirium Screening Checklist (ICDSC) (Inouye et al., 1990), two commonly used screening instruments for cognitive and behavioural dysfunction in critically ill patients, only provide a limited amount of guidance for the identification of behavioural phenotypes.

Despite the aforementioned challenges, a number of studies have found that there are delirium phenotypes and that they may be linked to varying rates of morbidity and death utilising CAMICU and ICDSC (Krewulak et al., 2018, 2020).

To detect terms and phrases like “combative” or “confused,” which may also be symptomatic of various phenotypes of NLP-diagnosed behaviour disturbance (NLP-Dx-BD), NLP may be used to examine the clinical notes of carers (Young, Holmes, Robbins, et al., 2023).

Many domains, such as big data (Jutla et al., 2013; Osinga et al., 2022), software effort estimation (Nassif et al., 2011), formal specification (Muhamad et al., 2019), augmented reality (Puspasari et al., 2020), e-commerce (Pujadi et al., 2020), health care (Vasilakis et al., 2008), safety-critical systems, and blockchain (Diaz et al., 2020), are among those where use cases are applicable. Its broader application serves as our source of inspiration. Use cases must be created using the free text criteria, which takes time, money, and human labour.

The majority of methods are semiautomated, require limited natural language, or both. Consequently, it is preferable to create use cases and recognise actors and their connections automatically, independent of formalism, constrained natural language, or extraneous information. Natural Language Processing (NLP) and Network Science are used to demonstrate a collection of algorithms that automatically construct use cases, actors, and their interactions from natural language needs.

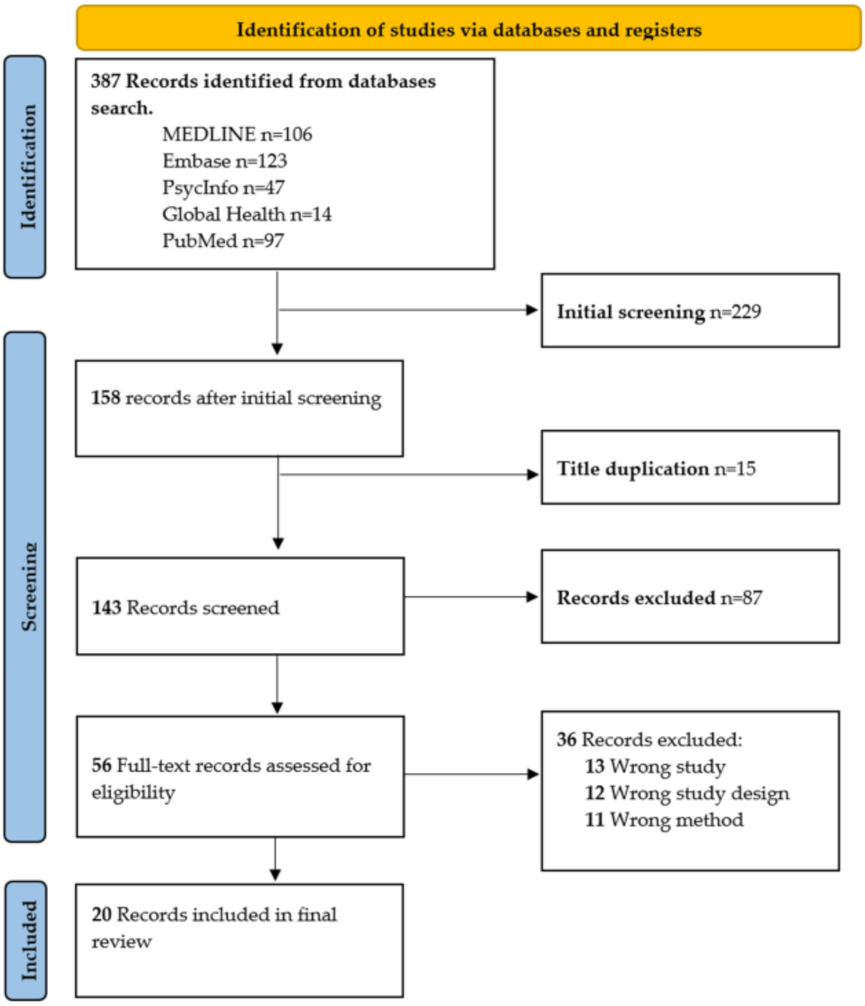
Materials and Methods

Preventing Suicide Ideation

387 hits were found overall in the preliminary search, which used the OVID platform to scan five different databases. Following the deduplication and preliminary filtering steps, 158 records in all were generated (Arowosegbe & Oyelade, 2023).

The 158 data were uploaded into Covidence, a systematic review management system, where the screening process was finished. After the entire text was reviewed, twenty (20) papers were evaluated and selected for publication. The (Preferred Reporting Items for Systematic Reviews and Meta-analyses) PRISMA (Page et al., 2021) flow diagram below is used to illustrate the search process, which is seen in Figure 1.

Figure 1.
PRISMA Diagram



The study tested the effectiveness of a suicide risk prediction model using Natural Language Processing (NLP/ML) in two South-eastern US emergency departments. The model (J. Pestian et al., 2016; J. P. Pestian et al., 2016), which was evaluated through interviews with 37 suicidal and 33 non-suicidal patients, demonstrated the feasibility of integrating technology into emergency department workflows. A prospective clinical trial also used NLP and semi-supervised machine learning techniques to differentiate between suicidal and non-suicidal individuals based on their conversations.

Neonatal fatalities have decreased globally by 51%, but not in low-income and middle-income countries (Hug et al., 2019; Mboya et al., 2020). Prompt delivery of high-quality healthcare services and early identification of pregnant women at risk for unfavourable outcomes during the prenatal period can enhance mother and neonatal survival (Kuhle et al., 2018). Machine learning and artificial intelligence models can be crucial in assessing risk factors for perinatal mortality and triaging pregnant women at high risk of severe postpartum depression, suicide ideation, and death. An NLP tool was developed to detect perinatal self-harm in electronic health records with sufficient recall and accuracy. (Zhong et al., 2018)created algorithms using NLP to detect pregnant women exhibiting suicidal behavior in electronic medical records. They used both structured and unstructured clinical notes to extract diagnostic information, demonstrating that using structured data and NLP to mine unstructured clinical notes significantly enhances the ability to identify suicidal behavior in pregnant women (Zhong et al., 2019). This approach led to an 11-fold increase in the number of pregnant women whose suicide behaviours were identified. Using NLP significantly increases the sensitivity of screening for suicidal behaviour in electronic health records, but the proportion of verified suicidal behaviour was lower among women who did not have diagnostic codes for suicidal behaviour.

Mobile health applications (MHA) have the potential to improve access to evidence-based care for those with suicidal thoughts by addressing limitations in traditional mental health therapy. The proliferation of smartphones has enabled MHA to provide timely, convenient, discrete, and cheap assistance during severe crises. An automated algorithm for analysing and estimating the risk of suicide based on social media data was developed by (Coppersmith et al., 2018), which allows for scalable screening for suicide risk before engaging with a healthcare system.

The Boamente program, developed by (Diniz et al., 2022), uses textual data from users' smartphones to detect suicidal ideation. It uses an Android virtual keyboard to passively gather user messages and transfer them to a web service using Natural Language Processing (NLP) and Deep Learning.

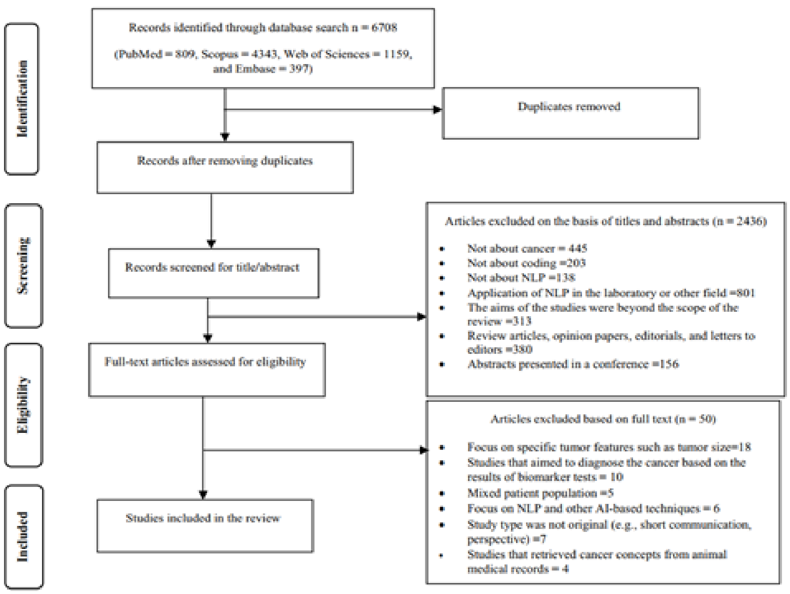
(Cook et al., 2016) used NLP and machine learning to predict suicide ideation and elevated mental symptoms among adults recently released from psychiatric inpatient or emergency hospital settings in Spain. They also created a domain Knowledge Aware Risk Assessment (KARA) model to enhance suicide identification in online counselling systems. The model can inform counsellors of potential risks in a user's information while engaging with the user.

Extracting Cancer Concepts

This work used natural language processing (NLP) to extract cancer concepts from papers in a systematic review manner. 6708 documents were initially retrieved in total. There were 2503 articles left for additional evaluation after duplicates were eliminated. The remaining papers' titles and abstracts were then filtered, and inclusion and exclusion criteria were used (Gholipour et al., 2023).

67 studies were deemed relevant after 2436 papers were eliminated due to the application of exclusion criteria. After going over the whole contents of these papers, 17 were chosen, and data was taken out of them (Figure 2).

Figure 2.
The PRISMA diagram of study selection



The study reveals that researchers have utilized various methods and algorithms to retrieve concepts from electronic texts in the field of cancer. The rule-based algorithm was the most commonly used, but deep learning has been more commonly used in healthcare (Casey et al., 2021; Shickel et al., 2017). Both rule-based and machine learning algorithms can demonstrate comparable performance when evaluated using the same dataset (Chapman et al., 2001; Solti et al., 2009). Despite the widespread adoption of deep learning methods, both rule-based and traditional algorithms remain popular due to their simplicity, ease of implementation, and interpretability (Rajula et al., 2020). Deep learning can be challenging to interpret due to unclear steps in the analytical output. Rule-based and traditional algorithms are more suitable for smaller datasets with few features, as they do not require massive amounts of data (Rajula et al., 2020; Vasudevan et al., 2021). However, ML techniques can lead to overfitting, which limits the generalizability of the model to different data sets and makes inaccurate predictions. Despite this, traditional algorithms may not always be a better approach than deep learning, as some situations may require more flexible and complex techniques (Vasudevan et al., 2021).

The application of Natural Language Processing (NLP) methods for cancer idea extraction is assessed in this systematic review, which is a novel area in the biological, clinical, and medical domains. According to the report, the most often used NLP terminology for extracting cancer concepts are SNOMED-CT and UMLS. In this discipline, rule-based procedures were the most employed approaches. The study advises academics to concentrate on combining the findings of these investigations and using ML and deep learning algorithms for information extraction. The outcomes of NLP software used to extract illness ideas from clinical documents such as radiology or laboratory reports should be compared in future studies. In order to assist developers in selecting the appropriate terminological system with appropriate coverage, future research should also focus on the content coverage of applicable terminological systems.

The study analysed the evaluation methods used in evaluating NLP algorithms, focusing on the recall (R), f1-score (F1), and precision (P) metrics. The research included articles using pre-developed software or software developed by researchers to interpret text and extract cancer concepts. Similar to previous studies, this review extracted concepts identified by included studies, the NLP methodology and tools used, and their application purpose and performance results.

The most commonly used terminologies in the articles were UMLS and SNOMEDCT, with UMLS being more frequently used. A 2020 study found that 42% of UMLS users were researchers, while 28% were programmers and software developers. The study divided articles concerning UMLS into six categories, with 78% falling under the NLP category.

The use of SNOMED-CT terminology in implementations has increased in recent years, while its use in theoretical discussions has recently been reduced. The results of this study indicated the practical use of this terminology to retrieve concepts from medical texts or documents.

A 2013 review paper categorized articles into five groups: unknown, theoretical, development and design, implementation, and evaluation. However, a 2013 study by Change et al. addressed 124 articles out of 622, highlighting the importance of this field and its attention in recent years. Most articles focused on the classification or coding of free-text clinical notes/narratives and radiology reports.

Despite the importance of content coverage as a metric in the evaluation of terminological systems, most articles in the review did not include this information in their results. This may be due to the focus on extracting concepts from narratives and identifying the best algorithms rather than evaluating applied terminological systems.

Behavioural Disturbance Phenotypes

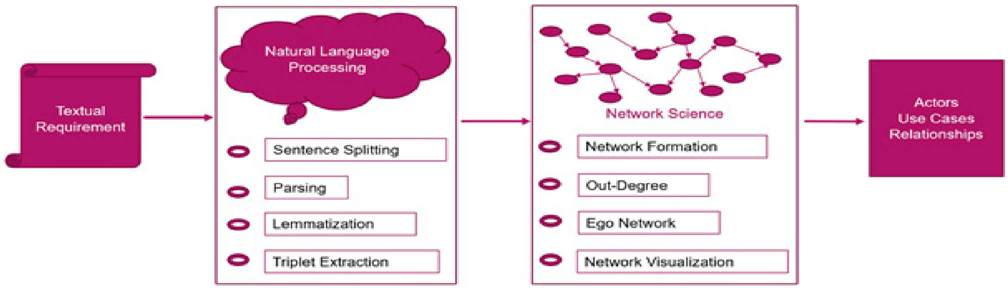
A retrospective, non-interventional research was conducted on a cohort of critically sick adult patients (≥18 years old) who were admitted to the three intensive care units (ICUs) of a hospital connected with a university in Melbourne, Australia, between May 1, 2019, and December 31, 2020 (Young, Holmes, Kishore, et al., 2023). The Austin Hospital Human Research Ethics Committee (LNR/19/Austin/38) accepted the project and disregarded the need for informed consent. Only the initial admission was included for patients who had multiple admissions. There were no further exclusion standards used. All patients received treatment during the trial period that was intended to lower the likelihood of developing delirium. This care included visits from family members, subdued lighting at night, less contact to promote sleep at night, and the use of visual and auditory aids wh0haracterization of NLP-Dx-BD (Young, Holmes, Robbins, et al., 2023) characteristics in patients are made possible using natural language processing in electronic carer notes. Furthermore, we discovered that the combination phenotype predominated and that critically sick research participants often switched between NLP-Dx-BD (Young, Holmes, Robbins, et al., 2023) behavioural phenotypes throughout the first 48 hours. Crucially, upon adjustment, antipsychotic medication was substantially more likely to be prescribed to patients who fit the agitated phenotype, either alone or in combination with other phenotypes. These findings have significant ramifications for trial design in this area as well as for our comprehension of the epidemiology of phenotypes of disordered behaviour in critical patients.

Extraction Of Use Case Diagram Elements

From natural language requirements, the method creates use cases, actors, and connections. We employ natural language processing (NLP) and network science methods. Sentence splitting, parsing, lemmatization, and triplet extraction are examples of NLP approaches. The method goes through many stages to identify the players from the textual requirement. Every stage enhances the performers' identification. The upper-level diagram of our suggested method is displayed in Figure 3.

Figure 3.

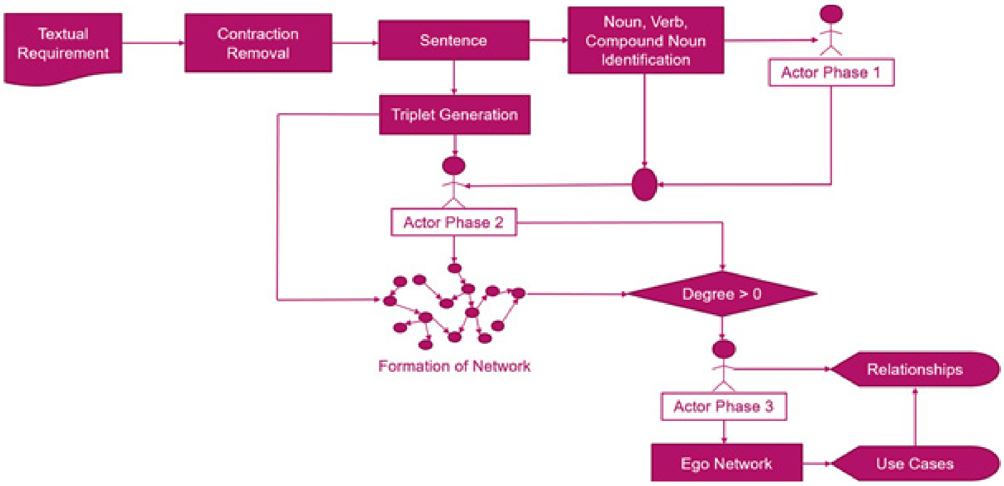
Use Case Diagram Approach



The method uses textual requirements as input to determine actors, use cases, and their connections. In Algorithm 1 (Imtiaz Malik et al., 2023), every textual requirement sentence is divided into a separate sentence. In Algorithm 2 (Imtiaz Malik et al., 2023), we have determined the noun, verb, and compound noun from every phrase. In the following algorithms, these nouns, verbs, and compound nouns make it easier to identify actors and use cases. Algorithm 3 (Imtiaz Malik et al., 2023) uses the noun list of each phrase as an input to determine who the actors in phase 1 are. The triplets in each sentence are recognised. Algorithm 4 (Imtiaz Malik et al., 2023) uses these triplets as input to determine who the actors in step 2 are. The graph's nodes and linkages may also be found using this approach. For the purpose of creating the network, identifying use cases, and identifying the players in the last stage, these actors and linkages are supplied in Algorithm 1. Figure 4 depicts the workflow of our suggested method.

Figure 4.

Process Flow Of Proposed Approach



For every case study, the outcomes are analysed in two categories. Using the manual actors and use cases found in (Al-Hroob et al., 2018), the outcomes are assessed in the first category.

The manual results in the second category are refined and found in (Al-Hroob et al., 2018). The majority of the manually selected use cases from the case studies include only one word, a verb, according to observations (Al-Hroob et al., 2018). The noun and verb need both be present in a use case, though. For an Assembly System Case Study (Imtiaz Malik et al., 2023), a few more actors and use cases have been found.

The findings show that either the triplets are missing, or the triplet does not have an actor in the topic, which accounts for the missing use instances. Our method distinguishes the actor from the subject in step 2 regardless of whether the phrase is written in the active or passive voice. For passive voice phrases, object-predicate-subject has been changed to subject-predicate-object.

An automated approach is proposed for generating actors, use cases, and their relationships without relying on formalism or restricted natural language. This approach uses Natural Language Processing (NLP) techniques and network science to generate both primary and external actors. The approach generates actors in three phases: natural language processing, network science, and use cases identification. The node values are set using NLP techniques. The approach comprises five algorithms: first, which discusses the extraction of actors and links through triplets of sentences; second, which identifies nouns, verbs, and compound nouns; third, which generates actors; fourth, which refines actors; and last, which generates the final actor, use cases, and relationships. The proposed approach outperforms the existing approach in five case studies, achieving 74.5% precision, 85% recall, 74% F-Measure, 25.45% False Discovery Rate, and 14.97% Miss Rate for the first category and 70% precision, 81% recall, 71.5% F-measure, 29.73% False Discovery Rate, and 19% Miss Rate for the second category (Imtiaz Malik et al., 2023).

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