Pamantasan ng Lungsod ng Maynila

Augmented Reality-Assisted Bone Imaging: AI-Driven Recommendations in OrthoMedics Mobile App

A Thesis Presented to
The Undergraduate Program
College of Information Systems and Technology Management
Pamantasan ng Lungsod ng Maynila

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Information Technology

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May 2024

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The thesis hereto titled

Augmented Reality-Assisted Bone Imaging: AI-Driven Recommendations in OrthoMedics Mobile App

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ABSTRACT

The maximum length of the abstract is one to two pages. Use 12-point Times New Roman and 1.5-line space.

An abstract should contain the summary of the study including significant findings, information, data and analysis. Also, problems and objectives are solved and addressed.

ACKNOWLEDGEMENTS

The acknowledgements should also be limited to one page but can exceed if necessary.

The CET-Graduate Program would like to thank Ms. Diana Jane Saya for helping us format this thesis manuscript for the undergraduate and graduate program of the College of Engineering and Technology.

The pattern of the manuscript was from the Chemical Engineering Department of De La Salle University.

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Chapter One

INTRODUCTION

1.1 Background of the Study

In the realm of orthopedic companies, Orthomedics stands out with its specialization in designing, manufacturing, distributing, and selling orthopedic medical devices, implants, and related products. Boasting a workforce of 10 or more employees, Orthomedics reflects a level of establishment and likely operates as a medium to large-sized enterprise, capable of managing various aspects of its operations effectively. With its inception around 1990, Orthomedics carries a substantial history, indicative of its experience in navigating the evolution of orthopedic technology and practices over the years.

A significant contemporary trend in orthopedic surgery involves the integration of augmented reality (AR) technology. Augmented reality, a cutting-edge innovation, overlays digital elements such as images, videos, and 3D models onto the physical environment, enriching users' perception of reality. Through accessible mediums like mobile applications and wearable devices, patients gain insights into their orthopedic conditions, explore treatment alternatives, and actively engage in decision-making processes alongside their healthcare providers. This integration fosters transparency, elevates patient satisfaction levels, and contributes to enhanced treatment adherence and ultimately, improved outcomes.

Orthomedics, positioned at the intersection of orthopedic innovation and patient-centric care, stands to harness the potential of augmented reality technology to augment its offerings, empowering both patients and healthcare professionals alike. This forward-looking approach underscores Orthomedics' commitment to advancing orthopedic practices while prioritizing patient well-being and engagement in the treatment journey. Despite its experience, OrthoMedics lack of integration with augmented reality, advanced implant tool recommendation technology, modern AI, and online appointment systems limit treatment planning solutions. Manual explanations and traditional methods might make it harder for patients to understand their conditions and treatment plans.

There are several challenges in the way of OrthoMedics' adoption of augmented reality (AR) technology, which might hinders the development of treatment planning strategies and thorough bone imaging. Doctors' capacity to view and work with 2D models of patient anatomy has limits in the absence of augmented reality capabilities, which might compromise patient outcomes and treatment correctness. If AI-driven technology will not exist, patients will also cannot see their physical characteristics or treatment plans in two dimensions, which makes it difficult for them to understand and participate in their orthopedic care. Furthermore, OrthoMedics is unable to adequately educate patients and offer novel therapy approaches due to a lack of AI-driven technology assistance. Moreover, the use of manual file systems and a lack of technological integration result in complications, confusion, and the possible loss of patient medical records, which makes it difficult to manage and retrieve critical data effectively. These difficulties highlight the urgent necessity to close the technology gap in order to keep OrthoMedics at the forefront of the provision of contemporary orthopedic care.

The purpose of this study is to improve treatment outcomes and the orthopedic patient experience, this study investigates how augmented reality (AR) technology can be integrated into the Orthomedics mobile application platform. Orthomedics aims to give patients easy access to bone imaging and associated medical information through the use of augmented reality (AR) capabilities, thereby promoting a better understanding of their orthopedic conditions. Furthermore, the app's AI-driven recommendations are intended to help patients and healthcare professionals make educated decisions about implant treatments and post-operative care plans. Through the app, patients can easily arrange visits with their orthopedic doctors after evaluating the findings of their bone imaging and AI-driven suggestions. This will lessen the effort to make separate phone calls or visit websites, making it a more practical and easy way to arrange follow-up treatment and consultation within the mobile app.

1.2 Statement of the Problem

1. How does the lack of augmented reality (AR) technology integration at OrthoMedics affect treatment planning solutions, bone visualization, doctors' ability to analyze patient's bones, diagnostic and treatment precision, patient health outcomes (recovery and health status), patient engagement including comprehension of treatment plans, and overall operational efficiency in orthopedic care?

2. How does OrthoMedics intend to address the challenges stemming from the lack of technology support for implant tool recommendations and the absence of modern AI technology?

3. What challenges does OrthoMedic face due to its reliance on manual filing systems and the absence of technology integration, particularly concerning the efficient management of medical records and communication processes?

1.3 Objective of the Study

1.3.1 General Objective

This study aims to create a bone visualization native mobile app using AR technology and AI recommendations for implant tools, aiming to improve treatment planning, patient education for OrthoMedics, and appointment scheduling to make the most use of their time and resources.

1.3.2 Specific Objectives

The study aims to design and develop an Augmented Reality-Assisted Bone Imaging: AI-Driven Recommendations in OrthoMedics Mobile App that specifically aims:

1.3.2.1 To develop a bone visualization native mobile app using augmented reality (AR) for OrthoMedics to enhance its treatment planning solutions. This will provide orthopedic doctors with a real-time, interactive view of bone structures. It also benefits patient education, as they can visualize their anatomy and treatment plans in 2D.

1.3.2.2 To implement AI-driven recommendations for implant tools in orthopedics within the OrthoMedics framework. The study aims to enhance OrthoMedics' capacity to provide innovative treatment planning solutions and effectively educate patients with comprehensive knowledge about their orthopedic conditions and treatment options.

1.3.2.3 To integrate an online appointment system into the mobile app, enabling patients to schedule consultations efficiently and conveniently. By automating the scheduling process, this system will maximize the use of time and resources for both patients and professionals.

1.3.2.4 To evaluate the newly mobile application in terms of functional suitability, usability, reliability, security and accuracy.

1.4 Scope and Limitations

1.4.1 Scope

The scope of the study includes developing and implementing a native mobile application using Augmented Reality (AR) to bone visualization that uses Artificial Intelligence (AI) to recommend orthopedic implant tools. By offering a seamless digital experience with personalized treatment insights, this program seeks to improve patient engagement. The development of AR can consider factors such as bone density, size, and condition. AI includes factors such as historical patient outcomes to recommend the most suitable implant tools for each individual case. Moreover, to develop an effective online appointment system for better communication between orthomedics, orthopedic doctors, and patients. Furthermore, the study uses one of the most popular algorithms in image processing which is the Convolutional Neural Networks (CNNs); it is the most widely used and effective algorithm for image recognition. Specifically, integrating the Fast R-CNN algorithm into OrthoMedics' workflow to be able to enhance the precision of treatment planning, accuracy of diagnosis, and effectiveness of clinical procedures.

The appointment system aims to provide the following features:

- Users Registration
  - This feature will allow patients and doctors to sign up/ log in for an appointment system. Patients will schedule an appointment for consultation with the orthopedic doctors, while doctors can see their appointment schedules.
- Viewing the history of appointments
  - This feature enables users to see a list of their past appointments, while doctors can see the information and history of their patients.

- Lists of hospitals
    - This feature provides users with information about available hospitals which displays a list of hospitals along with relevant details such as name of orthopedic clinic/hospital, location, ratings, etc.
- Contacts of orthopedic doctors
    - This feature provides a search functionality to find orthopedic doctors along with their contact information.

1.4.2 Limitations

- The implementation of native mobile applications is limited to the latest version of android users only.

- Augmented Reality (AR) for bone visualization and Artificial Intelligence (AI) recommendations for orthopedic implants are dependent on the quality and quantity of input data, including medical images and historical outcomes.

- Limitations in data availability, such as incomplete or inaccurate patient records, may affect the accuracy and reliability.

- In AR, the environmental factors such as lighting conditions, surface textures, or obstructions can affect the accuracy and stability of AR overlays, leading to suboptimal user experiences or errors in visualizations.

- Some users, particularly older patients or those with limited technological proficiency, may find AR interfaces confusing or difficult to navigate.

- When it comes to data privacy of the mobile application, confidentiality should be restricted only to authorized personnel, which involves collecting and keeping only the necessary patient data for the intended purpose.

- The online appointment system heavily relies on technological infrastructure and user adoption which means any limitations or disruptions in internet connectivity and device compatibility with AR technology may impact the usability and accessibility of the application.

Chapter Two

SYSTEM ANALYSIS

2.1 Conceptual Framework

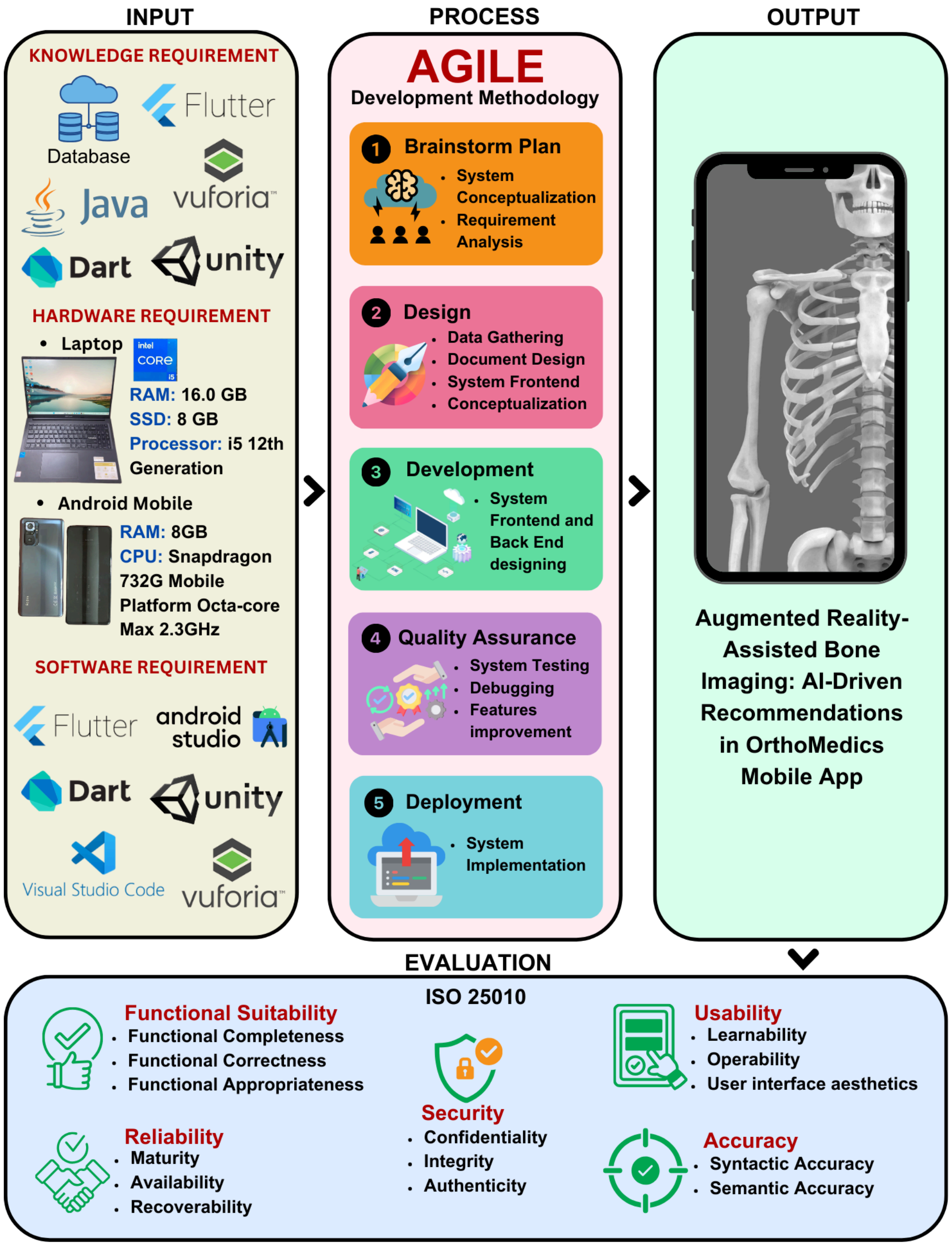

Figure 2.1.1 Conceptual Framework

The input requirements for this project outline the essential knowledge, hardware, and software needed for system development. In terms of knowledge, proficiency in database management, and programming languages such as android studio, flutter, dart, java, unity, vuforia engine and android studio. These will be the foundation for building the mobile application itself. Flutter provides the framework for creating the app's user interface, handling user interactions, and managing the overall application logic. Dart, as Flutter's primary programming language, will be used to write the code that brings the app to life. Unity is a cross-platform game engine for creating 2D models of bones and other anatomical features that may be shown in augmented reality (AR) to assist medical students and practitioners. Vuforia Engine, a popular AR software development kit (SDK), is used to create augmented reality applications. When used with Unity, Vuforia Engine can enhance AR projects by adding AR Foundation features such as vertical plane detection or environment probes, as well as the use of Model Targets and Area Targets. Vuforia engine tools and libraries will allow the app to recognize real-world objects, likely focusing on X-Rays captured through the phone's camera. Once an X-Ray is captured, Vuforia engine can facilitate overlaying a digital bone structure model on the image to aid in precise analysis. Android Studio has suite tools enabled to write, edit, test, and debug system application code. This includes integrated emulators or debuggers, syntax highlighting, and code completion. For instance, Java expertise could be beneficial for specific interactions between the app and the Android operating system, particularly if there are interactions with native device features.

Hardware specifications include a laptop with a minimum of 16GB RAM, 8GB SSD, and an i5 12th Generation processor for development purposes. Additionally, for mobile deployment, an Android device with 8GB RAM and a Snapdragon 732G Mobile Platform Octa-core processor with a maximum speed of 2.3GHz is necessary. On the software front, this includes Flutter, Dart, along with a code editor like Visual Studio Code, and a version control system like GitHub. Having these tools and knowledge will equip to build this augmented reality mobile application.

The process adheres to the Agile Development Methodology, which prioritizes adaptability and collaboration throughout the software development journey. Agile involves continual refinement and iteration rather than distinct phases. In Agile, the requirements phase initiates by defining initial goals and vision but evolves through frequent feedback loops. The Design Phase is more dynamic, with design and development occurring concurrently in short cycles known as sprints. Both frontend and backend components are iteratively developed, with each sprint delivering functional software for testing and validation. Verification is an ongoing process throughout development, with testing integrated into every sprint to ensure compliance with requirements and proper functionality. The Maintenance Phase begins early, with regular updates and enhancements made based on user and stakeholder input, ensuring the software's continued relevance and effectiveness.

Augmented Reality-Assisted Bone Imaging: AI-Driven Recommendations in OrthoMedics Mobile App: This is the final product or output of the development process, which is an application that provides augmented reality assistance for bone imaging and AI-driven recommendations. Users can use this app to assist with medical imaging tasks in orthopedics.

The evaluation component utilizes ISO 25010 standards to assess the quality attributes of the OrthoMedics Mobile App. ISO 25010 covers a wide array of dimensions including functionality, reliability, usability, performance, security, maintainability, and portability. Through this evaluation, the app's alignment with industry benchmarks and user demands is scrutinized meticulously, ensuring its effectiveness, reliability, and utility in the medical domain.

This assessment considers Functional Suitability, Usability, Reliability, Security and Accuracy. Functional Suitability represents the degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions. Usability evaluates the app's ease of use and intuitiveness for end-users, while Reliability has the capacity of a system or component to carry out its intended function for a prolonged amount of time under given conditions without experiencing failure. Security assesses its ability to protect sensitive data and ensure privacy. Accuracy ensures the system produces outputs that are free from errors and accurately reflect the intended measurement or representation. By comprehensively evaluating these dimensions alongside the ISO 25010 guidelines, a thorough assessment of the OrthoMedics Mobile App's quality and suitability in the medical sector is achieved.

2.2 Related Literatures

Local Literature

According to Concepcion et al. (2019) the AI trend of technological singularity is continuously accelerating and is being employed to the different facets of humanity from education, medicine, business, engineering, arts and the like.

Artificial intelligence (AI) technology adoption in the Philippines can be seen widely in many sectors such as industry, agriculture, and services. AI may have a negative effect, but AI can generate more employment in all economic sectors through proper talent training. To compensate for the detrimental effects of the implementation of AI, everyone must have enough understanding of the technology's positive benefits (Rosales et al., 2020).

The system is complex, representing the patient appointment time in the healthcare center and controlling the patient waiting time based on the type and duration of the patient appointment. These kinds of platforms aim to manage the doctor's time, reduce the patient's waiting time, reduce the doctor's idle time, reduce the nurse's idle time, and improve the quality of service in the healthcare industry (Reguyal et al., 2023).

This new epidemic of osteoporosis and hip fractures gave rise to the practice of orthogeriatric, which the Australian and New Zealand Society for Geriatric Medicine defined as “medical care for older patients with orthopedic disorders that is provided collaboratively by orthopedic services and, aged care or rehabilitation services” (Reyes et al., 2021).

Injuries about the foot and ankle account for a significant number of injuries that may lead to substantial functional impairment and disability. A standardized method of outcome assessment is necessary to evaluate and monitor patients’ progress (Robles & Gamboa, 2024).

This retrospective study assessed the impact of surgical timing on in-hospital complications in Filipino patients with fragility hip fractures. Analyzing data from 96 patients, the study found that early intervention within 72 hours significantly reduced complications such as pressure ulcers, pneumonia, urinary tract infections, and hospital stay compared to delayed intervention. On the other hand, delayed intervention showed higher rates of deep vein thrombosis and in-hospital mortality. The study emphasizes the importance of early surgical management for improving outcomes and lowering complication rates in fragility hip fractures among Filipino patients (Tud & Claudio, 2024).

This study focuses on developing an online scheduling system for a hospital's outpatient department (OPD). The objective is to streamline appointment scheduling, benefiting both the hospital and patients. By implementing this system, patients can check doctor availability and schedule appointments online, reducing waiting times and ensuring they only visit the hospital at their scheduled time. The system also enables doctors to view their daily appointment schedules, enhancing overall efficiency in OPD operations (De Guzman et al., 2021).

This study aimed to develop a deep learning model using a convolutional neural network (CNN) to detect bone metastasis from bone scintigram data. The research highlighted the importance of early diagnosis for improving patient treatment and quality of life. The study involved creating a CNN architecture through an exploratory process and experiments to optimize parameters. Results showed that the base CNN model achieved good metric performance, outperforming pre-trained architectures like VGG16, InceptionV3, and ResNet50. While DenseNet121 showed higher accuracy and precision, the base CNN model had better recall, making it a promising tool for clinical integration and potential enhancements in cancer metastasis detection and monitoring, ultimately improving patient care and survival rates (Magboo & Abu, 2022).

In this study by Ancheta et al. (2021), telemedicine is presented as a solution to improve healthcare accessibility and efficiency, especially for patients facing physical and financial challenges. The "NUCare" framework, a web and mobile application, allows virtual consultations between doctors and patients, offering features like e-prescriptions, laboratory referrals, and a chatbot for FAQs. The primary aim is to reduce costs and travel time while providing convenient access to medical services through text, audio, or video consultations. This research underscores the potential advantages of telemedicine in enhancing patient care and medical assistance.

The research on computer-aided diagnosis of Knee Osteoarthritis (KOA) severity using MRI and the YOLOv3 algorithm is pivotal in advancing medical diagnostics for osteoarthritis. By integrating deep learning techniques, the study aimed to overcome the limitations of traditional radiographic imaging in assessing OA severity. The YOLOv3-based detection model showcased exceptional performance metrics, including an mAP value of 96.58%, training precision of 98.73%, and evaluation accuracy of 99.32%. These results underscore the potential of AI-driven approaches in enhancing diagnostic accuracy and efficiency, which could significantly impact the quality of care and treatment outcomes for patients with osteoarthritis and similar musculoskeletal conditions (Antonio et al., 2022).

Skeletal dysplasias comprise a heterogenous group of genetic disorders that have generalized abnormalities in cartilage and bone. Although individually rare, collectively it is common with an estimate of 1 in 2000 to 3000. Individuals with skeletal dysplasias are known to be at risk for a myriad of medical complications associated with their conditions; hence a multidisciplinary approach to care is essential (Alcausin et al., 2020).

Limb deformity in terms of length discrepancy, angular and rotational deformities are amenable to correction using the Ilizarov method. The corrections can be achieved using the Ortho SUV Frame (OSF), a computer assisted six axes external fixator. Previous studies have reported easier and more accurate deformity correction. In this study, we report on our initial experience and treatment outcomes in using this system (Javiel et al., 2021).

Skills training using artificial bones became more critical in response to the Orthopedic surgical training restriction caused by the COVID-19 pandemic. To cut the expenses of buying commercial artificial bones, the Ilizarov Limb Reconstruction Service has decided to fabricate its artificial bones for surgical skills training (Bagares et al., 2022).

The latissimus dorsi muscle has been the “workhorse” of reconstructive surgery because of its predictable neurovascular anatomy and ability to perform both wound coverage and restoration of function (Genuino & Estrella, 2022).

Smartphone Chat Apps (SPCA) is an integral part of people’s daily routine including orthopedic education. SPCA facilitates efficient communication and learner-based management especially now as remote flexible learning is becoming the new norm in this COVID-19 pandemic medical training. The study described the use of a chat app (Viber) as experienced by residents and consultants in the Section of Adult Orthopaedics of the institution of the principal author. It described the mode and dynamics of the chat discussion amongst its participants, its perceived usefulness in teaching and learning specifically its relevance and applicability, its potential as a supplementary assessment tool, as well as its perceived effects (Lavadia et al., 2023).

The Philippine Board of Orthopedics has implemented strict quarantine lockdowns, barangay curfews, and liquor bans to reduce trauma cases and hospital beds in training institutions. These measures have led to a decrease in trauma cases and hospital beds, as institutions have adapted to meet the requirements set by the Board (Bantolo et al., 2023).

This study was conducted to determine the clinic-demographic profile of orthopedic trauma locally which would be a basis for the data for the community. There were 4299 orthopedic qualified patients for this study. Checklist for the demographic profile of the patients was used to gather the data (Yucal & Tacay, 2022).

As a first-year resident, we rotated in adult and trauma for twenty weeks each and in spine for another ten weeks. The second year residents, up until fourth year, had spine, adult, trauma, hand, and pediatric orthopedics for ten weeks each. A slight difference in the third-year's curriculum was that they didn't rotate in spine that year but instead had an elective programme (Mella et al., 2020).

One of the most widely used cephalomedullary devices for unstable peri-trochanteric fractures is the Proximal Femoral Nail Antirotation (PFNA). Adequate reduction and fixation are crucial to achieving ideal function and fracture union. Many factors can contribute to the ease of reduction; one of these is the positioning technique. (Condor & How, 2024).

Pertrochanteric fractures, commonly incurred by the elderly from low-energy falls, require surgical management. Visible blood loss in the perioperative period is inconsistent with the big drop in hemoglobin seen postoperatively. This discrepancy is attributed to the hidden blood loss (HBL), which must be anticipated in anemia management (Dollete et al., 2024).

Foreign Literature

Tsukada et al. (2021) conducted a study evaluating the efficacy of an augmented reality (AR)-based navigation system, AR-KNEE, in improving the accuracy of distal femoral resection during total knee arthroplasty (TKA). Results demonstrated that the AR-KNEE system provided significantly greater accuracy in distal femoral resection, with mean errors $<1.0°$ in both coronal and sagittal planes during experimental use. In the clinical setting, the AR-based system showed a significantly smaller mean absolute error in coronal alignment compared to the intramedullary guide. This study underscores the clinical relevance of AR technology in enhancing the precision of bone resection in TKA, validating its potential for improving surgical outcomes in orthopedic procedures.

Lin et al. (2022) aimed to address the challenges of visual field limitations in zygomaticomaxillary complex fracture reduction by exploring the use of an augmented reality (AR) navigation system. Patients with such fractures underwent preoperative 3D CT modeling, with one group using traditional optical navigation and the other using the AR system during surgery. Results showed that the AR navigation group had significantly reduced fracture point error and shorter fracture reduction time compared to the traditional navigation group. However, there were no differences in operative duration, blood loss volume, or complication rates between the two groups. The study concludes that the AR navigation system provides effective guidance and enhances accuracy in zygomaticomaxillary complex fracture reduction, presenting a promising alternative to traditional surgical methods.

The study by Siemionow et al. (2020) focused on developing and evaluating an augmented reality and artificial intelligence (ARAI)-assisted surgical navigation system for lumbar vertebrae pedicle instrumentation. This system uses intraoperative computer tomography-generated DICOM images to overlay virtual bony spine anatomy onto real spinal anatomy. The findings demonstrated that the virtual image overlay accurately corresponded to the actual anatomy, highlighting the high accuracy and feasibility of the navigation system. The authors suggest that implementing the ARAI system could potentially lead to improved surgical outcomes and reduced learning curves in minimally invasive spine surgery.

This article emphasizes the growing importance of deep learning, particularly Convolutional Neural Networks (CNNs), in analyzing large datasets effectively. It acknowledges the strengths of deep learning in handling complex data but also highlights the potential for misinterpretation, necessitating human oversight during data analysis. The article focuses on comparing R-CNN and Fast R-CNN, highlighting their significance in visual image analysis. It concludes that Fast R-CNN shows the most suitable performance in both testing and training phases, underlining its effectiveness in image analysis tasks (Mijwil et al., 2022).

Algorithm	Description	Advantages	Disadvantages
R-CNN	A region-based convolutional neural network that uses a selective search algorithm to generate region proposals and applies a CNN to extract features and classify objects.	High accuracy	Slow and requires a separate region proposal algorithm.
Fast R-CNN	An extension of R-CNN that uses a region proposal network (RPN) to generate region proposals, eliminating the need for a separate region proposal algorithm.	Faster than R-CNN and provides higher accuracy. Simpler architecture and fewer parameters.	Requires careful tuning of hyperparameters.

Algorithm	Accuracy	Precision	Recall	F1-score	MAP	Inference Time (ms)
R-CNN	0.85	0.82	0.88	0.85	0.83	150
Fast R-CNN	0.92	0.90	0.94	0.92	0.91	100

In this study by Oka et al. (2021), the researchers aimed to develop an AI system capable of accurately diagnosing distal radius fractures using bi-planar X-ray images, even with a relatively small dataset. They used a modified VGG16 convolutional neural network (CNN) to identify fractures in plain X-ray images and conducted diagnostic tests on distal radius fractures and styloid process fractures. Despite the limited dataset, the AI system achieved a good diagnostic rate, demonstrating the potential of AI-driven image diagnostic technologies in improving diagnostic accuracy and speed. The study suggests the applicability of AI systems in diagnosing various diseases seen on imaging modalities like X-rays, CT scans, and MRIs, with implications for clinical use and further development.

The application of virtual and augmented reality technologies to orthopedic surgery training and practice aims to increase the safety and accuracy of procedures and reduce complications and costs. The purpose of this systematic review is to summarize the present literature on this topic while providing a detailed analysis of current flaws and benefits (Salvatore et al., 2021).

The assistance of artificial intelligence and augmented reality enables precise positioning and navigation in arthroscopic surgery, as well as personalized operations based on patient conditions, which lifts the objective limitations of traditional sports medicine surgery. The integration of artificial intelligence and augmented reality with orthopedic arthroscopy surgery is still in infancy, even though there are still some insufficient to be solved, but it's prospect is bright (Chen et al., 2023).

This narrative review focuses on clinical applications of artificial intelligence (AI) in musculoskeletal imaging. A range of musculoskeletal disorders are discussed using a clinical-based approach, including trauma, bone age estimation, osteoarthritis, bone and soft-tissue tumors, and orthopedic implant-related pathology (Gitto et al., 2024).

Augmented reality (AR) is becoming increasingly popular in modern-day medicine. Computer-driven tools are progressively integrated into clinical and surgical procedures. The purpose of this review was to provide a comprehensive overview of the current technology and its challenges based on recent literature mainly focusing on clinical, cadaver, and innovative sawbone studies in the field of orthopedic surgery (Casari et al., 2021).

The center where the study was done was one of the worst affected hospitals in the United Kingdom at the outset of the pandemic. Our study evaluates the impact of the pandemic and national lockdown on the outcomes for patients undergoing orthopedic trauma surgery (Chauhan et al., 2024).

The use of artificial intelligence (AI) in the interpretation of orthopedic X-rays has shown great potential to improve the accuracy and efficiency of fracture diagnosis. AI algorithms rely on large datasets of annotated images to learn how to accurately classify and diagnose abnormalities. One way to improve AI interpretation of X-rays is to increase the size and quality of the datasets used for training, and to incorporate more advanced machine learning techniques, such as deep reinforcement learning, into the algorithms (Sharma, 2023).

Imaging technologies (X-ray, CT, MRI, and ultrasound) have revolutionized orthopedic surgery, allowing for the more efficient diagnosis, monitoring, and treatment of musculoskeletal ailments. The current review investigates recent literature surrounding the impact of augmented reality (AR) imaging technologies on orthopedic surgery (Furman & Hsu, 2021).

Exact placement of bone conduction implants requires avoidance of critical structures. Existing guidance technologies for intraoperative placement have lacked widespread adoption given accessibility challenges and significant cognitive loading. The purpose of this study is to examine the application of augmented reality (AR) guided surgery on accuracy, duration, and ease on bone conduction implantation. Five surgeons surgically implanted two different types of conduction implants on cadaveric specimens with and without AR projection. Pre- and postoperative computer tomography scans were superimposed to calculate center-to-center distances and angular accuracies (Lui et al., 2023).

Artificial intelligence is paving the way in contemporary medical advances, with the potential to revolutionize orthopedic surgical care. By harnessing the power of complex algorithms, artificial intelligence yields outputs that have diverse applications including, but not limited to, identifying implants, diagnostic imaging for fracture and tumour recognition, prognostic tools through the use of electronic medical records, assessing arthroplasty outcomes, length of hospital stay and economic costs, monitoring the progress of functional rehabilitation, and innovative surgical training via simulation (Powling et al., 2023).

Orthopedic oncology is integrating 3D printing and AR technologies to improve accuracy and clinical outcomes. A new surgical workflow includes 3D printed models and an AR-based smartphone app. The app displays the patient's anatomy and tumor location, and a 3D-printed reference marker allows automatic registration. The system has been evaluated for visualization accuracy and usability during the entire surgical workflow (Martinez et al., 2019).

AR can be considered a variant of virtual environments (VE), otherwise known as virtual reality (VR). VE/VR systems work by completely immersing the user in a digital world. In comparison, AR helps the user to see the real world and it allows virtual objects to be superimposed on or combined with the real world (Butaslac et al., 2023).

The use of AI to predict in-patient cost and length of stay and to predict factors for sport injury is also introduced, as is the potential for AI to provide patient level data for rehabilitation and treatment after orthopedic procedures (Shaikh et al., 2023).

With the advent and growing evidence for the use of orthobiologics in orthopedic medicine, we realized these substances could be injected in far more tissue areas than the traditional steroids and local anesthetics. Because these substances can be used to treat joints, bursae, fibrocartilage structures, tendons, ligaments, muscles, bones, and perineural, they open up a whole new world of procedures that were previously not described (Williams et al., 2022).

Orthopedic trainees were redirected to COVID-19 facing areas including ICU and emergency departments, reducing their orthopedic exposure (Al-kulabi et al., 2020).

Orthopedic injuries of National Hockey League (NHL) players are common and may significantly affect players' abilities to return to play and compete at the highest level. Due to the high-profile nature of the NHL, player injuries and team injury reports are closely followed by the media and often publicly reported, making it possible to track player injuries (Berube et al., 2020).

2.3 Related Studies

Local Studies

According to Garduce et al. (2022), the study showed a generally positive perception by the orthopedic residents to the hybrid set-up in the Hand Surgery rotation in response to the COVID-19 pandemic. No clear correlations or trends were seen between the trainees' perceptions of the changes implemented and his/her objective performance based on the final grade for his/her rotation. Potential topics for investigation related to this may focus on using larger sample size or clinical outcomes of cases done by trainees who have undergone the hybrid training set-up.

According to Genuino et al. (2021), this study found that it has at least satisfactorily matched the learning platform to the learning component. While knowledge may be taught via asynchronous recorded lectures or reading materials, attitude and thinking processes are better formed through synchronous discussion. Skills in medical education, including Orthopedics, are still best taught via face-to-face demoreturn demo. With this information, the department can investigate the causes of these differences and improve on the identified weaknesses.

Rotator cuff tears are one of the common etiologies of shoulder pain. Rotator cuff repair is recommended for a patient who failed conservative treatment. Proper knowledge of the rotator cuff footprint is needed in restoring correct anatomy during the repair. The size of the footprint is important in determining the kind of repair (Dizon et al., 2023).

In spite of the heterogeneous nature of the hip fracture population, functional outcome measures show generally good outcomes of patients under the UP-PGH Orthogeriatric FLS, with no significant difference among patients who receive complete rehabilitation from those who undergo incomplete rehabilitation (Peña et al., 2022).

The delay in diagnosis leads to significant gaps in management and consequent morbidities. Thus, a computer-aided hip fracture recognition through the Artificial Neural

Network deep learning model, which allows the program to learn and gain experience with more images processed, has been created. The study aimed to determine the accuracy and sensitivity of the artificial neural network model in detecting fractures of the hip and explored the feasibility of its use as a diagnostic screening tool (Grozman et al., 2021).

The challenge now presented to Philippine medical practitioners is to develop clinical research that will translate into improved care for patients. As majority of literature dictating treatment for musculoskeletal disorders come from developed countries, case series or observational cohorts reporting local data in our setting is greatly important in guiding patient care (Gaston, 2021).

Subtrochanteric fractures in the pediatric population are rare, and there are currently no existing management guidelines. In this innately unstable fracture type, intramedullary devices preferred for adults cannot be used in children with open growth plates (Morales et al., 2024).

The objective of this study was to present a case of Spondylolisthesis of the Isthmic Type (IIC), with Meyerding Grade III, high-grade dysplastic morphology, presenting with no neurologic deficits, which underwent spinal arthrodesis with acute reduction of L5-S1 segment. Spondylolisthesis itself is rare, presenting in 6% of the adult population with low back pain (Odiamar et al., 2024).

The primary objective of this study was to assess the outcomes of arthroscopic management of popliteal cysts using the modified Gillquist maneuver for visualization. The original Gillquist maneuver was originally developed to gain access to the posterior knee compartment (Braganza et al., 2024).

Increased healthcare demands due to the COVID-19 pandemic have overwhelmed nurses worldwide. Resilience of nurses has been impacted due to many factors (e.g., longer work shifts) causing psychological distress. The study aimed to determine the correlation of burnout, compassion fatigue, and moral injury with resilience among nurses assigned in COVID-19 wards. Virtual survey tools were sent to nurses of a public hospital to obtain data (Castro et al., 2023).

Foreign Studies

Real-time individual medical records accompany each patient in the form of an omni-accessible medical tattoo, and providers no longer have to struggle to treat a patient whose medical history is murky at best. Accurate records help obviate unnecessary tests, curtailing the financial cost of medical care (Wilke & Dowdle, 2023).

There is a paucity of data in the literature regarding negative articles concerning surgery in orthopedics and trauma. Knowledge pertaining to treatments or techniques which confer a beneficial effect remains important, as does knowledge regarding those which have a null or pejorative effect (Bauters et al., 2023).

Nowadays, 3D printing technology is woven into the fabric of orthopedic medicine, revolutionizing the field with the promise of new personalized treatment approaches. Furthermore, this technique facilitates the fabrication of patient-specific implants and prosthetics, enhancing precision and compatibility, thereby reducing post-operative complications, fostering patient satisfaction, and overall improving recovery times (Chen et al., 2023).

Thus, it becomes vital to investigate masticatory efficiency in patients undergoing treatment with functional jaw orthopedics as growing youngsters have high nutritional requirements for optimal growth. Through the present study, the authors aimed to measure changes in masticatory efficiency and functional occlusal contacts in such patients (Ashok et al., 2023).

Most orthopedic studies involve survival analysis examining the time to an event of interest, such as a specific complication or revision surgery. Competing risks commonly arise in such studies when patients are at risk of more than one mutually exclusive event, such as death, or when the rate of an event depends on the rates of other competing events (Kremers et al., 2021).

Liu et al. (2024) narratively reviewed the latest applications of AI in orthopedic diseases, encompassing severity evaluation, triage, diagnosis, treatment, and rehabilitation. They discussed the research point, relevant advantages, and disadvantages of orthopedic AI, combining with their own research experiences into the discussion. The authors aimed to summarize past achievements and advocate for increased attention and effective applications of AI in the field of orthopedics.

The study by Ding & Hoehle (2023), introduces a holistic AI-assisted orthopedic clinical diagnosis system developed through an Action Design Research approach. By fine-tuning AI algorithms to meet actual clinical needs, the authors bridge the gap between technological innovation and healthcare relevance. Their research offers innovative insights into the design and evaluation of AI-assisted systems, emphasizing the role of empirical data and diverse evaluation metrics.

The aim of the review article is to provide a comprehensive understanding of AI and its subfields, as well as to delineate its existing clinical applications in trauma and orthopedic surgery. Furthermore, the narrative review expands upon the limitations of AI and future directions (Lisacek-Kiosoglous et al., 2023).

In their study, Nassour et al. (2023) aimed to develop an AI-based ankle fracture detection tool for smart devices using machine learning models. The researchers examined 2,193 patients' charts and collected ankle X-rays from both digital records and smart devices. They developed a fracture detection model named the "combination model" using machine learning and tested it on different datasets, achieving high accuracy and sensitivity, especially when tested on smart device-captured images. The results showed promising performance comparable to original digital X-rays, indicating the potential of AI in assisting clinicians with fracture detection, especially for less experienced providers and trainees in the field of orthopedics.

According to Qi et al. (2020), their study aims to achieve an automatic detection and classification system for femoral fractures in X-ray images. They curated a benchmark dataset of 2333 images with 9 fracture types, labeled with ground truth boxes following the AO classification. Using a Faster RCNN detection model with ResNet-50 as the backbone in a multi-resolution feature pyramid network (FPN), they achieved a total image level accuracy of 71.5%. This accuracy surpasses that of some orthopedic surgeons, particularly younger ones, highlighting the practicality of AI in detecting and classifying femoral shaft fractures accurately.

2.4 Operational Definition of Terms

Artificial Intelligence - The Mobile App can offer more precise and specific recommendations for bone imaging methods by using AI in this study, which will enhance patient outcomes and lessen the work of medical personnel.

Augmented Reality - Augmented Reality (AR) can play a significant role in this study by providing a more immersive and interactive experience for medical professionals and patients.

CNN - Convolutional Neural Network is used to extract features from the input image.

CT Scan - The study could benefit from the use of CT scan results, which may give high-resolution bone images that the app's AI algorithms can evaluate to generate individualized bone health recommendations.

Fast R-CNN - Automating and enhancing various aspects of orthopedic care, from diagnosis and treatment planning to post-operative monitoring and remote consultations.

Native Application - This application would be specifically optimized for Android devices, ensuring smooth performance and compatibility with a wide range of Android smartphones and tablets.

Orthopedic - In this study, orthopedic plays a crucial role in preventive care and education, advising patients on lifestyle modifications, injury prevention techniques, and rehabilitation exercises to maintain musculoskeletal health and prevent future problems.

X-ray - X-ray results will be used by the augmented reality (AR) system to generate 3D models or visualizations of the bone structures, allowing for a more detailed and interactive analysis. The artificial intelligence (AI) system would analyze the X-ray images to make recommendations for implants tools.

Chapter Three

THEORETICAL FRAMEWORK

3.1 System Design

3.1.1 System Flowchart

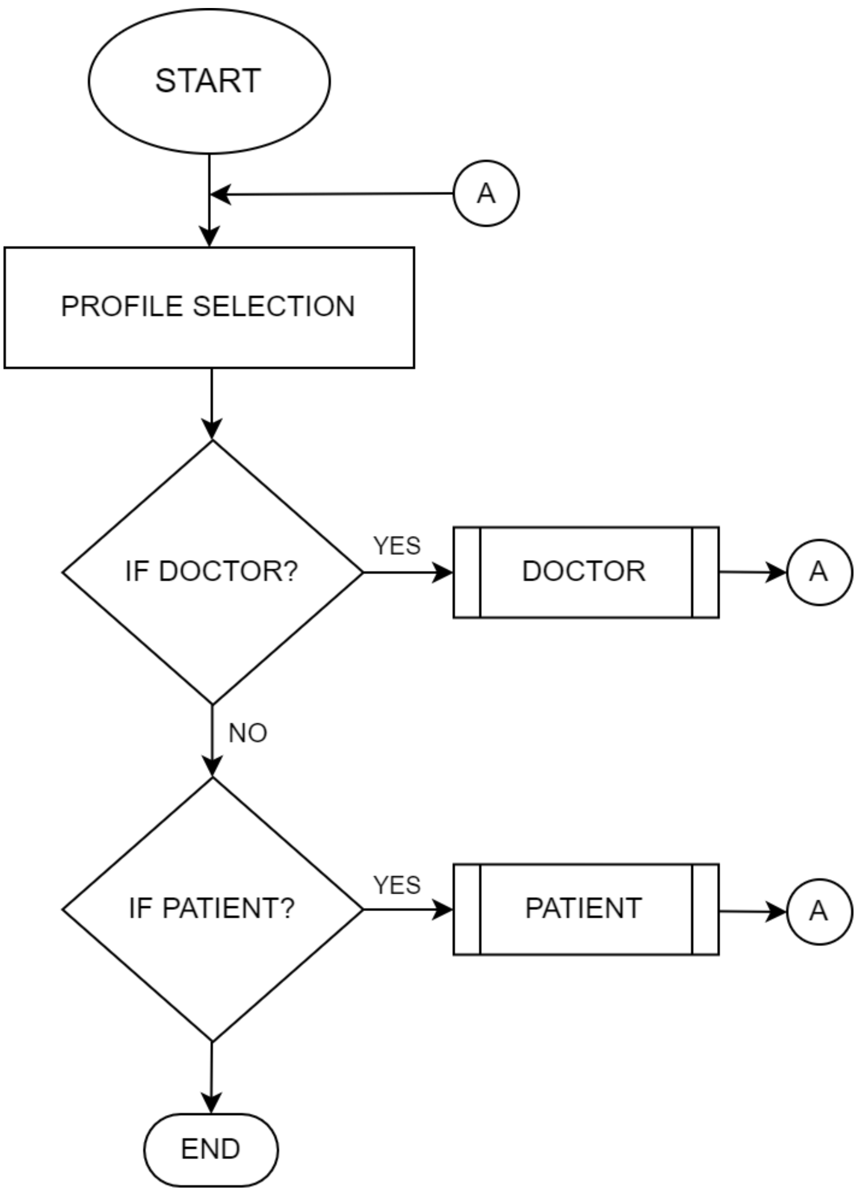

Figure 3.1.1 Profile Selection (Subprocess) Flowchart

The flowchart illustrates the sequential steps, decision points, and interactions of the system, providing an in-depth overview of its design, development, and implementation. In Figure 3.1.1, the process begins at the "START" node. The user is prompted to select a profile, if the user chose doctor, the system will direct to the doctor interface while if the user chose patient, the system will direct to the patient interface.

3.1.2 System Flowchart per Process

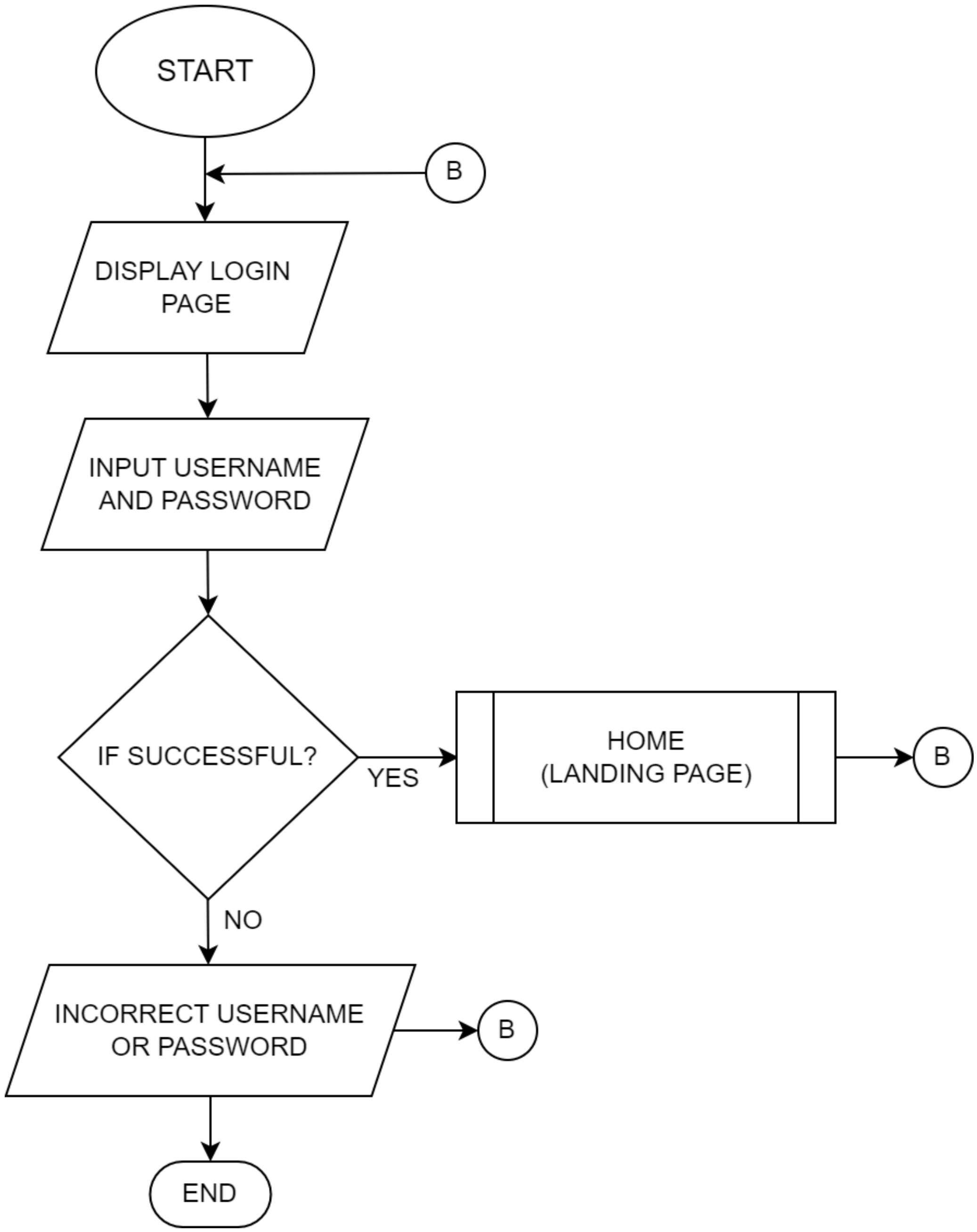

Figure 3.1.2 Doctor - Login Page Process Flowchart

In Figure 3.1.2, the “DOCTOR” subprocess is continued on this page. The user will direct on the login page wherein they must input their username and password. However, if the user enters a wrong email or password, it will display an error message then the user is required to input the username or password again. If the login was not successful, the system will show an error that the username or password is incorrect whereas if the login was successful the user will direct to the home landing page. The “HOME (LANDING PAGE)” subprocess will be continued on a separate page.

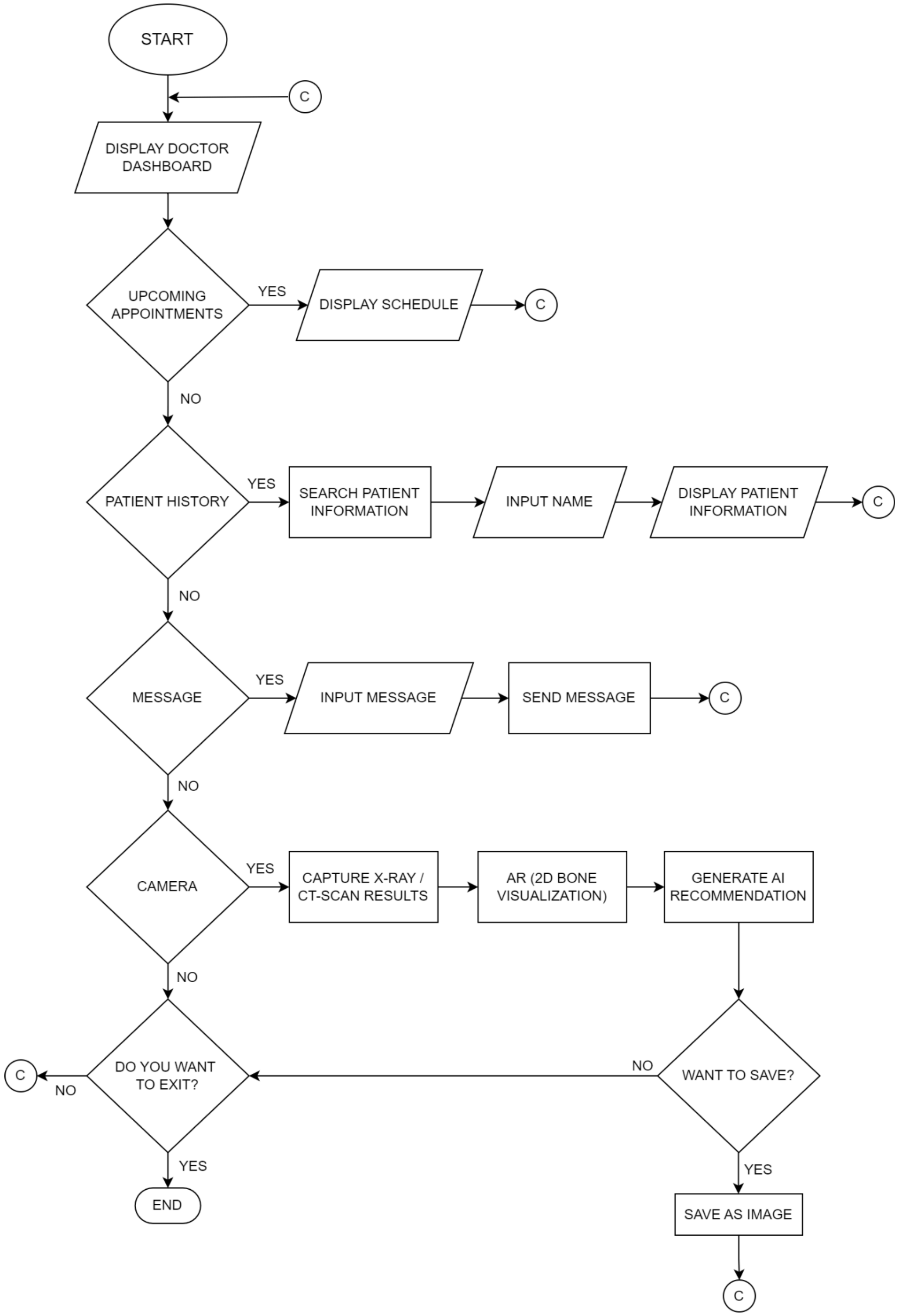

Figure 3.1.3 Doctor - Dashboard Process Flowchart

In Figure 3.1.3, the “HOME (LANDING PAGE)” subprocess is continued on this page. After the login is successful, the user will direct to the doctor dashboard. The user can select buttons or features in the home page, if the user wants to select upcoming appointments, the system will display the schedule wherein the user can see his schedule appointments. Next, if the user wants to select patient history, the user can search the patient's name then display the specific patient information. In message, the doctor and patient have an interaction wherein the doctor can reply and send a message to the patient. Lastly, if the user wants to select a camera, the user can use the camera to capture X-ray/CT Scan results in which the user can move or rotate the 2D bone visualization then after that, the system will automatically generate AI to recommend implant tools. The user can save the results in an image. If the user is done, they can choose to exit or not. If yes, the user will direct to exit, if not the user will go back to the landing page.

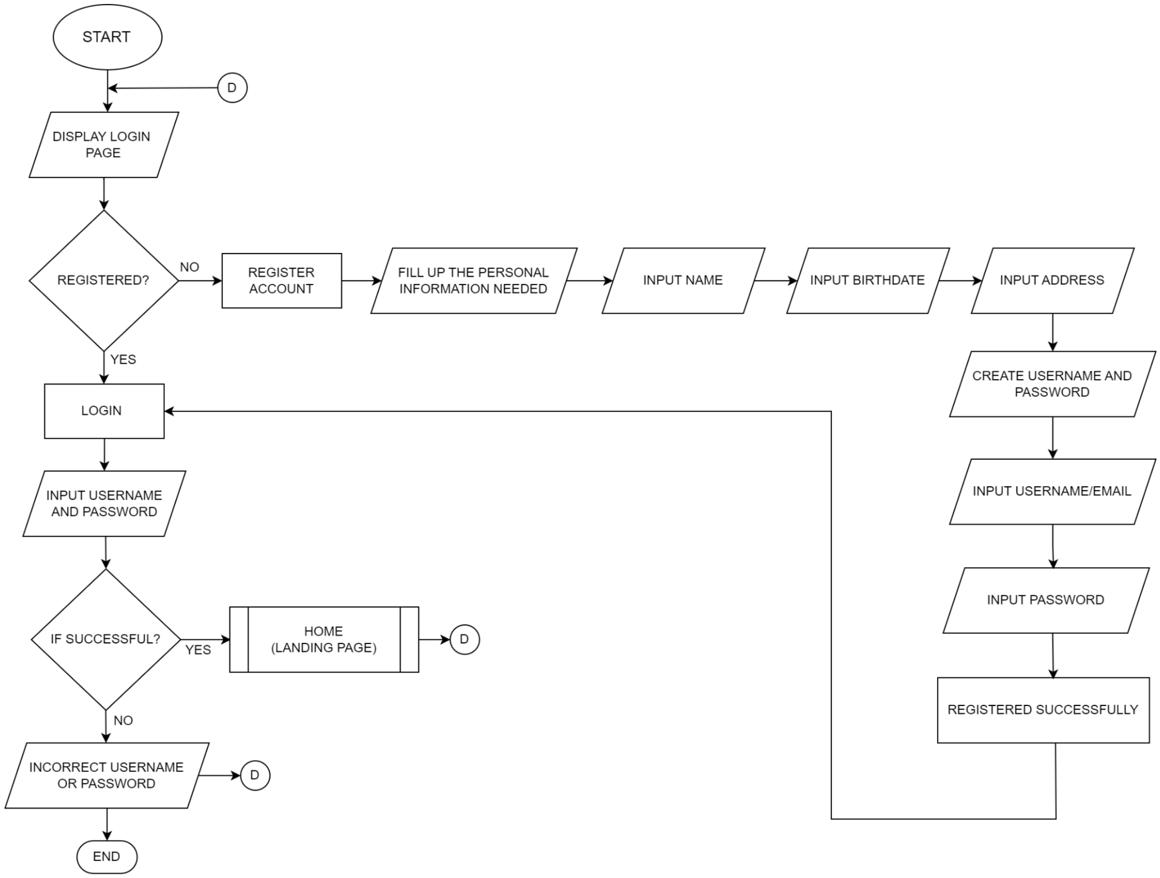

Figure 3.1.4 Patient - Login Page Process Flowchart

In Figure 3.1.4, the "PATIENT" subprocess is continued on this page. If the user is not yet registered, the user has to register an account, then they have to fill out all needed information such as name, birthdate and address. Then, the user has to create a username and password. Once the user has registered successfully, the user will direct on the login page wherein they must input their username and password. However, if the user enters a wrong email or password, it will display an error message then the user is required to input the username or password again. If the login was not successful, the system will show an error that the username or password is incorrect whereas if the login was successful the user will direct to the home landing page. The "HOME (LANDING PAGE)" subprocess will be continued on a separate page..

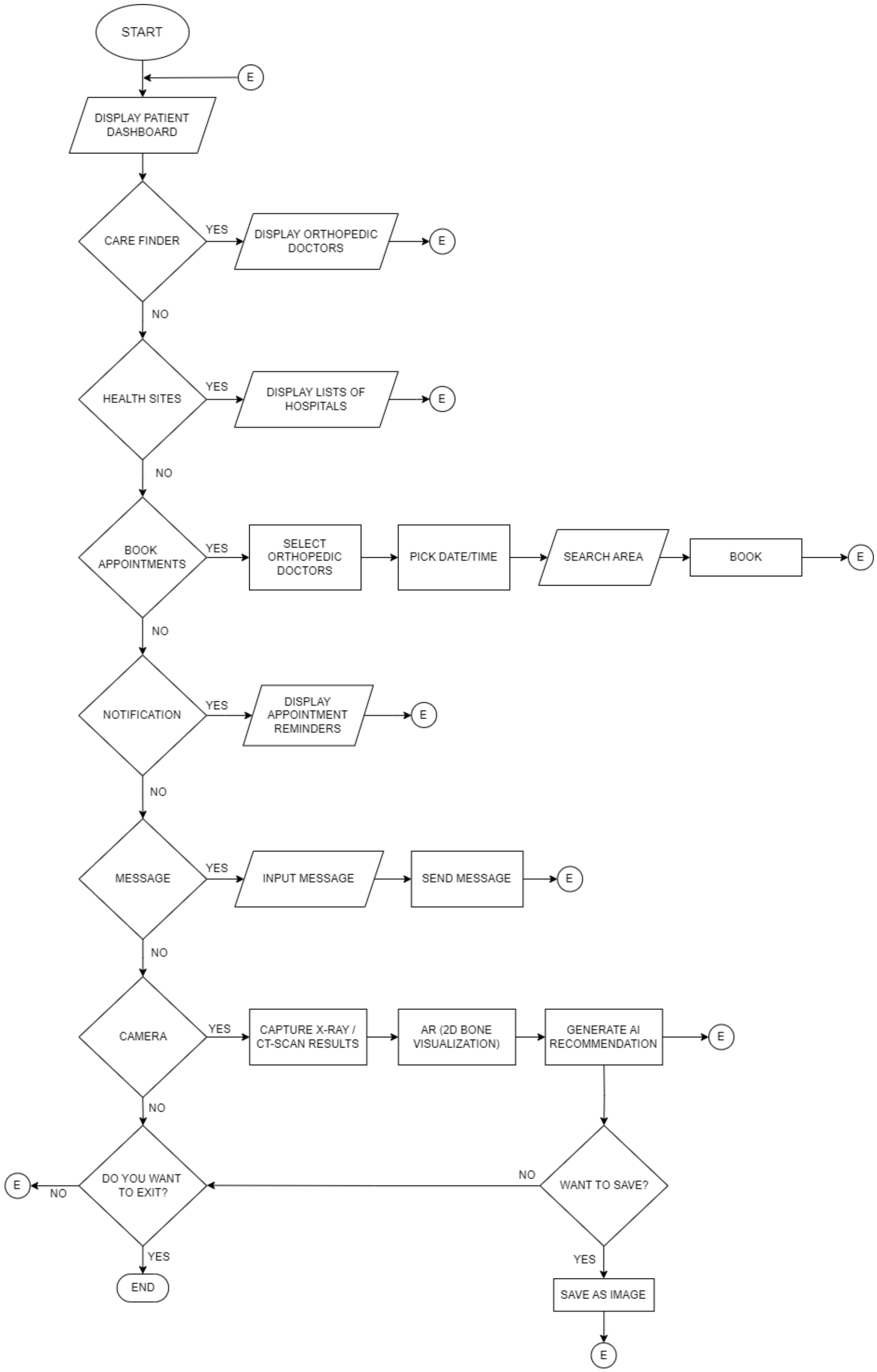

Figure 3.1.5 Patient - Dashboard Process Flowchart

In Figure 3.1.5, the “HOME (LANDING PAGE)” subprocess is continued on this page. After the login is successful, the user will direct to the patient dashboard. The user can select buttons or features in the home, if the user wants to select care finder, the user can view orthopedic doctors. Next, if the user wants to select care health sites, the user can view lists of hospitals. Next, if the user wants to book an appointment, the user needs to select an orthopedic doctor, pick a date and time, and then book for confirmation. After confirming the scheduled appointment, the user can see the appointment reminders in the notifications. In message, the doctor and patient have an interaction wherein the patient can reply and send a message to the doctor. Lastly, if the user wants to select a camera, the user can use the camera to capture X-ray/CT Scan results in which the user can move or rotate the 2D bone visualization then after that, the system will automatically generate AI to recommend implant tools. The user can save the results in an image. If the user is done, they can choose to exit or not. If yes, the user will direct to exit, if not the user will go back to the landing page.

3.2 DFD/ Context Diagram/ System Architecture

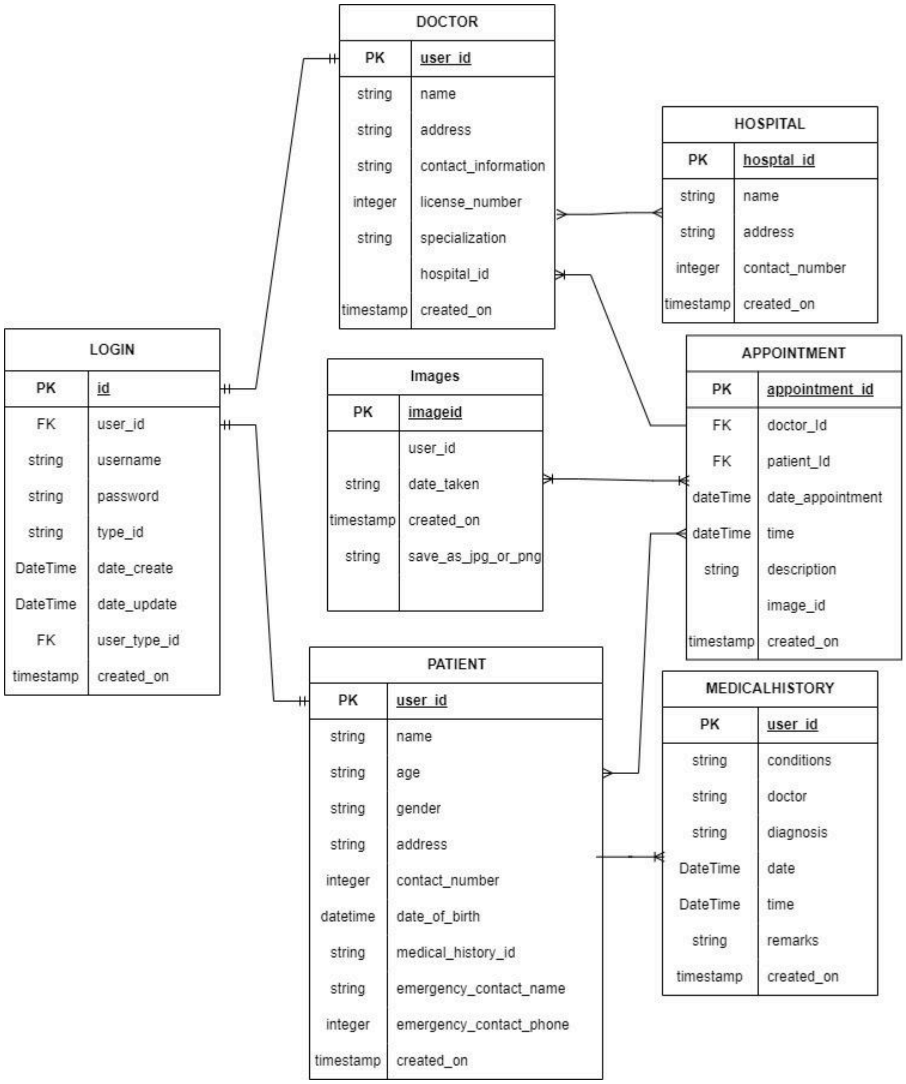

Figure 3.2.1 Entity Relationship Diagram

Figure 3.2.1 shows the overview of the medical appointment system, including appointment scheduling, medical data management (images and history), separate user roles (Doctors and Patients), user login and administration, and optional hospital association. The system is customizable, allowing you to incorporate unique features to perfectly suit your specific needs.

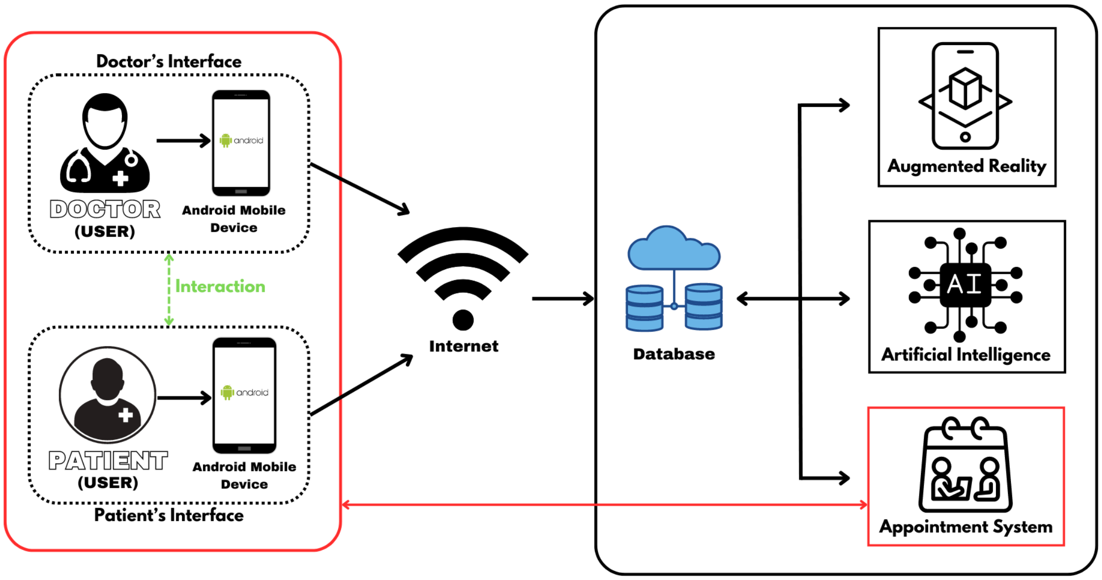

Figure 3.2.2 System Architecture

Figure 3.2.2 illustrates the system architecture that incorporates a native mobile device with the internet connection. The foundation that links artificial intelligence, augmented reality, and an appointment scheduling system using a strong database. Doctors have access to an extensive interface for managing patients remotely, while patients can make consultation for easier appointment scheduling within the native app. AI helps with implant tool recommendations, and augmented reality improves bone visualization.

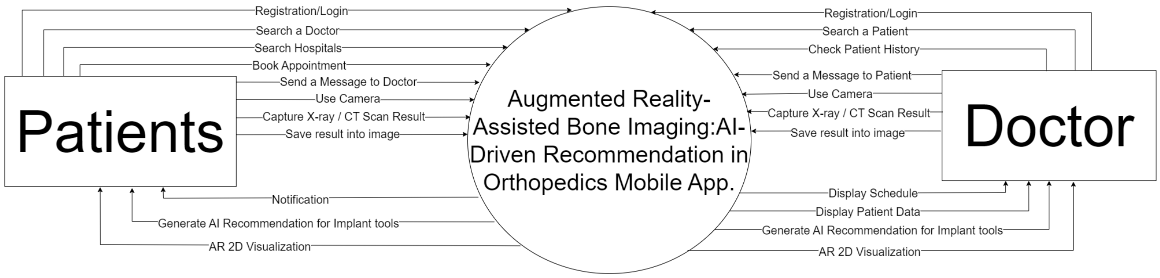

Figure 3.2.3 Context Diagram

This context diagram illustrates the interaction between patients and doctors through an Augmented Reality-Assisted Bone Imaging:Al-Driven Recommendation in Orthopedics Mobile App. Patients can use the app to book appointments, search for doctors and hospitals, send messages, and capture X-ray/CT scan results. The app can then generate AI recommendations for implant tools, which can be visualized in AR 2D. Doctors can access the patient data, schedule appointments, and utilize the AI recommendations. This technology bridges the gap between patients and doctors, providing a streamlined and efficient healthcare experience.

3.3 System Development

Figure 3.3.1 Agile Framework

In Figure 3.3.1, the system development methodology utilizes the Agile framework to develop an augmented reality-assisted bone imaging with AI-driven recommendations for OrthoMedics. Agile Development Methodology is an iterative and incremental method to software development. Agile development divides the development process into smaller, manageable sections known as iterations or sprints. Each iteration focuses on producing feasible software increments, allowing for constant feedback and development. This iterative technique assists in identifying and mitigating risks early in the development process. For example, doing early testing on AR performance in various lighting conditions and user preferences could help in finding solutions of possible usability problems. Agile also promotes collaboration among cross-functional teams, which comprise developers, designers, and users. Collaboration between the development team and orthopedic professionals guarantees that the app meets clinical and usability standards. This collaborative approach ensures that the app is both clinically accurate and user-friendly, leading to higher adoption rates and better outcomes for patients.

3.3.2 BRAINSTORM PLAN

The initial phase in which developers gather, evaluate, and specify the software system's requirements, such as functionality, features, and limitations.

1. Data Gathering
2. Requirement Analysis

3.3.3 DESIGN

After collecting all of the relevant information, the developers create a system layout which includes the user interface, data structures, and overall architecture.

1. UI Design using Figma

3.3.4 DEVELOPMENT

This phase involves coding and developing the system in accordance with the design specifications. The developers work on both the system's frontend and backend to ensure that it functions properly.

1. Development of native mobile app through the use of Android Studio, Flutter and Dart
2. Development of AR and AI through the use of Unity and Vuforia Engine

3.3.5 QUALITY ASSURANCE

Once the system is fully developed, the developers thoroughly test the system for errors, bugs and inconsistencies with the initial specifications.

1. System Testing
2. Debugging
3. Features Improvement

3.3.6 DEPLOYMENT

The final phase is to deploy the fully functional system to the end-users.

1. System Implementation

3.4 System Hardware and Software

a. Software

The developers will create and test the system application using the following software.

Frontend: Flutter, Dart, Android Studio

Backend: Java, Unity, Vuforia engine, MySQL

b. Hardware

The system application will be created and tested on the **ASUS Vivobook X1605ZA**, a laptop with an i5 12th Generation CPU and 8 gigabytes of Solid State Drive 16.0 Random Access Memory (RAM). The developers will also test the system's mobile perspective on the **Redmi Note 10 pro**, featuring a Snapdragon 732G CPU with up to 8 gigabytes of RAM and the User Interface (UI) software, both of which are based on Android 10. These two gadgets will enable the system to carry out program execution swiftly.

3.5 Instruments Used

Developers are going to employ a checklist in this study. A checklist is a form that may be used to indicate tasks or requirements or to quickly and conveniently capture data. When interviewing patients and doctors for research, it is helpful to use a checklist because it offers an organized and structured approach, guarantees that all pertinent topics are covered, permits the use of a predetermined set of questions, conducts the interview in a consistent manner, keeps the interviewer focused, and guarantees that important data is obtained in a condensed amount of time. This is essential since doctors could only have a little amount of time for the consultation, and that will make sure to get the most useful information out of them in that time.

3.5.1 System Evaluation

In evaluating the system app for users, the developers will use the ISO/IEC 25010 to ensure that the system meets the standard of quality in terms of functionality suitability, usability, reliability, security and accuracy of the system based on user perception. ISO/IEC 25010 provides useful advice on how to use the quality models as well as an explanation of the models, which are made up of features and sub-characteristics for software product quality and software quality in use (PERFORCE, 2021). When assessing the system, it is important to take into account factors such as functionality suitability, usability, reliability, security, and accuracy to make sure that its features work as intended—that is, to develop a system application. When the system has been implemented and is being utilized for its intended purpose, the remaining characteristics of ISO/IEC 25010 will be taken into account.

Table 3.5.1 ISO 25010 Characteristics used for System Quality Evaluation

Characteristics		1	2	3	4	5
Functional Suitability	**Functional Completeness -** It refers to the group of operations that addresses the developers of the given tasks and user goals. **Functional Correctness -** The developers' system app yields the system outcomes. **Functional Appropriateness -** The developers' requirements and goals can be supported and facilitated by the system app for its development.					
Usability	**Appropriateness Recognizability -** It relates to the point at which it can determine if a system app is suitable for the specific needs of the users. **Learnability -** The system enables users to take time to learn and use it for the system app. **User Interface Aesthetics -** The system app for developers has a perceived or real usefulness and trust.					
Security	**Confidentiality -** The extent to which the system app makes sure that the developers only those with permission may access data. **Integrity-** The system app is shielded against unwanted additions or deletions due to malicious programs or human error. **Authenticity -** The system app for developers has a perceived or real usefulness and trust.					
Reliability	**Maturity -** The system app has undergone extensive testing, and its minimal human maintenance requirements reduce the possibility of mistakes occurring during production. **Availability-** The system app has undergone extensive testing, and its minimal human maintenance requirements reduce the possibility of mistakes occurring during production. **Recoverability -** The system app's capacity to recover data in the case of an interruption or breakdown.					

Accuracy	**Syntactic Accuracy-** It focuses on whether the system app's output of the data follows the specified format or range of values. **Semantic Accuracy -** This guarantees that the analysis of the system app appropriately depicts the reality of the real image..					

In particular, this study aims to assess the system according to the following characteristics:

(1) **Functional Suitability -** it focuses on whether the system delivers the intended functionalities and meets the user's needs.

(2) **Usability -** the ability of the system app by the developers for the user to accomplish specific goals in a specific context of usage effectively, efficiently, and satisfactorily. Stated differently, the system app needs to be a procedure for users to navigate and utilize in order for them to accomplish their intended goals.

(3) **Security -** the ability of the system apps' security for developers to safeguard information so that users or other systems can access it to the right extent depending on the types and degrees of permission.

(4) **Reliability -** It consistently shows how the system app operates as planned under particular circumstances and for a predetermined amount of time. It basically emphasizes on how reliably, when used as intended, the system app produces the desired outputs.

(5) **Accuracy -** it delivers when the system app's outputs correctly reflect the intended measurement or representation and are free from errors.

Table 3.5.2 The five-point Likert Scale

Criteria	Numerical Value
Strongly Disagree	1.00 – 1.80
Disagree	1.81 – 2.60
Neutral/Uncertain	2.61 – 3.40
Agree	3.41 – 4.20
Strongly Agree	4.21 – 5.00

This figure presents an analysis of the evaluation; because it is simple to use and enables respondents to effectively express their opinions, the developers plan to use a five-point Likert scale to interpret the numerical value of the data that they can gather in implementing a system application for developers. It enables the developers to collect information from users and evaluate how well they think the system is working, which aids in identifying areas that require development. The Likert scale technique for gathering data for surveys that evaluates respondents' attitudes, views, or perceptions. Respondents to this scale are presented with a series of statements or questions. Numerical values are assigned to the replies, enabling quantitative data analysis. It offers enough variety at a modest degree of granularity to allow for precise preferences without offering an excessive number of options. A broader variety of opinions, including neutral choices, are captured by the balanced distribution. It makes user engagement convenient by allowing prompt feedback on system features. The Likert scale provides developers working on the system application's implementation with a user-friendly interface while guaranteeing effective data collecting and analysis.

Chapter Four

RESULTS AND DISCUSSION

4.1. Results

4.2. Evaluation

(Tables -Evaluation ISO/Confusion Matrix)

All tables should be explained in the text. Figures should be inserted after they are first mentioned in the text. They should be placed as close as possible to the text while considering layout and paging. Tables should be located on a single page.

If a table is to be oriented in “landscape” format, then it should be oriented such that the table is facing right.

Chapter Five

CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary of Findings

5.2. Conclusions

5.3. Recommendations

LIST OF REFERENCES

APPENDICES