rAIdiologist

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Certification

       This is to certify that **Hassan Masood**, **01-131192-010** and **Syed Hammad Ali**, **01-131192-032** have successfully completed the final project **rAIdiologist,** at the **Bahria University, Islamabad**, to fulfill the partial requirement of the degree **Bachelor of Software Engineering.**

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Project Title (mention project title here)
Sustainable Development Goals

SDG No	Description of SDG	SDG No	Description of SDG
SDG 1	No Poverty	SDG 9 ✖	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger	SDG 10	Reduced Inequalities
SDG 3	Good Health and Well Being	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals

	Range of Complex Problem Solving		
	Attribute	**Complex Problem**	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	x
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	x
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	
7	Consequences	Have significant consequences in a range of contexts.	
8	Interdependence	Are high level problems including many component parts or sub-problems	
	Range of Complex Problem Activities		
	Attribute	**Complex Activities**	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).	x
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	x
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	

Abstract

The rAIdiologist is an innovative final year project that aims to revolutionize the field of radiology by facilitating seamless collaboration among radiologists across the world. Through our comprehensive and feature rich DICOM studio, radiologists can collaborate effectively, exchange knowledge, and enhance disease detection accuracy, particularly in chest X-rays. The primary goal of the rAIdiologist is to provide a platform where radiologists can leverage the collective expertise of their peers, regardless of geographical boundaries. By utilizing our advanced collaborative features, radiologists can add annotations, comments, and notes to medical images, fostering a collaborative environment where professionals can share insights, discuss complex cases, and collectively arrive at more accurate diagnoses. Furthermore, the rAIdiologist incorporates a robust artificial intelligence (AI) model specifically designed for disease detection in patient lung X-rays. Our AI model assists radiologists in identifying potential abnormalities and pathologies in chest X-ray images. This AI-powered system not only acts as a reliable second opinion but also serves as a valuable tool for radiologists, improving efficiency and accuracy in their diagnostic processes.

Keywords: Collaborative Environment, DICOM studio, disease detection, chest X-rays, organization, annotations, comments, notes, artificial intelligence, second opinion, diagnostic accuracy, patient care.

Undertaking

I certify that the project **rAIdiologist** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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Acknowledgement

This project had a lot of challenges that have tested our engineering skills. There are many people who have helped us throughout this journey. We would like to thank Allah almighty who has enabled us to gain knowledge and blessed us with success at every step of our life.

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We are thankful to software engineering department and Bahria university in providing us the required facilities and environment that helped us in completing this project.

In the end we would also like to express gratitude to our families and friends who gave us moral support. "Do good as Allah has done good to you". May Allah (SWT) help all of us in helping others in need.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

In this chapter, we document the details of our final year project, **rAIdiologist** – an AI-powered system with collaborative environment and a state-of-the-art DICOM Studio. rAIdiologist provides radiologists with a comprehensive platform to create online repositories for their DICOM images, collaborate with colleagues, and even predict lung disease using cutting-edge AI technology.

1.1. Motivation

The motivation behind undertaking the rAIdiologist project stems from the recognition of the critical importance of collaboration and knowledge sharing in the field of radiology. Radiologists play a vital role in diagnosing diseases and guiding patient care, but they often face challenges due to limited access to expertise beyond their immediate networks. The need to consult with peers, discuss complex cases, and seek second opinions is essential for accurate diagnoses and improved patient outcomes.

The context of the problem domain lies in the field of radiology, where disease detection in medical imaging studies, including X-rays, is a complex task requiring expertise and collaboration. X-rays are widely used in medical imaging and serve as a primary diagnostic tool for various conditions in different parts of the body. However, interpreting X-rays accurately and identifying abnormalities can be challenging, often necessitating collaboration and collective expertise.

The issues we aim to solve through the rAIdiologist project are multifaceted. Firstly, we address the lack of seamless collaboration among radiologists by creating a platform that transcends geographical boundaries and enables radiologists from around the world to connect, communicate, and collaborate effectively. This collaboration facilitates knowledge sharing, peer consultation, and collective problem-solving, ultimately improving diagnostic accuracy.

Secondly, we tackle the limitation of existing DICOM studios by developing a feature-rich platform. The traditional viewing capabilities fall short when it comes to facilitating detailed analysis and comprehensive communication. Our DICOM studio empowers radiologists to add annotations, comments, and notes directly to medical images, enhancing communication and enabling a more thorough understanding of complex cases.

Lastly, we address the need for a reliable second opinion system by incorporating an AI model specifically designed for disease detection in chest X-rays. The AI model, trained over a vast dataset, acts as a valuable tool for radiologists, augmenting their expertise and improving efficiency in identifying potential abnormalities and pathologies.

Overall, the motivation behind the rAIdiologist project is to overcome the challenges of limited collaboration, lack of comprehensive DICOM studio functionality, and the absence of a reliable

second opinion system in the domain of radiology. By addressing these issues, we strive to empower radiologists, improve diagnostic accuracy, and ultimately enhance patient care in the field of disease detection.

1.2. Problem statement

The problem statement addressed by the rAIdiologist project is the lack of seamless collaboration and knowledge sharing among radiologists, particularly in the context of disease detection. Radiologists often face challenges in accessing expertise beyond their immediate networks, limiting their ability to consult with peers, discuss complex cases, and arrive at accurate diagnoses.

Moreover, the absence of a comprehensive and feature-rich DICOM studio further hinders effective collaboration. Traditional viewing capabilities in existing systems do not provide sufficient tools for radiologists to add annotations, comments, or notes to medical images, hindering detailed analysis and comprehensive communication.

Additionally, the reliance solely on individual expertise for disease detection in chest X-rays can lead to variations in diagnosis and potentially compromise patient care. A reliable second opinion system, such as an AI model, is lacking, which could assist radiologists in identifying abnormalities and pathologies with increased accuracy and efficiency.

Therefore, the problem statement revolves around the need to bridge these gaps in collaboration, DICOM studio functionality, and disease detection capabilities. The rAIdiologist project aims to address these challenges by providing a collaborative platform, a feature-rich DICOM studio, and an AI model for disease detection, enabling radiologists to collaborate effectively, enhance their diagnostic accuracy, and improve patient care.

1.3. Objectives

Given below are the objectives of the rAIdiologist: -
• To use Machine Learning Models to help radiologists examine patient's chest X-rays.
• To help radiologists using DICOM viewer studio to examine the medical images and add comments and findings.
• To help radiologists to collaborate with other radiologists around the world.
• To help radiologists in maintaining patient information files in a safe and secure repository.

1.4. Main contributions

The rAIdiologist introduces several novel and significant contributions to the field of radiology, ultimately leading to improvements in disease detection and patient care.

1.4.1. What is new, different, better, significant?

Collaborative Platform: The rAIdiologist provides a unique platform that enables radiologists from around the world to collaborate seamlessly. This collaborative environment empowers radiologists to share their expertise, exchange insights, and collectively improve diagnostic accuracy, ultimately benefiting patients.

Feature-Rich DICOM Studio: The rAIdiologist offers a feature-rich DICOM studio that goes beyond traditional viewing capabilities. Radiologists can now add annotations, comments, and notes directly to medical images, facilitating a more detailed and comprehensive analysis. This functionality significantly enhances communication and collaboration among radiologists.

AI Model for Disease Detection: The incorporation of a robust AI model specifically designed for disease detection in patient lung X-rays is a significant advancement. The AI model leverages deep learning techniques and a large dataset to assist radiologists in identifying potential abnormalities and pathologies, acting as a reliable second opinion and improving diagnostic accuracy.

1.4.2. What is now known/possible/better because of this project?

Enhanced Collaborative Practices: The rAIdiologist project establishes new norms for collaboration in the radiology community. Radiologists now have access to a comprehensive platform that facilitates collaboration, knowledge sharing, and collective problem-solving. This project broadens the horizons of radiology practice, fostering a global network of professionals who collaborate and learn from one another.

Improved Disease Detection: The integration of the AI model into the CRN introduces a powerful tool for disease detection in chest X-rays. Radiologists can leverage the AI model's capabilities to improve their accuracy and efficiency in identifying potential abnormalities, ultimately leading to improved patient care.

Increased Efficiency in Diagnosis: The rAIdiologist project streamlines the diagnostic process by providing a centralized platform where radiologists can view, annotate, and discuss medical images. This efficient workflow promotes better utilization of resources, optimizes diagnostic timelines, and enhances the overall efficiency of radiology departments.

In summary, the rAIdiologist project introduces a collaborative platform, a feature-rich DICOM studio, and an AI model for disease detection, leading to improved access to expertise, timely and accurate diagnoses, and enhanced collaborative practices in the radiology community. This project contributes to better patient care, increased diagnostic efficiency, and a global network of radiologists collaborating to improve the field of radiology.

1.5. Report organisation

Chapter 2 discusses the literature review from various papers/journals. The key concepts that being implemented are discussed. Similar systems and evaluation of their features and critiques are discussed.

Chapter 3 focuses on the key functionalities of the system. The high-level use case diagram shows the overall functionality of the system. The functional. Requirements are discussed as use case descriptions. System constraints and quality attributes are discussed as non-functional requirements.

Chapter 4 highlights the overall design and different design approaches used in implementation of the system. High fidelity prototypes were also discussed.

Chapter 5 discusses the overall implementation details of the system and how key functionalities are achieved.

Chapter 6 covers the system testing and evaluation of all functionalities performed by the system. It conforms to the user requirements and satisfy all the guidelines and standards.

Chapter 7 concludes the thesis by summarizing different aspects of the work.

Chapter 2

Background Study/Literature Review

2.1. Introduction

In recent years, advancements in medical imaging technology have revolutionized the field of radiology. However, the interpretation and analysis of medical images still heavily rely on the expertise of radiologists. As radiology becomes increasingly specialized and the demand for accurate diagnoses rises, there is a growing need for collaborative platforms that enable radiologists from different parts of the world to work together, share knowledge, and improve patient care. This chapter provides a comprehensive background study on existing software applications, state-of-the-art techniques, and related research in the field of collaborative radiology, highlighting strengths, weaknesses, and identifying potential areas of improvement.

2.2. Existing Software Applications

2.2.1. Qure.ai [1]

2.2.1.1. Description

qure.ai is a leading software company focused on developing artificial intelligence (AI) solutions for radiology and healthcare. The company's primary purpose is to enhance the accuracy, efficiency, and accessibility of radiological imaging interpretation, ultimately leading to improved patient care. By leveraging advanced machine learning algorithms and deep learning techniques, qure.ai's software aims to assist radiologists in diagnosing various conditions and diseases by analysing medical images such as X-rays, CT scans, and MRIs.

2.2.1.2. Evaluation of Features and Capabilities

Strengths:
1. **Automated Detection and Classification:** qure.ai's software excels in automatically detecting and classifying abnormalities within medical images. Its AI algorithms have demonstrated high accuracy in identifying potential indicators of diseases, assisting radiologists in making accurate diagnoses.
2. **Quantitative Analysis:** The software provides precise and objective quantitative measurements of specific regions of interest within the images. This feature aids radiologists in obtaining valuable data for treatment planning and monitoring.
3. **Workflow Optimization:** qure.ai's software effectively optimizes radiology workflows by automating tasks such as case prioritization and flagging urgent findings. This streamlining helps radiologists manage their workload efficiently.

Weaknesses:

1. **Limited Scope:** While qure.ai's software performs well in detecting specific abnormalities and providing quantitative analysis, its capabilities may be limited to certain types of conditions or organs. It may not cover the entire spectrum of radiological interpretations.
2. **Interpretation Variability:** The software's accuracy and performance may vary depending on the complexity and variability of cases. In challenging scenarios or rare conditions, the software may face difficulties in providing accurate interpretations.

2.2.1.3. Critique of Limitations and Areas for Improvement

1. **Internet Connectivity:** qure.ai's software assumes a stable and reliable internet connection for seamless collaboration among radiologists. In regions with limited internet access, the effectiveness of collaborative features may be compromised.
2. **Data Sharing and Privacy:** The software assumes proper data sharing agreements and adherence to patient privacy regulations. In settings where data sharing is restricted or privacy concerns are not adequately addressed, collaborative features may face limitations.

2.2.1.4. Assumptions Limiting Effectiveness in a Collaborative Environment

1. **Expanded Coverage:** qure.ai could further expand the coverage of abnormalities and conditions detected by their software to encompass a wider range of radiological interpretations. By addressing this limitation, the software could become more versatile and applicable to a broader array of cases.
2. **Improved Adaptability:** Enhancing the software's adaptability to handle complex and rare cases would contribute to its overall accuracy and reliability. Additional training on diverse datasets and incorporation of specialized algorithms could assist in overcoming challenges associated with interpretation variability.

2.2.2. MedDream Web DICOM Viewer [2]

2.2.2.1. Description

MedDream is a web-based DICOM viewer designed for medical professionals to efficiently access and interpret medical images. Its purpose is to provide a versatile and user-friendly platform for radiologists, physicians, and other healthcare providers to view, analyze, and collaborate on DICOM (Digital Imaging and Communications in Medicine) images. MedDream offers a wide range of features and capabilities to support efficient image interpretation and diagnosis.

2.2.2.2. Evaluation of Features and Capabilities

Strengths:
1. **Web-Based Accessibility:** Meddream's web-based architecture allows users to access the DICOM viewer from any web browser without the need for additional software installations. This flexibility enables easy accessibility across different devices and operating systems.
2. **Intuitive User Interface:** Meddream provides a user-friendly interface with customizable layouts and tools. Its intuitive design allows users to quickly navigate through images, adjust settings, and perform various measurements and annotations.
3. **Multi-Modality Support:** The viewer is capable of displaying various medical imaging modalities, including X-ray, CT, MRI, and ultrasound. This versatility enables radiologists to interpret different types of medical images within a single platform.

Weaknesses:
1. **Limited Advanced Analysis Tools:** While Meddream offers basic measurement and annotation tools, it may lack some advanced analysis features found in more specialized DICOM viewers. Advanced image processing capabilities, such as 3D reconstruction or specialized measurements, may not be available in Meddream.
2. **Performance with Large Data Sets:** Meddream's performance may be impacted when handling large DICOM datasets or high-resolution images. Loading and processing large volumes of data may lead to slower response times and affect the user experience.

2.2.2.3. Assumptions Limiting Effectiveness in a Collaborative Environment

1. **Internet Connectivity:** Meddream assumes a reliable internet connection for collaborative use, as it relies on real-time data exchange and image sharing. In areas with limited or unstable internet access, the collaborative features may be hindered.
2. **Compatibility with External Systems:** Meddream assumes compatibility and integration with other healthcare systems, such as Picture Archiving and Communication Systems (PACS) or Electronic Health Record (EHR) systems. Integration challenges or lack of interoperability may impact its effectiveness in collaborative environments.

2.2.2.4. Critique of Limitations and Areas for Improvement

1. **Enhanced Analysis Tools:** Expanding Meddream's analysis capabilities with advanced tools, such as 3D reconstruction, volume rendering, or computer-aided detection (CAD) algorithms, would enable more comprehensive image analysis and aid in diagnosis.
2. **Optimized Performance:** Improving the viewer's performance with large datasets and high-resolution images would enhance the user experience. Enhancements could include optimizing data loading, caching

2.2.3. Techniques and Related Research: Artificial intelligence in radiology [3]

Authors: T. Martín-Noguerol, F. Paulano-Godino, R. López-Ortega, J.M. Górriz, R.F. Riascos.
Published: National Library of Medicine, 2020
Summary: This research paper discusses the challenges and importance of collaborative work between radiologists, software engineers, and data science experts in the development and application of artificial intelligence (AI) algorithms in radiology. The integration of AI into radiology has the potential to improve diagnostic accuracy and patient healthcare. However, the multidisciplinary nature of AI development requires effective communication and understanding between radiologists and technical experts. The collaborative efforts outlined in the paper are essential for the validation and advancement of AI applications in radiology.

2.2.4. Web-based platform for collaborative medical imaging research [4]

Authors: Leticia Rittner, Mariana Pinheiro Bento, André L. Costa, Roberto Souza.
Published: SPIE Medical Imaging, 2015
Summary: This research paper proposes a collaborative research environment called Adessowiki for medical imaging research. The paper highlights the importance of having large image collections, image processing algorithms, hardware resources, and a multidisciplinary research team in medical imaging research. The Adessowiki platform aims to address these requirements by providing an integrated and accessible web-based environment. The platform also stores and displays the processing history and intermediate results, providing transparency and reproducibility. Additionally, Adessowiki leverages centralized tools and specialized hardware resources in the cloud for efficient processing. Overall, the paper presents Adessowiki as a collaborative solution that enhances the research capabilities in medical imaging by facilitating teamwork, accessibility, and reproducibility.

2.2.5. CheXpert [5]

Authors: Jeremy Irvin, Pranav Rajpurkar, Michael Ko, Yifan Yu, Silviana Ciurea-Ilcus, Chris Chute, Henrik Marklund, Behzad Haghgoo, Robyn Ball, Katie Shpanskaya, Jayne Seekins, David A. Mong, Safwan S. Halabi, Jesse K. Sandberg, Ricky Jones, David B. Larson, Curtis P. Langlotz, Bhavik N. Patel, Matthew P. Lungren, Andrew Y. Ng.
Published: Association for the Advancement of Artificial Intelligence, 2019
Summary: This research paper introduces CheXpert, a large dataset consisting of 224,316 chest radiographic images from 65,240 patients. The dataset includes a labeler designed to automatically detect 14 observations in radiology reports, accounting for the uncertainties involved in radiograph interpretation. The study explores different approaches to leveraging uncertainty labels in training convolutional neural networks for predicting the probability of these observations. The performance of the models is evaluated on validation and test sets, with comparisons made against radiologists' performance in detecting selected pathologies. The results show that the model outperforms the radiologists in detecting Cardiomegaly, Edema, and Pleural Effusion. The dataset is released to the public as a benchmark for evaluating chest radiograph interpretation models.

Chapter 3
System Requirements

The chapter on system requirements covers various aspects of the system, including functional, non-functional, database, and interface requirements. It delves into the specific needs and functionalities that the system should fulfil.

3.1. System Level Use Case Diagram
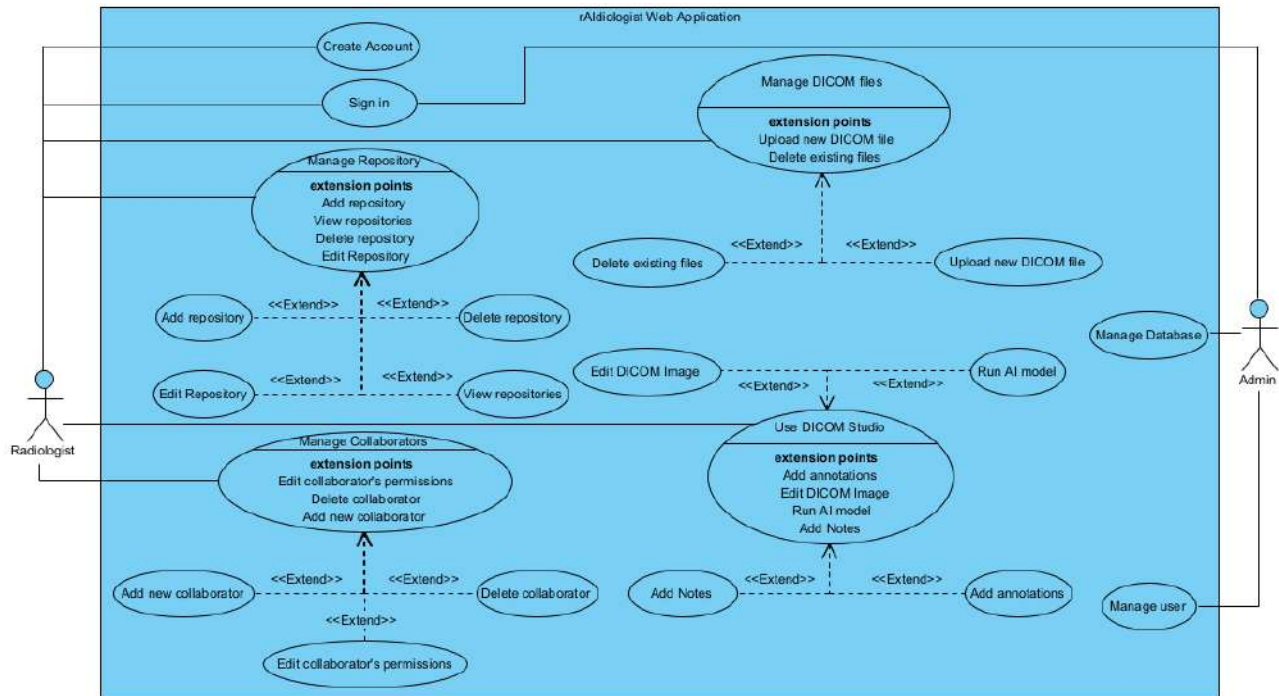
Figure 3.1: Use Case Diagram

3.1.2. Actors Description

3.1.2.1. Radiologist

Radiologist is the targeted audience of this project The radiologist is a healthcare expert with specialized knowledge in analyzing medical images, including X-rays, CT scans, MRI scans, and ultrasound images. Their primary role involves interpreting these images to accurately diagnose and monitor diseases or conditions in patients.

3.1.2.2. Admin

Admin is the superuser that will control all the other users. Admin will have special permission to enable/disable or permanently delete user from the system.

3.2. Functional Requirements presented as Use Case Descriptions

3.2.1. Radiologist

3.2.1.1. Create Account

Table 3.1: Create Account Use Case Description.

Use Case ID:	**UC-US-01**	
Use Case Name:	**Create Account**	
Actor(s):	**Radiologist**	
Pre-Conditions:	User is at Sign up screen. User is not previously registered.	
Priority:	Medium	
Basic Flow:	User enters his/her data and presses sign up button.	
Actor Actions		**System Response**
1	User enters a unique username, password, and gender in the relevant fields. User clicks on "Sign Up" button	**1.** System validates the entered data and user is registered.
Alternative Course of Action (if any)		
Actor Action		**System Response**
1	User enters invalid data.	1a) Empty field error. 1b) Password not matching. 1c) Weak Password. 1d) User already registered.

3.2.1.2. Sign in for Radiologist.

Table 3.2: Sign in for Radiologist Use Case Description.

Use Case ID:	**UC-US-02**	
Use Case Name:	**Sign In for Radiologist**	
Actor(s):	**Radiologist**	
Pre-Conditions:	User is at Sign in screen. User is already registered.	
Priority:	High	
Basic Flow:	User enters his/her credentials and presses sign in button.	
Actor Actions		**System Response**
1	User enters a username and password in the relevant fields. User clicks on "Sign In" button	**1.** System validates the credentials and Home Screen is displayed.
Alternative Course of Action (if any)		
Actor Action		**System Response**
1	User enters invalid credentials.	1a) Empty field error 1b) Invalid password 1c) Sign in blocked after 3 consecutive failed attempts. 1d) User not registered

3.2.1.3. Manage Repository

Table 3.3: Manage Repository Use Case Description.

Use Case ID:	UC-US-03	
Use Case Name:	**Manage Repository**	
Actor(s):	**Radiologist**	
Pre-Conditions:	User is already Signed in. User is at Home Screen	
Priority:	High	
Basic Flow:	User manages all his/her repositories.	
Actor Actions		**System Response**
1	User enters repository details in the relevant fields. User clicks on "Add" button	1. System creates a new repository.
2	User opens Repository Settings Screen. User clicks on "Delete" button	1. System deletes the selected repository.
3	User opens Repository Settings Screen. User clicks on "Edit" button.	1. System validates the changes. 2. System saves changes in database.
4	User view list of all repositories.	1. System retrieves all the repositories from database. 2. System displays repositories to user.
Alternative Course of Action (if any)		
Actor Action		**System Response**

3.2.1.4. Manage Collaborators

Table 3.4: Manage Collaborators Use Case Description.

Use Case ID:	UC-US-04	
Use Case Name:	**Manage Collaborators**	
Actor(s):	**Radiologist**	
Pre-Conditions:	User is already Signed in. User is at Collaborator Screen	
Priority:	High	
Basic Flow:	User manages collaborators for his/her repositories.	
Actor Actions		**System Response**
1	User presses "Add Collaborator" button. User enters an email of another user and presses "Add" button	1. System verifies the email then add user as a collaborator to repository.
2	User selects a Collaborator from list and presses "Remove" button,	1. System removes the selected collaborator.
3	Users selects checkbox to set permissions for the collaborator.	1. System saves the selected permissions for the collaborator.
Alternative Course of Action (if any)		
Actor Action		**System Response**
1	User enters an invalid email.	1a) Empty field error. 1a) System displays invalid email error.
2	Users enters email of already added collaborator	2a) System displays user already added error.

3.2.1.5. Manage DICOM Files

Table 3.5: Manage DICOM Files Use Case Description.

Use Case ID:	UC-US-05	
Use Case Name:	**Manage DICOM Files**	
Actor(s):	**Radiologist**	
Pre-Conditions:	User is already Signed in. User is at File Explorer Screen	
Priority:	High	
Basic Flow:	User manages all his/her DICOM Files.	
Actor Actions		**System Response**
1	Users presses "Add" button, selects a file and presses "Upload" button.	**1.** System uploads the selected file into the repository.
2	User selects a file and presses "Delete" button.	**1.** System deletes the selected file from the repository.
Alternative Course of Action (if any)		
Actor Action		**System Response**
1	User cancels/interrupts uploading process.	1a) System displays upload error

3.2.1.6. Use DICOM Studio

Table 3.6: Use DICOM Studio Use Case Description.

Use Case ID:	UC-US-06	
Use Case Name:	**Use DICOM Studio**	
Actor(s):	**Radiologist**	
Pre-Conditions:	User is already Signed in. User is at DICOM Studio screen	
Priority:	High	
Basic Flow:	User open file in DICOM studio.	
Actor Actions		**System Response**
1	User clicks on "Add Note" button, writes a Note.	**1.** System saves the note in database.
2	User uses sliders to adjust brightness and opacity of DICOM image.	**1.** System adjusts brightness, and opacity of DICOM image according to user's input.
3	User clicks on "Draw" button and draws different shapes on DICOM images.	**1.** System responds to user input and draws shapes on DICOM Image.
4	User clicks on "Run AI Model" buttons to run and view results of AI model.	**1.** System runs AI model on DICOM images and displays results to user.
Alternative Course of Action (if any)		
Actor Action		**System Response**

3.2.2. Admin

3.2.2.1. Manage User

Table 3.7: Manage User Use Case Description.

Use Case ID:	UC-US-7	
Use Case Name:	**Manage User**	
Actor(s):	**Admin**	
Pre-Conditions:	User is at Admin Dashboard screen.	
Priority:	Medium	
Basic Flow:	User enters details of a new user and presses "Add" button.	
Actor Actions		**System Response**
1	User selects a user from the list and presses "Enable" button.	**1.** System changes the selected user status to "Enabled".
2	User selects a user from the list and presses "Disable" button.	**1.** System changes the selected user status to "Disabled".
3	User selects a user from the list and presses "Delete" button.	**1.** System deletes the selected user.
Alternative Course of Action (if any)		
Actor Action		**System Response**

3.2.2.2. Manage Database

Table 3.8: Manage Database Use Case Description.

Use Case ID:	UC-US-8	
Use Case Name:	**Manage Database**	
Actor(s):	**Admin**	
Pre-Conditions:	User is at Admin Dashboard screen.	
Priority:	Low	
Basic Flow:	User selects a user and change his/her status.	
Actor Actions		**System Response**
1	Admin selects a user and permanently deletes his/her data from database.	**1.** System deletes all the selected user data from database.
Alternative Course of Action (if any)		
Actor Action		**System Response**

3.2.2.3. Sign in for Admin.

Table 3.9: Sign in for Admin Use Case Description.

Use Case ID:	UC-US-7	
Use Case Name:	Sign In for admin	
Actor(s):	Admin	
Pre-Conditions:	User is at Sign in screen.	
Priority:	High	
Basic Flow:	User enters his/her credentials and presses sign in button.	
Actor Actions		System Response
1	User enters a username and password in the relevant fields. User clicks on "Sign In" button	1. System validates the credentials and Admin Dashboard Screen is displayed.
Alternative Course of Action (if any)		
Actor Action		System Response
1	User enters invalid credentials.	1a) Empty field error 1b) Invalid password 1c) Sign in blocked after 3 consecutive failed attempts

3.3. Non-Functional Requirements

3.3.1. Performance Requirements

- The system response time to the user requests must not exceed 1 seconds.
- System should be able to handle around 10000 users concurrently without affecting its performance.

3.3.2. Safety Requirements

There is no possible damage by using our system.

3.3.3. Software Quality Attributes

- **Reliability**: The system should be reliable enough to sustain in any condition and should protect its user's private data. It Should give the correct results consistently.
- **Availability**: The system should be available 24/7 for its users.
- **Usability**: The system should prioritize user-friendliness, ensuring ease of use and a simple learning curve. It should offer straightforward navigation, making it easy for users to find their way around.
- **Portability**: Our System will be a web application so it can run on any web bowers without any porting issues
- **Efficiency**: The system should utilize processor capacity, disk space, and memory efficiently and provide faster results
- **Integrity:** The system's integrity and security measures should be robust enough to prevent unauthorized access to system functions, safeguard against information loss, protect the software from virus infections, and ensure the privacy of the data stored within the system.

3.3.4. Security Requirements

- Authorized access for each user (log-in)
- Each user will be restricted to their respective functionalities.

3.3.5. Business Rules

- Only a Signed in user should be able to use DICOM Studio.
- Only Data related to the patient should be stored in the Personal Repositories of Radiologists.

3.4. Interface Requirements

3.4.1. User Interfaces

rAIdiologist must have the following user interfaces: -
- Sign Up
- Sign In
- Home Screen
- Files Explorer
- DICOM Studio
- Collaborator Screen
- Admin Dashboard Screen

3.4.2. Hardware Interfaces

Not Applicable for our system.

3.4.3. Software Interfaces

The tools and technologies which will be used in the development of the system are:
- Frameworks: Flutter, Node JS
- Language: Dart for front and Python and JavaScript for backend.
- Libraries: DWV, TensorFlow, FastAPI, Express
- Database: PostgreSQL
- Tools: VS Code, Google Collab

3.4.4. Communications Interfaces

- Backend API and AI Model
- Web browser
- TCP/IP and HTTP

3.5. Conclusion

The project requirements are most important part of project development. They should be found and accurate with discussions with stakeholders. The requirements can be functional, non-functional, database or interface etc related. Their accuracy can minimize or remove major issues that arise in project development and delivery.

Chapter 4

System Design

In this section, we will discuss the design and architecture of our system and how it has been implemented to develop the system.

4.1. Design Approach

The design approach employed in the development of this application is object-oriented. By adopting this approach, we structured our application around the fundamental concept of objects. In the object-oriented design approach, we identified the key entities within the application and encapsulated their data and behavior into objects. Each object represents a distinct entity or concept within the application, possessing its own attributes (data) and methods (behavior). These objects interact with one another, exchanging information and collaborating to achieve the desired functionality.

By utilizing the object-oriented design approach, we were able to create a modular and scalable application. The encapsulation of data and behavior within objects promotes code reusability, as objects can be easily reused and extended in different parts of the application. Additionally, this approach allows for a clearer understanding of the application's structure, making it easier to maintain and modify the codebase in the future.

4.2. System Architecture

The software follows service-oriented architecture. The software will have three tiers architecture consisting of following layers: -
• Presentation layer, which is Flutter.
• Business layer, which is FastAPI, Node JS.
• Data layer, which is PostgreSQL Server.
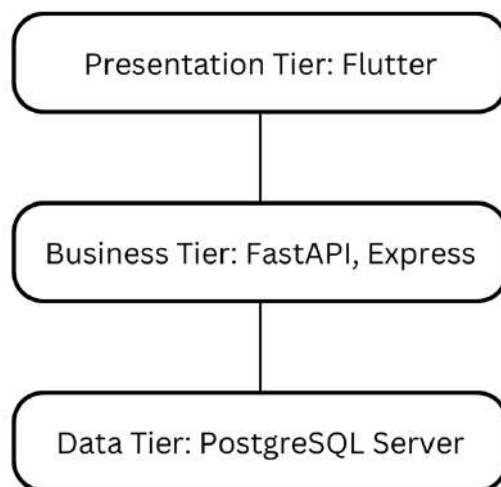
Figure 4.1: Architecture Diagram
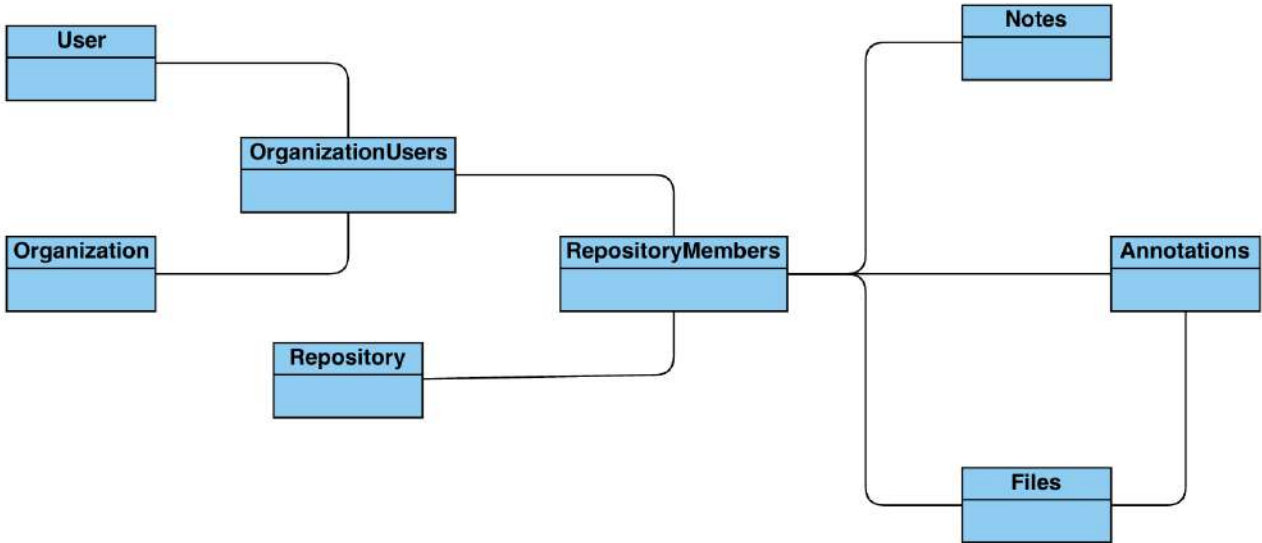
4.3. Logical Design

4.3.1. Domain Model

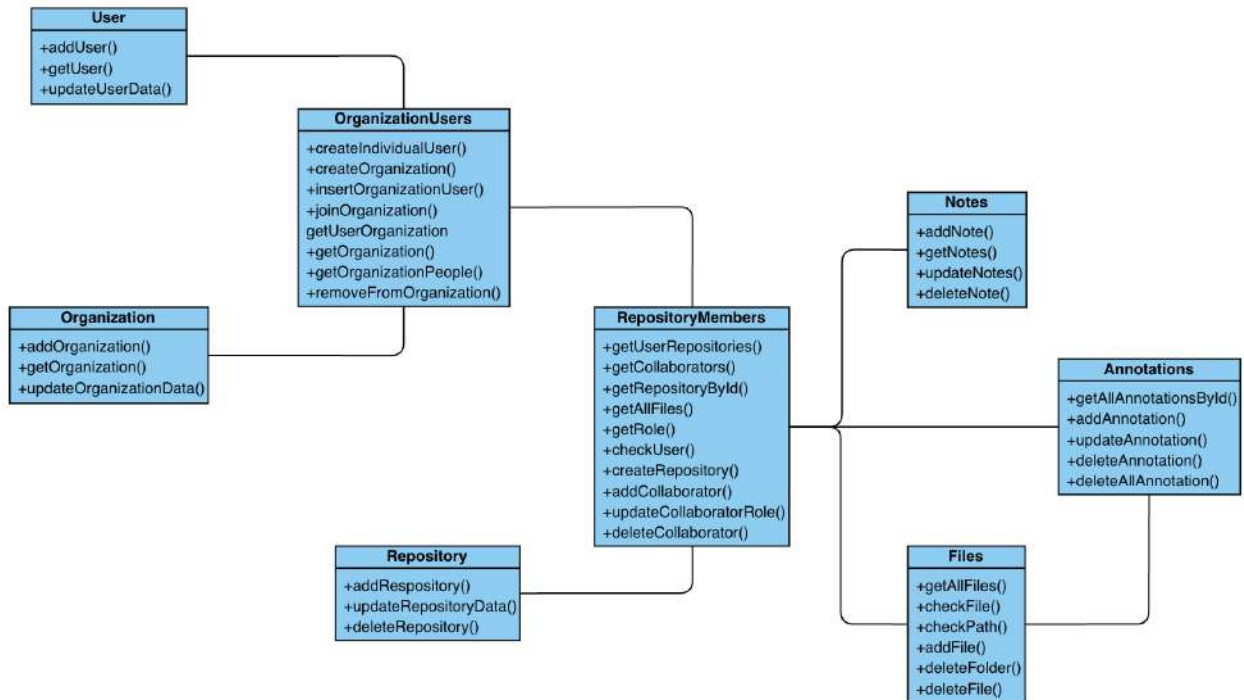**Figure 4.2:** Domain Model

4.3.2. Class Diagram

Figure 4.3: Class Diagram

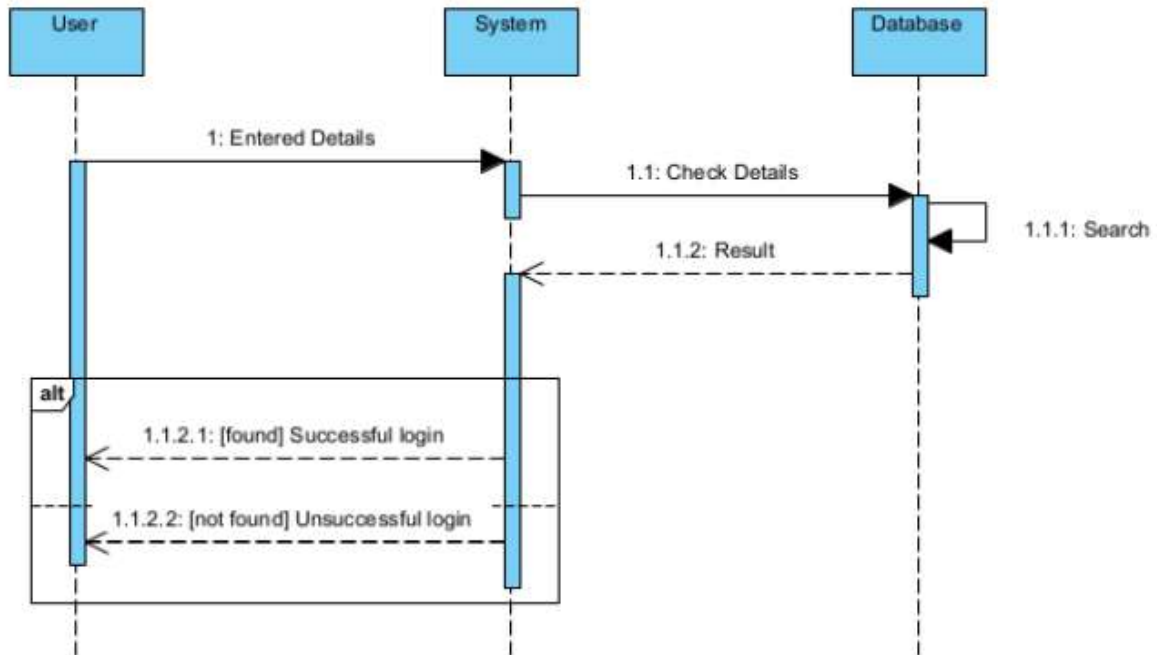## 4.4. Dynamic View

3.2.1. Login Sequence

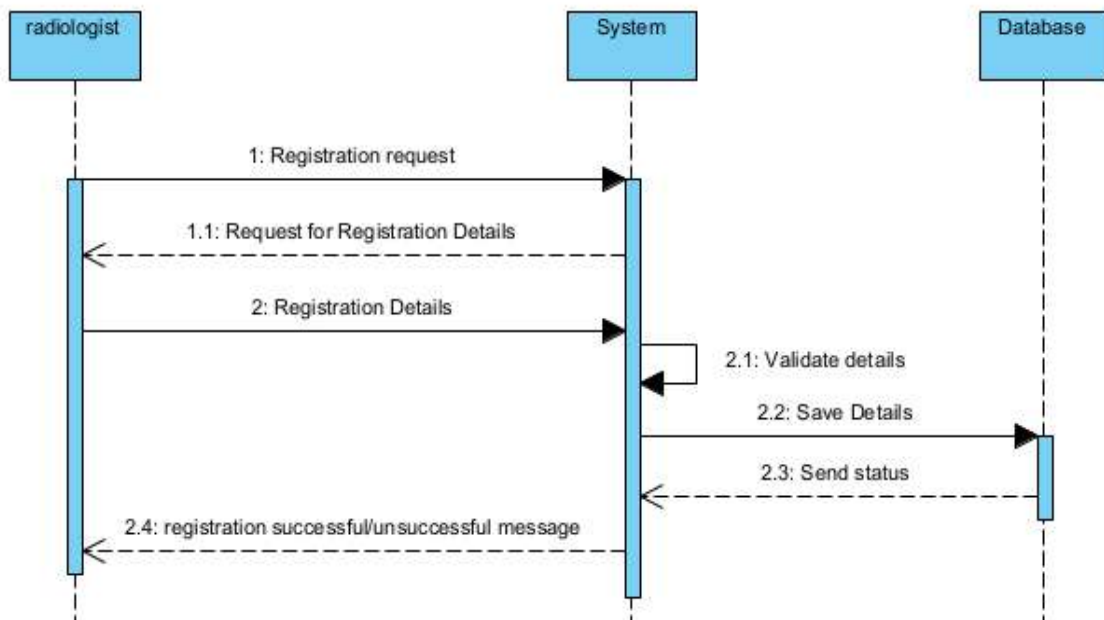**Figure 4.4:** Login Sequence Diagram

3.2.2. Signup sequence

Figure 4.5: Signup Sequence Diagram
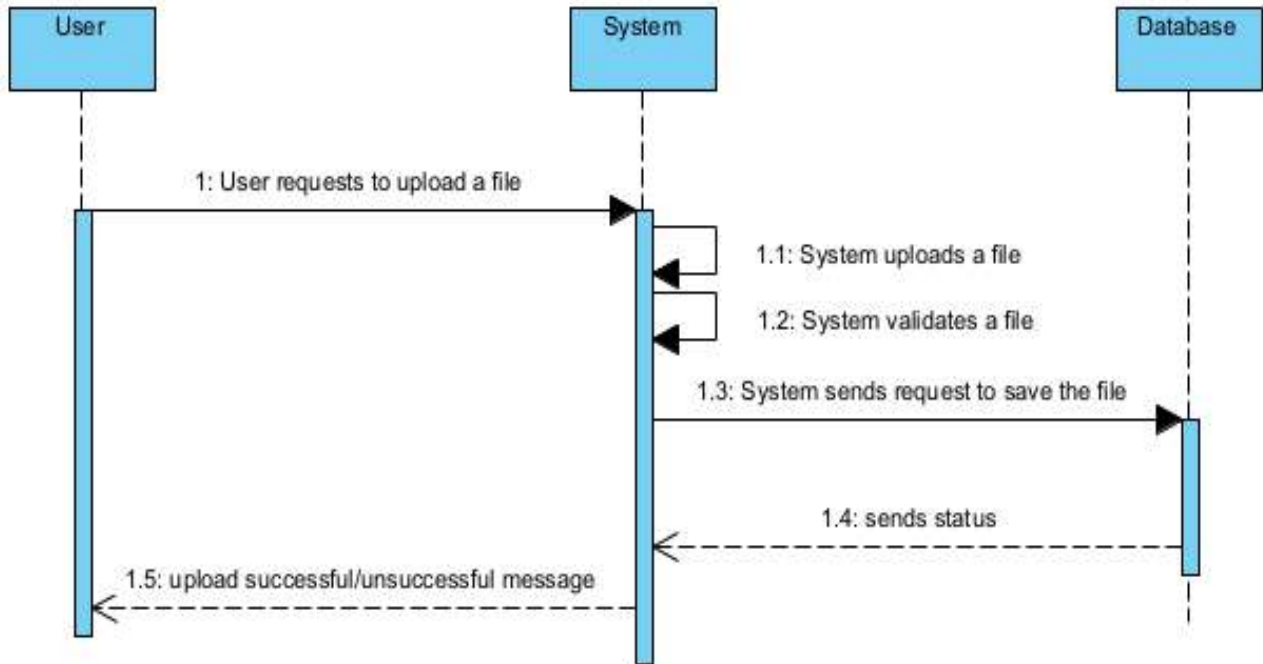
3.2.3. Upload Sequence

Figure 4.6: Upload Sequence Diagram
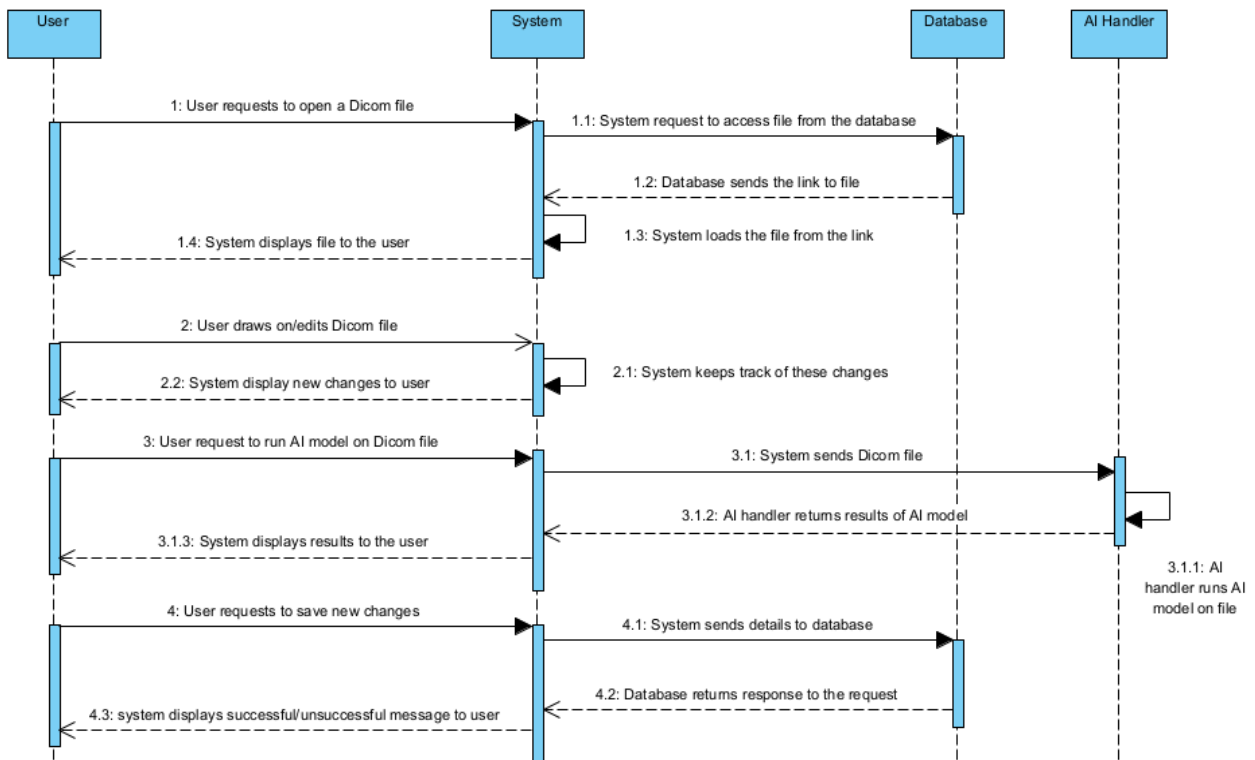
3.2.4. DICOM Studio Sequence

Figure 4.7: DICOM Studio Sequence Diagram
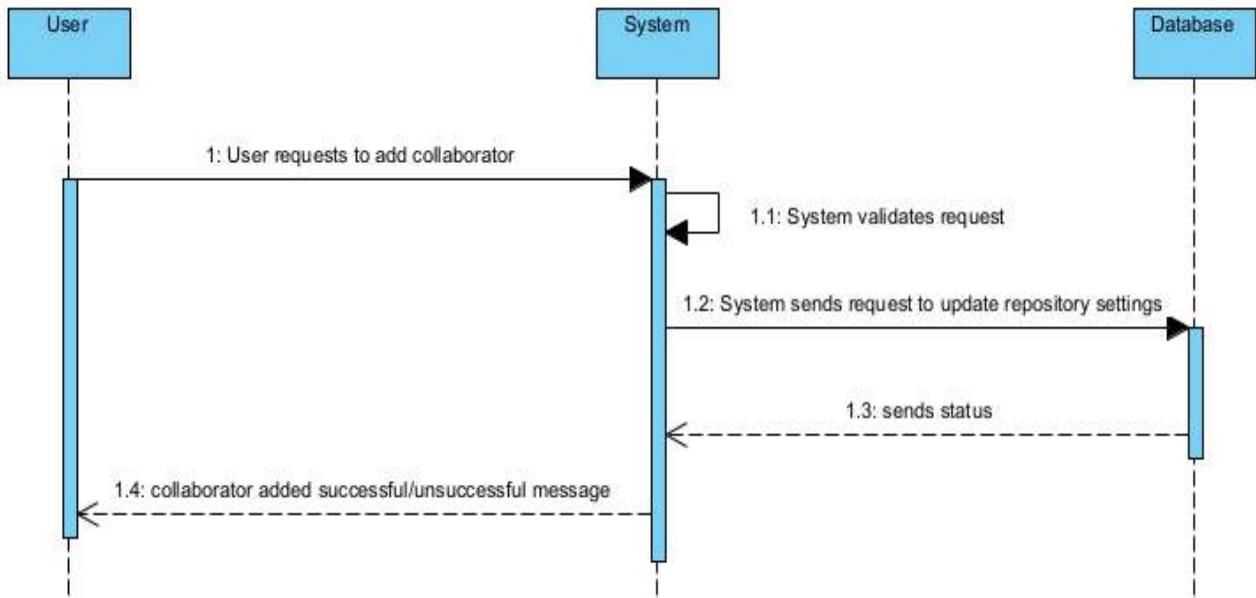
3.2.5. Add collaborator Sequence

Figure 4.8: Add collaborator Sequence Diagram

4.5. Component Design
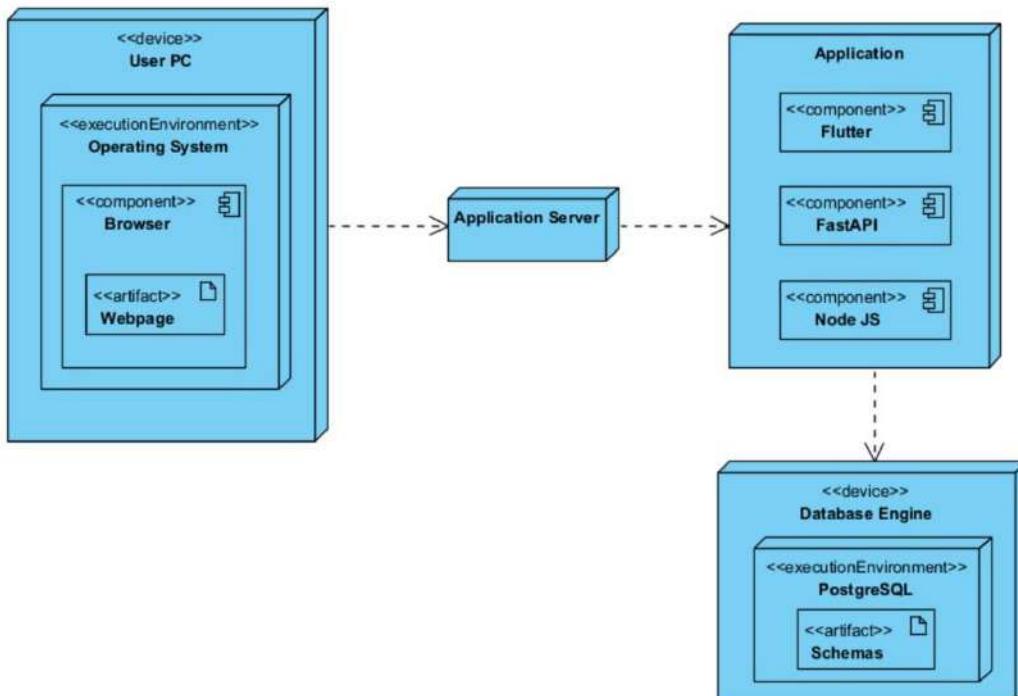
Figure 4.9: Deployment Diagram

4.6. Data Models
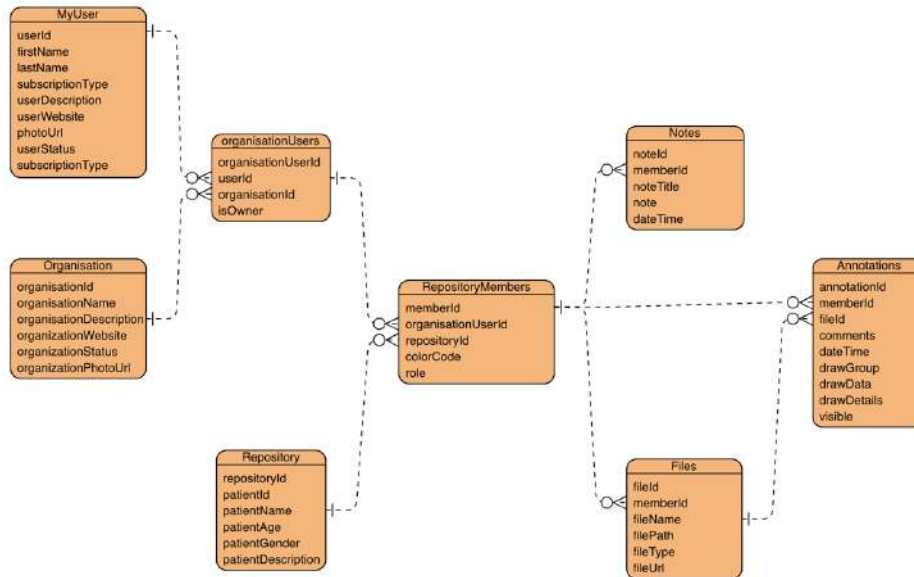
Figure 4.10: Entity Relationship Diagram

4.7. User Interface Design

User interface designs helps users in understanding and using system features. Low fidelity prototypes of the system are:

4.7.1. Sign In Screen
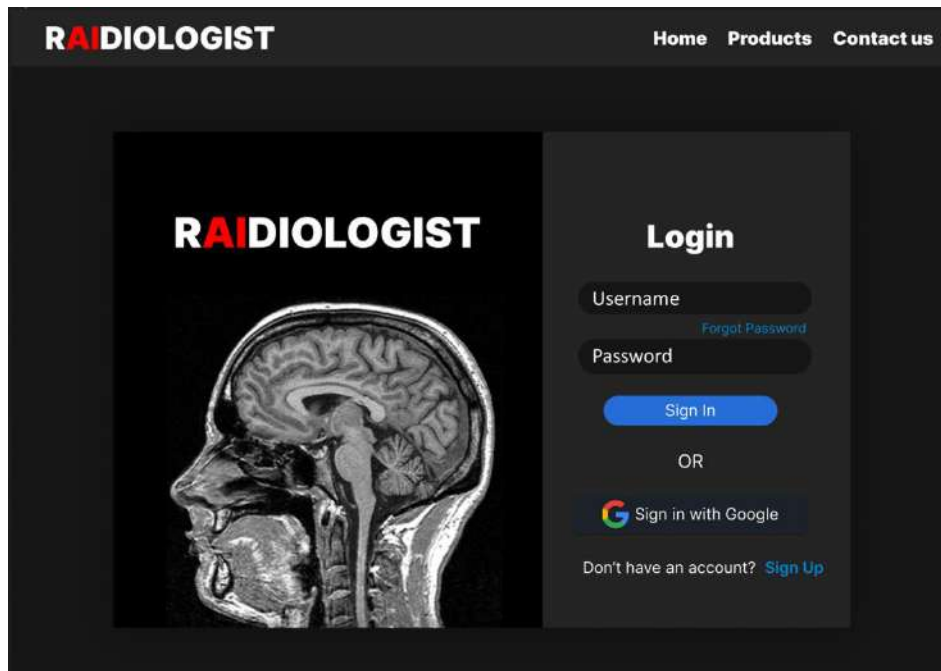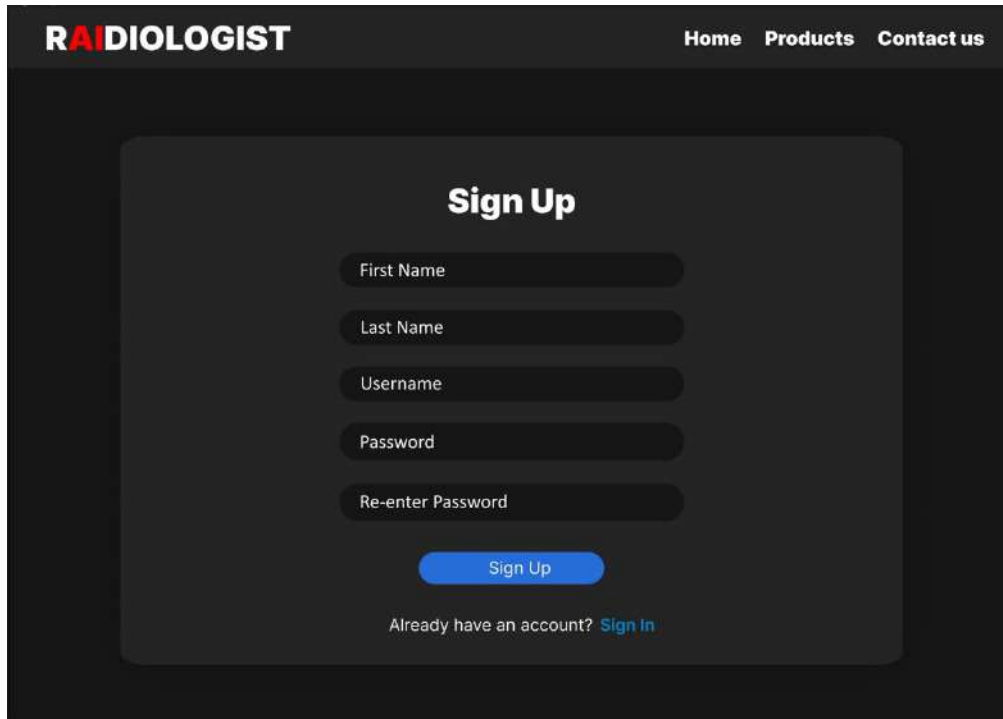
Figure 4.11: Sign In Screen Prototype

4.7.2. Sign Up Screen

Figure 4.12: Sign Up Screen Prototype

4.7.3. Home Screen

Figure 4.13: Home Screen Prototype

36

4.7.4. File Explorer Screen
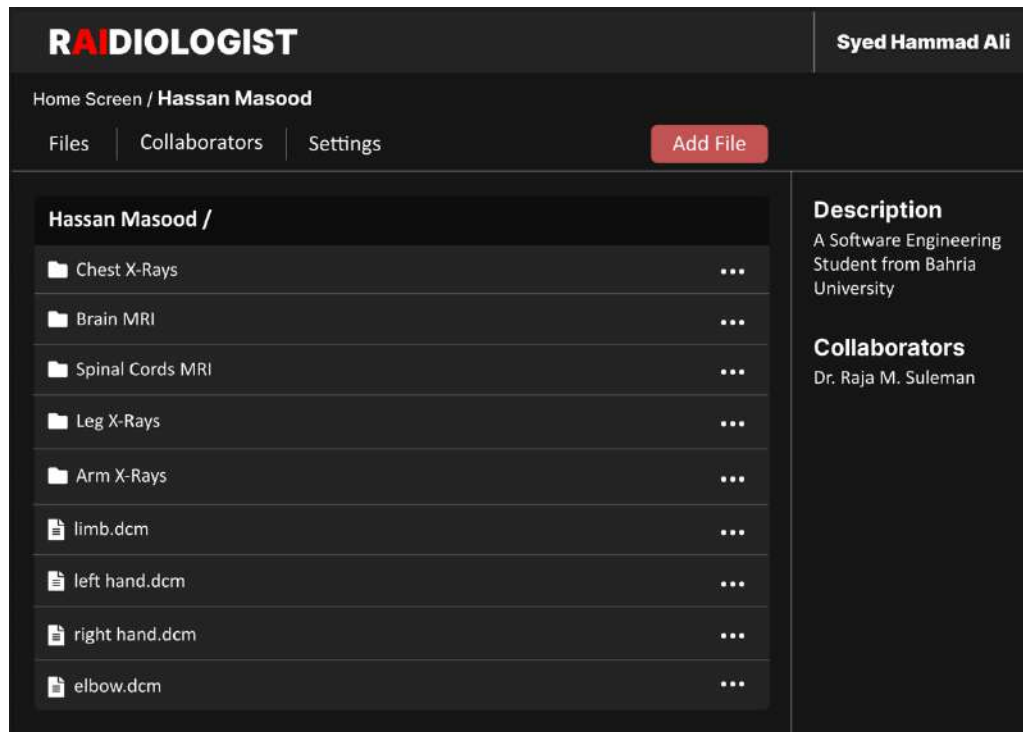
Figure 4.14: File Explorer Prototype

4.7.5. Collaborators Screen
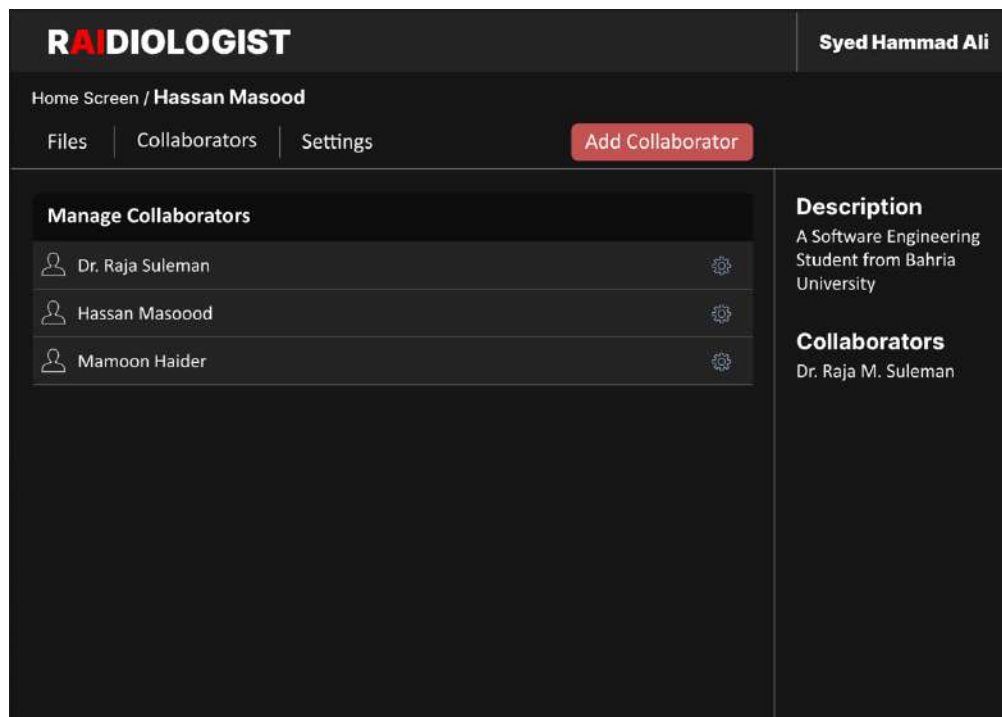
Figure 4.15: Collaborators Screen Prototype

4.7.6. DICOM Studio
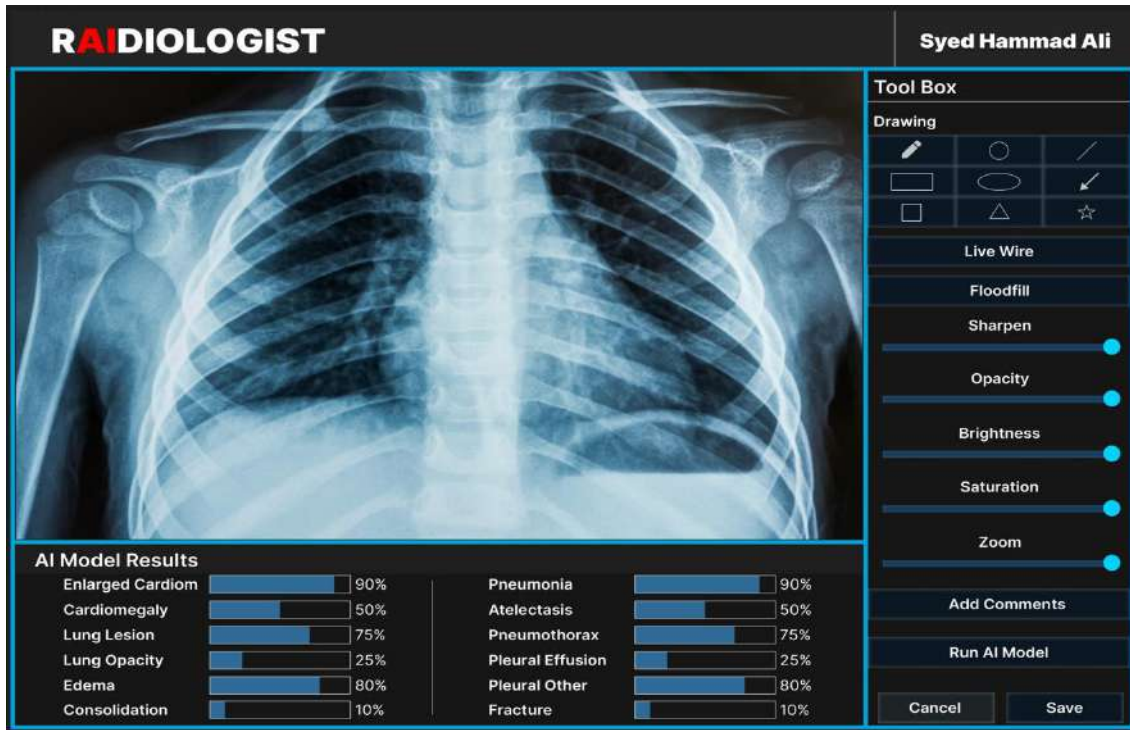
Figure 4.16: DICOM Studio Prototype

4.8. System Prototype

4.8.1. DICOM Studio
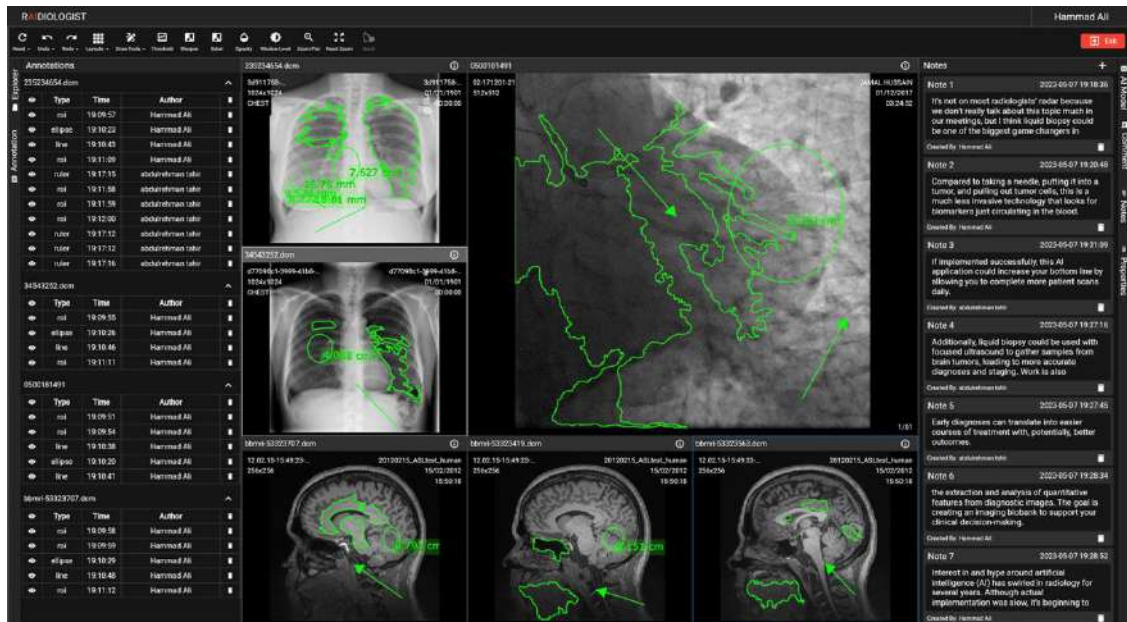
Figure 4.17: DICOM Studio

4.8.2. DICOM Studio (AI Results)
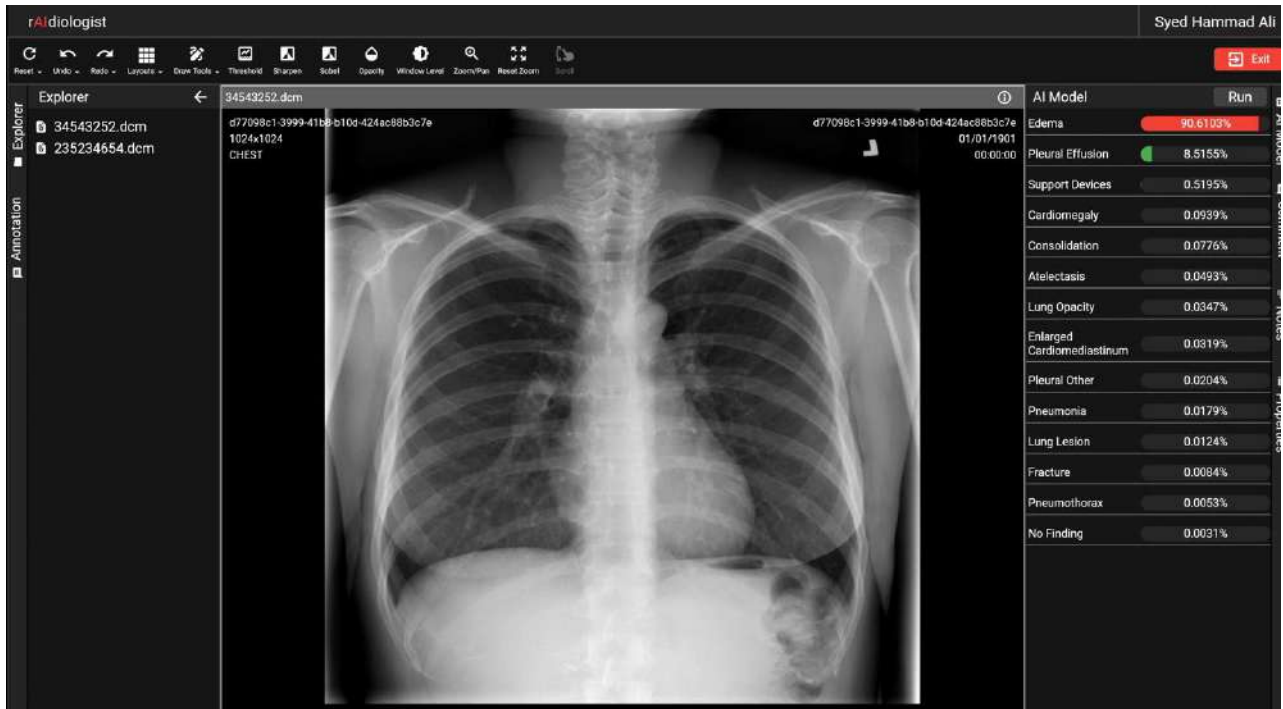
Figure 4.18: DICOM Studio (AI Results)

4.8.3. Create Personal Repository
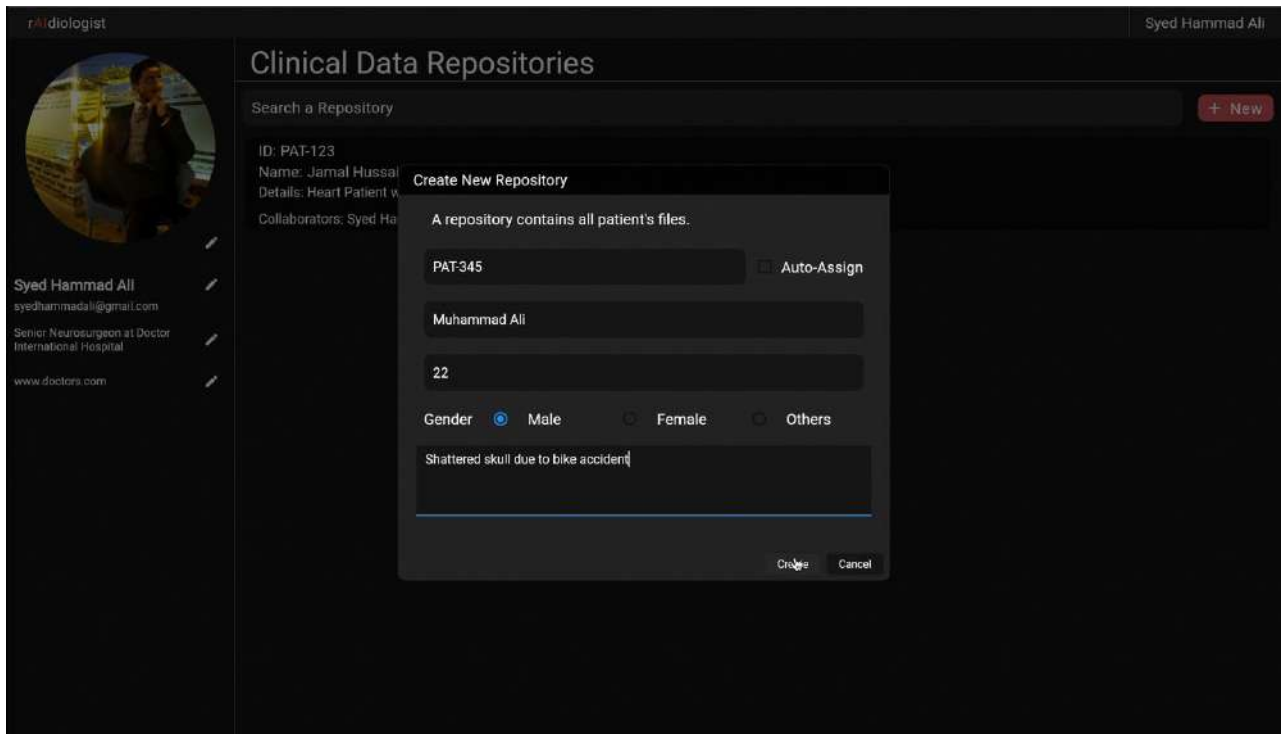
Figure 4.19: Create Personal Repository

4.8.4. Personal Repositories Screen
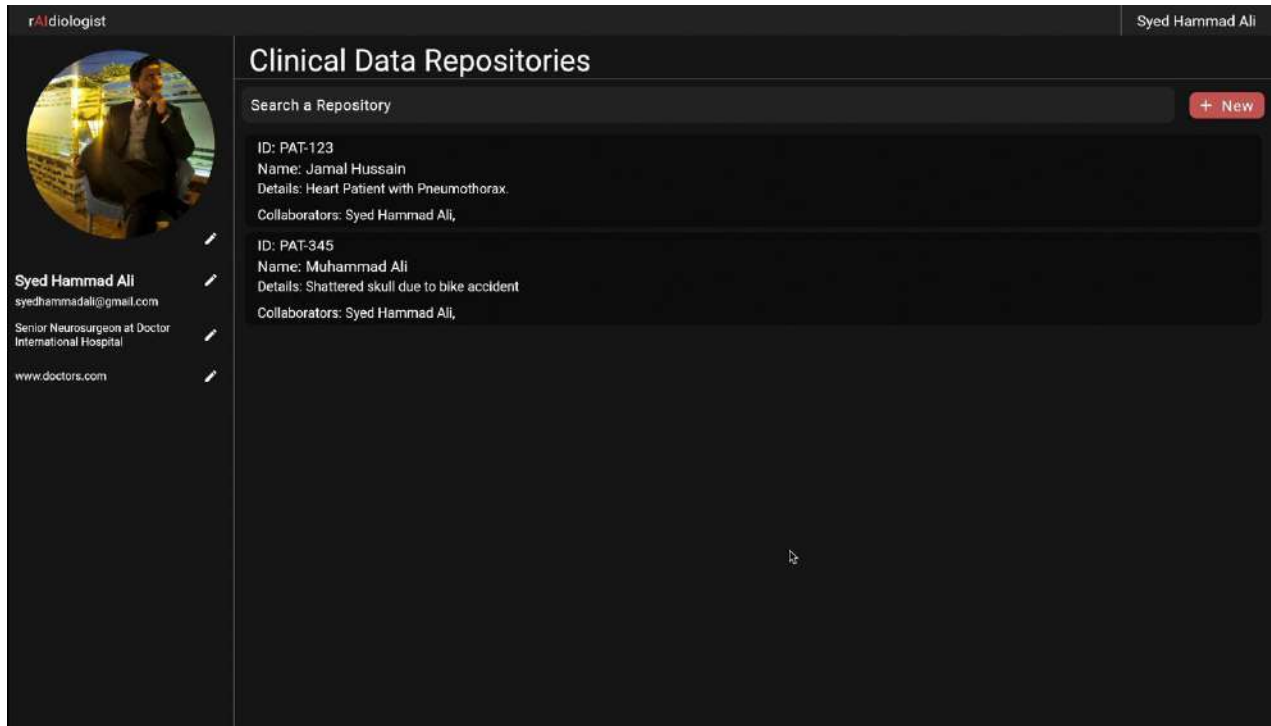
Figure 4.20: Personal Repositories Screen

4.8.5. File Explorer Screen
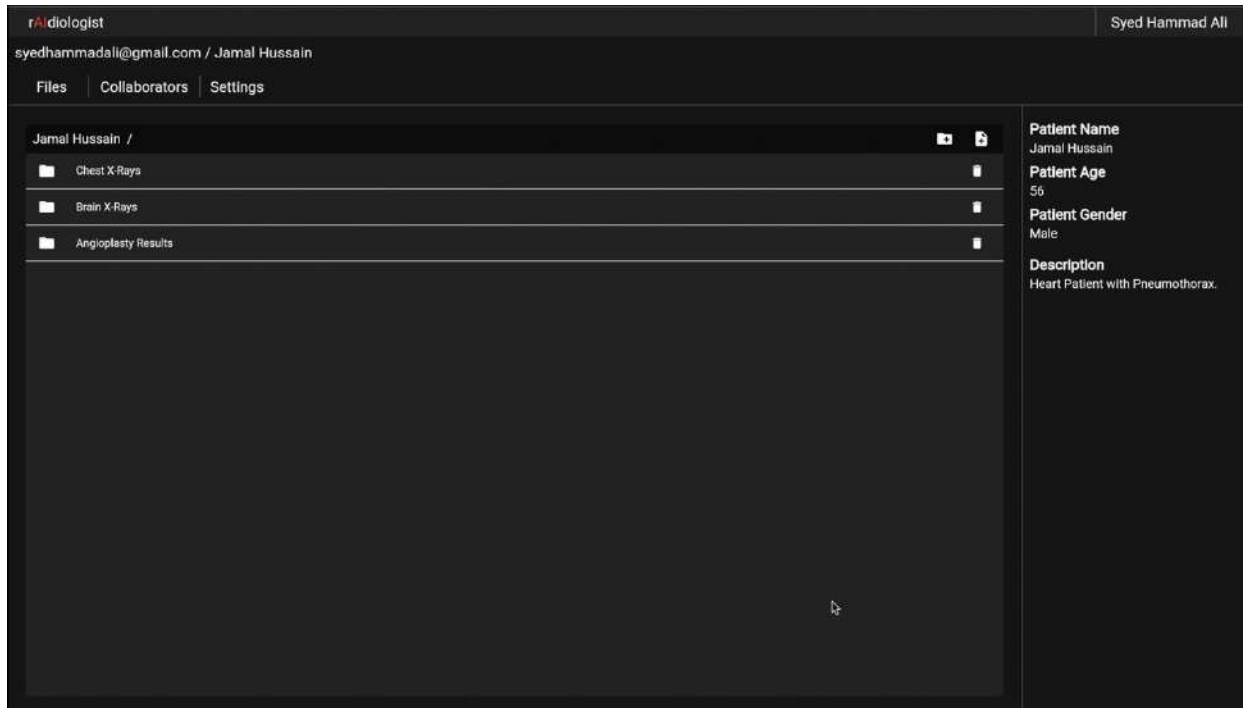
Figure 4.21: File Explorer Screen

4.8.6. Manage Collaborators Screen
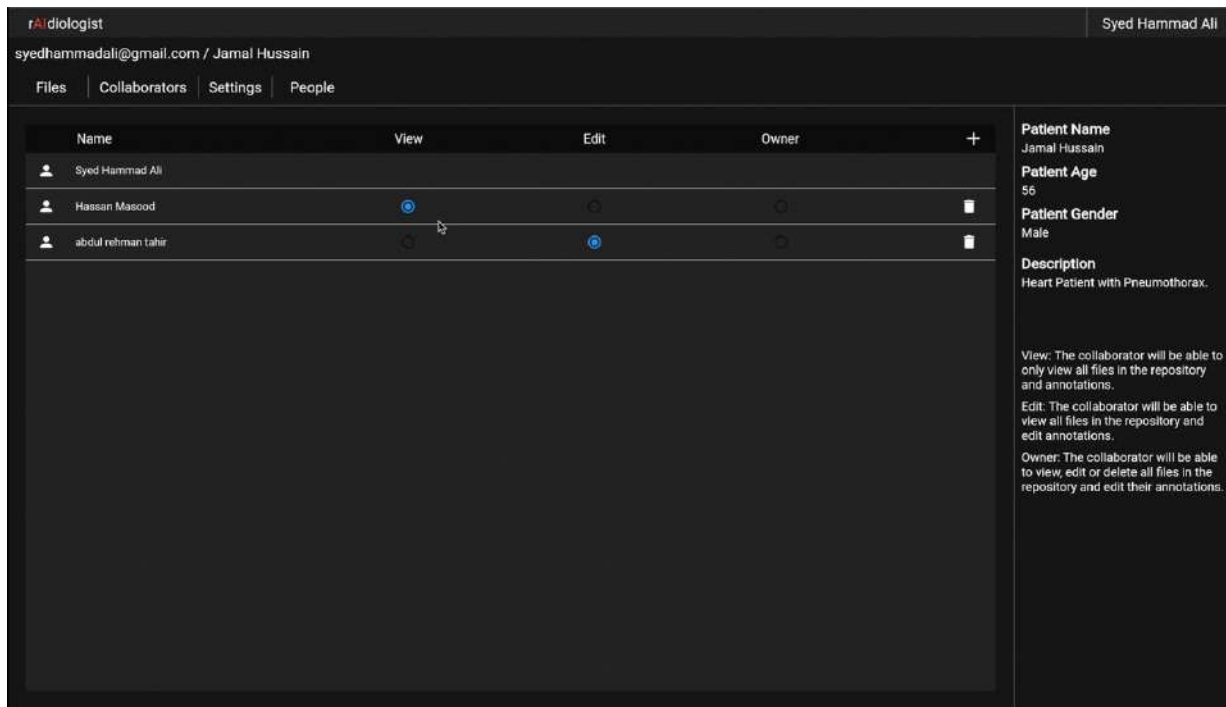
Figure 4.22: Manage Collaborators Screen

4.8.7. Organization Dashboard Screen (Members List)
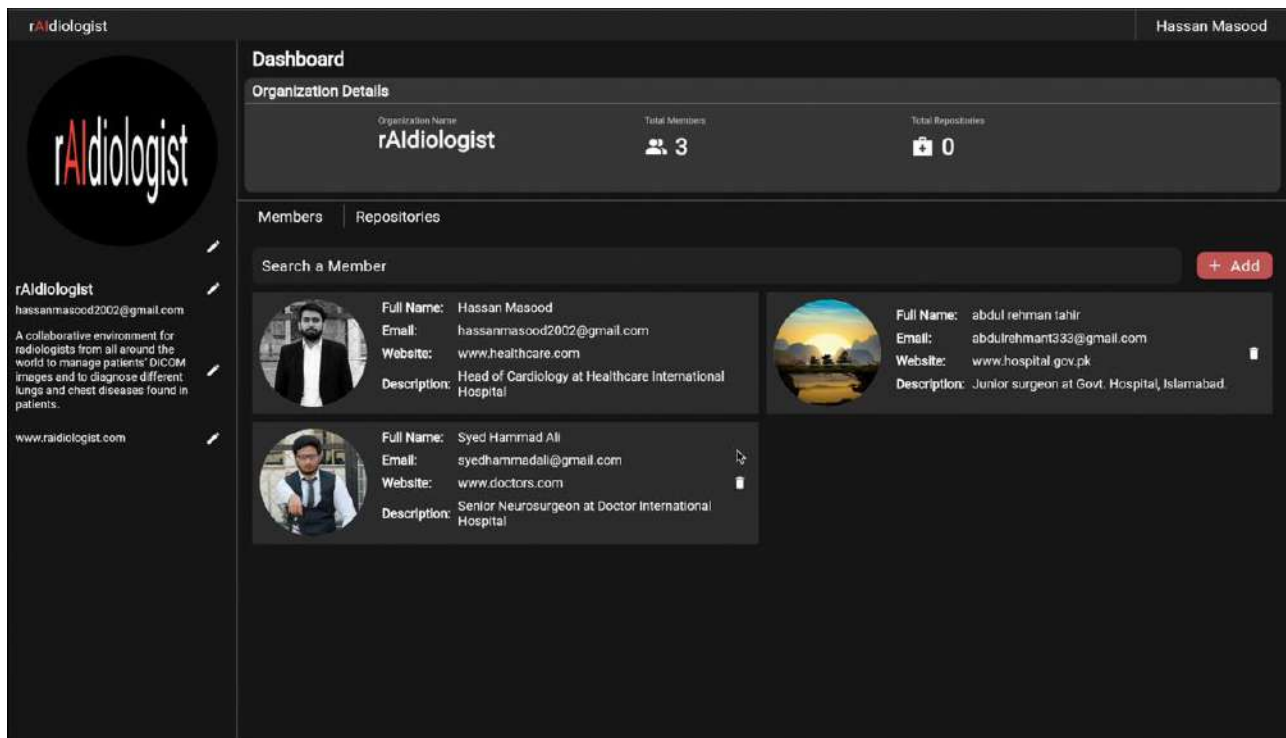
Figure 4.23: Organization Dashboard Screen (Members List)

4.8.8. Organization Dashboard Screen (Repositories List)
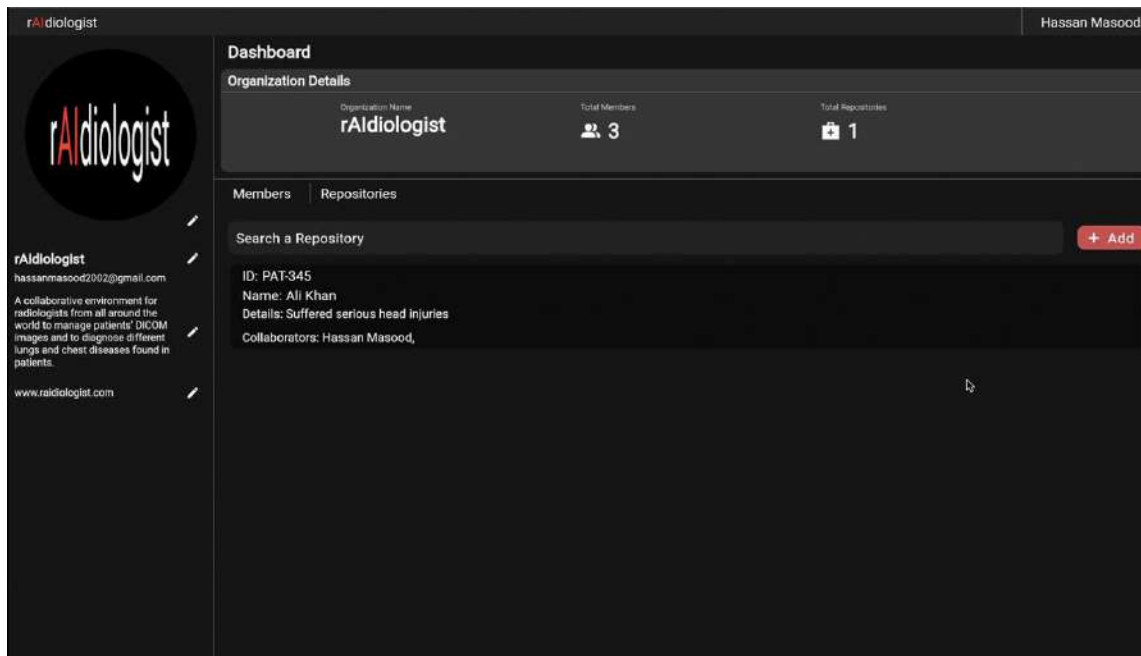
Figure 4.24: Organization Dashboard Screen (Repositories List)

4.9. Conclusion

System Design gives detailed information about the system. In its system models and views are made which helps in making development/implementation consistent with system architecture. It can help in reusability. It makes communication between the system development teams more accurate.

Chapter 5

System Implementation

5.1. Tool Used

The tools and libraries which will be used in the development of the system are:
- Frameworks: Flutter, Node JS
- Language: Dart for front and Python and JavaScript for backend.
- Database: PostgreSQL
- Tools: VS Code, Google Collab

5.2. Libraries

The libraries that we have used for this project implementation are:
1. DWV
2. Express
3. Cors
4. Pg
5. LibAUC
6. BytesIO
7. Matplotlib
8. Pydicom
9. Cv2
10. Requests
11. PIL
12. Numpy
13. Torchivision
14. Pylibjpeg
15. Json
16. FastAPI
17. Tensorflow

5.3. Front-end

rAIdiologist is web application and **Flutter** framework is used to implement its front-end. Flutter uses Node JS package to parse and add annotations to DICOM Images.

5.3.1. Flutter

Flutter is a freely available framework developed by Google, designed to create visually appealing, natively compiled applications that can run on multiple platforms using a single codebase. It allows developers to build cross-platform applications for various operating systems, including Android, iOS, Linux, macOS, Windows, Google Fuchsia, and the web. Initially introduced in 2015, Flutter was officially launched in May 2017. It enjoys extensive support from Google, is widely embraced by renowned brands globally, and benefits from continuous maintenance and contributions from a diverse community of developers worldwide.

5.3.2. Why Flutter?

Flutter is one of the best choices for web development in 2023 and going to be in trend for several years. Nowadays web apps for start-ups and large-scale enterprises are very important because digital presence helps to grow the business. Flutter has a layered architecture that helps developers in data management and streamlines the workflow. It helps to boost the productivity of the developers through the most efficient designs of web apps.

5.4. AI Model

The system uses AI model to predict lungs and chest disease in patient's chest X-ray. The model is trained using Stanford's CheXpert. The model is designed to analyze a single-view chest radiograph as input and provide the probability values for each of the 14 observations as output.

5.4.1. CheXpert

CheXpert is a publicly available extensive dataset designed for the interpretation of chest radiographs. It encompasses a collection of 224,316 chest radiographs derived from 65,240 patients. Notably, this dataset incorporates uncertainty labels and reference standard evaluation sets labeled by radiologists. The AI model employed in our system utilizes this dataset as a foundational resource.

5.4.2. Why CheXpert?

Chest radiography holds global significance as the most frequently conducted imaging examination, playing a crucial role in the screening, diagnosis, and management of numerous life-threatening diseases. The integration of automated chest radiograph interpretation, comparable to the expertise of practicing radiologists, can bring substantial advantages across various medical settings. To advance the development and validation of automated algorithms, it became evident that a labelled dataset meeting specific criteria was required. This dataset needed to be extensive in size, possess robust reference standards, and provide expert human performance metrics for effective comparison.

5.5. DICOM Web Viewer

The system uses Node package **dwv** to parse DICOM images and add annotations on them. It is integrated with Flutter in the front-end to display DICOM Images and their data. It is also used to add annotations on the image or change its brightness level, opacity level and threshold levels.

5.5.1. DWV

DWV (DICOM Web Viewer) is a freely available medical image viewer library that operates without leaving any footprint. It is developed using JavaScript and HTML5 technologies, enabling it to run seamlessly on various platforms equipped with modern web browsers, including laptops, tablets, smartphones, and even modern televisions. The viewer is capable of loading both local and remote data in DICOM format, which is the standard for medical imaging data encompassing modalities like MR, CT, Echo, Mammo, and NM. It offers a range of standard tools for image manipulation, such as contrast adjustment, zooming, dragging, and the ability to draw regions on top of the image. Additionally, it provides imaging filters like thresholding and sharpening.

5.5.2. Why DWV

Dwv is light weight DICOM Web Viewer that provides fast and easy parsing of DICOM files as well as different editing and annotations options. DWV provides functionalities such as sharpening the image, applying filters, adjust brightness, opacity and threshold levels, draw different annotations on DICOM Images.

5.6. Conclusion

In this era each software is made using some existing software and tools that we also have used to make this project. The system is implemented according to the requirements. The development approaches made were appropriate and helpful. Most of the software development time was spent on system implementation.

Chapter 6

System Testing & Evaluation

We put the system through a series of tests to ensure that each part of it was functioning properly and giving us the results, we expected. Our goal was to make sure that every feature in the system was working correctly and producing the outcomes we wanted. By doing these tests, we wanted to make sure that everything was running smoothly, and that the system was doing what it was supposed to do.

6.1. Test Strategy

First unit testing was performed to test each component of the application. Integration testing were carried out to check that system components are working fine with each other. Finally, the black box testing was performed to test the application against the requirements specification.

6.2. Unit Testing

Unit testing was performed for each module to confirm that it gives the expected result. The intent of unit testing was to find bug in individual component of the application and to confirm that each module meets the requirement specification.

6.3. Integrated Testing

Integration testing was performed to test all the module as a combined entity and to confirm that all modules work fine when they are integrated.

6.4. System Testing

System testing was performed to test the system against the system specification. This was black box testing and test suites were made from the use case of the system.

6.5. Test Cases

Following are the test suite to test the system against the specifications.

6.5.1. Test Case 1

Use Case Name: Create Account.
User: Radiologist

Table 6.1: Test Case: Sign in for Admin.

UC ID	TC ID	Pre-Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-01	1.1	User is at Sign up screen. User is not previously registered. User has an internet connection.	1. User enters a valid first name. 2. User enters a valid last name. 3. User enters a valid unique email. 4. User enters a valid password. 5. User clicks on "Sign Up" button	User is successfully Signed up.	User is successfully Signed up.	Pass
	1.2	User is at Sign up screen. User is not previously registered. User has an internet connection.	1. User enters a first name. 2. User enters a name. 3. User enters a unique email. 4. User enters a password. 5. One or more given information is invalid. 6. User clicks on "Sign Up" button	System displays invalid data error.	System displays invalid data error.	Pass
	1.3	User is at Sign up screen. User is previously registered. User has an internet connection.	1. User enters a first name. 2. User enters a name. 3. User enters a an already used email. 4. User enters a password. 5. User clicks on "Sign Up" button	The system displays email is already in used message.	The system displays email is already in used message.	Pass

6.5.2. Test Case 2

Use Case Name: Manage Repository.
User: Radiologist

Table 6.2: Test Case: Manage Repository.

UC ID	TC ID	Pre-Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-03	2.1	User is already Signed in. User is at Home Screen.	1. User views his list of all repositories.	System displays all user's repositories	System displays all user's repositories	Pass
	2.2	User is already Signed in. User is at Home Screen.	1. User clicks on "New" Button. 2. User enters unique patient id. 3. User enters details of patient in relevant fields. 4. User clicks on "Create" Button.	System creates a new repository	System creates a new repository	Pass
	2.3	User is already Signed in. User is at Home Screen.	1. User clicks on "New" Button. 2. User enters a duplicate patient id. 3. User enters details of patient in relevant fields. 4. User clicks on "Create" Button.	System displays duplicate patient id error.	System displays duplicate patient id error.	Pass
	2.4	User is already Signed in. User is at Repository Settings Screen.	1. User clicks on "Delete Repository" Button. 2. User clicks on "Confirm" button.	System permanently deletes repository and all its data.	System permanently deletes repository and all its data.	Pass
	2.5	User is already Signed in. User is at Repository Settings Screen.	1. User updates repository information. 2. User clicks on "Update" Button.	System updates the repository information.	System updates the repository information.	Pass

6.5.3. Test Case 3

Use Case Name: Manage Collaborators.
User: Radiologist

Table 6.3: Test Case: Manage Collaborators.

UC ID	TC ID	Pre-Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-04	3.1	User is already Signed in. User is at Collaborator Screen.	1. User clicks on "Add Collaborator" Button. 2. User enters a valid email. 3. User clicks on "Add" Button.	System adds collaborator to the current repository.	System adds collaborator to the current repository.	Pass
	3.2	User is already Signed in. User is at Collaborator Screen.	1. User clicks on "Add Collaborator" Button. 2. User enters an invalid email. 3. User clicks on "Add" Button.	System displays user not found error.	System displays user not found error.	Pass
	3.3	User is already Signed in. User is at Collaborator Screen.	1. User clicks on "Delete" Button. 2. User clicks on "Confirm" Button.	System removes the collaborator from the current repository.	System removes the collaborator from the current repository.	Pass
	3.4	User is already Signed in. User is at Collaborator Screen.	1. User clicks on check Button to update collaborator's role.	System updates the collaborator's role in the current repository.	System updates the collaborator's role in the current repository.	Pass

6.5.4. Test Case 4

Use Case Name: Manage DICOM Files.
User: Radiologist

Table 6.4: Test Case: Manage DICOM Files.

UC ID	TC ID	Pre-Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-05	4.1	User is already Signed in. User is at File Explorer Screen.	1. User clicks on "Add" Button. 2. User selects a file. 3. User clicks on "Open" Button.	System uploads the file and adds it to the current repository.	System uploads the file and adds it to the current repository.	Pass
	4.2	User is already Signed in. User is at File Explorer Screen.	1. User selects a file. 2. User clicks on "Delete" Button.	System deletes the file from the current repository.	System deletes the file from the current repository.	Pass

6.5.5. Test Case 5

Use Case Name: Sign in for Radiologist.
User: Radiologist

Table 6.5: Test Case: Sign in for Radiologist.

UC ID	TC ID	Pre-Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-02	5.1	User is at Sign In screen. User has an internet connection.	1. User enters a valid email. 2. User enters a valid password. 3. User clicks on "Sign In" button	User is successfully Signed in.	User is successfully Signed in.	Pass
	5.2	User is at Sign In screen. User has an internet connection.	1. User enters an email. 2. User enters a password. 3. One or more given information is invalid. 4. User clicks on "Sign In" button	System displays invalid credentials error.	System displays invalid credentials error.	Pass

6.5.6. Test Case 6

Use Case Name: Use DICOM Studio
User: Radiologist

Table 6.6: Test Case: Use DICOM Studio.

UC ID	TC ID	Pre-Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-06	6.1	User is already Signed in. User is at DICOM Studio screen.	1. User clicks on "Add Note" Button. 2. User writes a note.	System saves the note to the current repository.	System saves the note to the current repository.	Pass
	6.2	User is already Signed in. User is at DICOM Studio screen.	1. User uses sliders to adjust brightness of DICOM image. 2. User uses sliders to adjust opacity of DICOM image.	System updates the brightness and opacity of current DICOM image.	System updates the brightness and opacity of current DICOM image.	Pass
	6.3	User is already Signed in. User is at DICOM Studio screen.	1. User opens "Draw Tools" menu. 2. User selects shape from the menu. 3. User draws the selected shape on a DICOM image.	System displays the shapes and saves its draw details in the database.	System displays the shapes and saves its draw details in the database.	Pass
	6.4	User is already Signed in. User is at DICOM Studio screen.	1. User opens "AI Model" tab from sidebar. 2. User clicks on "Run AI Model" button.	System runs the AI model on the select file and displays results to the user.	System runs the AI model on the select file and displays results to the user.	Pass

6.5.7. Test Case 7

Use Case Name: Manage User.
User: Admin

Table 6.7: Test Case**:** Manage User.

UC ID	TC ID	Pre- Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-07	7.1	Admin is already Signed in. Admin is at Admin Dashboard screen.	1. Admin selects a user. 2. Admin clicks on "Disable" Button.	System changes the user's status to disabled.	System changes the user's status to disabled.	Pass
	7.2	Admin is already Signed in. Admin is at Admin Dashboard screen.	1. Admin selects a user. 2. Admin clicks on "Enable" Button.	System changes the user's status to enabled.	System changes the user's status to enabled.	Pass
	7.3	Admin is already Signed in. Admin is at Admin Dashboard screen.	1. Admin selects a user. 2. Admin clicks on "Delete" Button.	System deletes the user.	System deletes the user.	Pass

6.5.8. Test Case 8

Use Case Name: Manage Database.
User: Admin

Table 6.7: Test Case**:** Manage Database.

UC ID	TC ID	Pre- Condition	Actions/Steps	Expected Output	Actual Output	Pass/Fail Criteria
UC-US-08	8.1	Admin is already Signed in. Admin is at Admin Dashboard screen.	1. Admin selects a user. 2. Admin clicks on "Delete from database" Button.	System permanently deletes user's data from the database.	System permanently deletes user's data from the database.	Pass

6.6. Results & Evaluation

We executed all the above test cases, and the system passed all the test cases. This showed that system behave according to the requirements specification because above test cases were developed from the system use cases.

6.7. Conclusion

In this chapter we covered the testing strategy, what type of testing we performed for the system, and we developed test suite against requirements specifications. The test cases tried to cover all the aspects of the system to uncover any bugs/defects that might have been ignored. This guarantees overall quality of the system.

Chapter 7
Conclusion

Throughout the course of this project, we had the valuable opportunity to put our engineering knowledge into practice. It allowed us to gain hands-on experience and apply the principles we learned in a practical setting. We were able to delve into the various phases of the software development life cycle and progress through them systematically, ensuring a comprehensive and well-executed project. By immersing ourselves in this project, we not only enhanced our technical skills but also deepened our understanding of how software is developed from start to finish. We navigated through the different stages, including requirements gathering, design, implementation, testing, and deployment. Each step provided us with valuable insights and learning experiences, contributing to our growth as engineers.

One of the remarkable aspects of this project is its potential to foster collaborations among radiologists worldwide. By facilitating seamless communication and knowledge sharing, it opens avenues for radiologists from diverse backgrounds and geographical locations to collaborate effectively. This can lead to a broader exchange of ideas, insights, and best practices, ultimately benefiting the radiology community. Through increased collaborations, radiologists can leverage each other's expertise, share difficult cases for consultation, and collectively work towards advancements in disease detection and patient care. This project serves as a catalyst for bridging geographical barriers and creating a global network of professionals committed to improving radiology practices.

In conclusion, the development of this project provided us with a practical application of our engineering knowledge, allowing us to gain valuable experience in the software development life cycle. Moreover, the project's potential to enhance collaborations among radiologists worldwide is truly exciting, as it paves the way for accelerated progress, knowledge exchange, and improved patient outcomes in the field of radiology.

7.1. Contributions

This project and document development have been a joint effort. Syed Hammad Ali took care of creating the front end, which is the part of the project that users interact with, while Hassan Masood handled the creation of the backend, which is the behind-the-scenes part that processes data and makes everything work smoothly.

It's important to mention that throughout the entire project, a respected supervisor provided guidance and oversaw the progress. His expertise and knowledge were invaluable in ensuring that the project was completed successfully.

By working together and with the guidance of their supervisor, we were able to combine our skills and efforts to bring this project to life. Their collaboration resulted in the development of both the front end and the backend, contributing to the overall success of the project.

7.2. Reflections

In general, the rAIdiologist project holds great potential for tackling important challenges in collaborative radiology and disease detection. By using advanced technology and working together, this project aims to overcome obstacles and make a positive difference. If rAIdiologist is implemented successfully, it can bring about many benefits. These benefits would affect the radiology community, patient care, and the overall advancement of knowledge in the field.The rAIdiologist project has the power to revolutionize how radiologists work together. By using artificial intelligence and collaboration tools, it can make the process of detecting diseases more accurate and efficient. This, in turn, can lead to better care for patients and help save lives.

Additionally, the project can contribute to the growth of knowledge in the field of radiology. By analyzing large amounts of medical data and utilizing the power of artificial intelligence, rAIdiologist can uncover patterns and connections that may not be obvious to humans alone. These discoveries can lead to new insights, advancements in diagnosis, and improved medical practices. Overall, while there may be some challenges to overcome, the successful implementation of the rAIdiologist project can have far-reaching positive effects. It can transform the way radiologists work together, improve patient care, and drive innovation in the field of radiology. With its potential to address critical challenges, rAIdiologist can make a lasting impact on the healthcare community and the advancement of medical knowledge.

7.3. Future work

In the future, there are plans to expand the system by adding the capability to export user annotations in widely recognized reporting formats. This means that users will be able to save and share their notes and observations in a format that is commonly used and accepted by professionals in the field. Additionally, there are efforts underway to enhance the system's functionality to support entire organizations, not just individual users. This means that multiple users within an organization will be able to collaborate, share information, and work together seamlessly within the system.

These future improvements aim to make the system more versatile and user-friendly, catering to the needs of both individuals and larger organizations. By enabling the export of user annotations in proper reporting formats, it will be easier for users to communicate their findings effectively and in a standardized manner. This will enhance collaboration and streamline communication between professionals involved in radiology and disease detection. Furthermore, expanding the system to accommodate full organizations will promote teamwork and facilitate a more integrated approach to radiology practices. It will enable multiple users from the same organization to access and contribute to the system's functionalities, fostering better coordination, knowledge sharing, and overall efficiency. Overall, these future developments will provide valuable enhancements to the system, enabling users to export their annotations in recognized formats and supporting the collaborative efforts of entire organizations. By adapting to the evolving needs of users, the system aims to promote effective communication, streamline workflows, and contribute to advancements in the field of radiology.

REFERENCES

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APPENDIX A

Dictionary

DB	Database
SQL	Structured Query Language
DWV	DICOM Web Viewer
DICOM	Digital Imaging and Communications in Medicine