Bilkent University
Department of Computer Engineering

Senior Design Project

T2312

MediXAI

Analysis and Requirement Report

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Contents

1 Introduction

We have identified challenges in the current healthcare system that lead to difficulties for individuals and institutions involved, including high costs, time-consuming processes, and significant error rates. The growing population and diversity of diseases further complicate the ability of the current healthcare systems to meet the demand. Additionally, inadequate working conditions for doctors have led us to develop a project to make improvements in this field.

Technological advancements, such as robotic applications and machine learning techniques, have started to automate the healthcare system inevitably due to the advantages they offer. We are focusing on this transition process and aim to propose a transition model developed with novel technologies.

In our project, we have chosen to focus on breast cancer. Breast cancer accounts for 12.5% of all new annual cancer cases worldwide, making it the most common cancer in the world [1]. It is more common among women. One out of every eight women has the possibility of having breast cancer [2]. Breast cancer can become fatal in late stages, comprising 15.5% of cancer-related deaths [2]. However, if it is detected in early stages and treatment begins, about 70-80% recovery rate has been observed [3]. Therefore, periodic controls are necessary to enable early diagnosis, particularly mammography is recommended once a year for women between the ages of 40 and 69 for breast cancer screening [2].

We propose an end-to-end system that is a doctor and patient assistant for early breast cancer screening. Empowered by XAI (explainable AI), it helps doctors, especially radiologists, to diagnose breast cancer at early stages with higher accuracy. The flexibility and accessibility that our system provides make it easier for patients to follow their screening results and contact their doctors. The availability of many doctors on one platform allows patients to access many opinions, satisfying the desire of the second opinion market.

In our system's workflow, patients upload their mammography images, which are analyzed by a doctor and our XAI model separately. Then, if the results match, the diagnosis will be finalized; otherwise, another doctor will review both results by taking advantage of the explainability of the model and give a terminal decision.

The key objectives of our project include improving healthcare accessibility, reducing diagnosis errors through doctor and XAI collaboration, and providing a more flexible and comfortable working environment for doctors. Ultimately, our pioneering work seeks to revolutionize breast cancer screening and contribute to broader improvements in the healthcare system by integrating medical expertise with cutting-edge technology for the benefit of both patients and healthcare providers.

2 Current System

Currently, as it is common in all healthcare domains, periodic breast cancer check is also heavily dependent on the doctors in the decision-making process. In the current system, women who are between 40-69 are highly suggested to do their checks from a health center every 18 months. The process is like this: firstly, the patient describes her clinical information, diseases in the past, having a child or not. After that, they took a mammography image, and according to mammography classification, which is in the BI-RAD classification standard, they are guided to take further actions or come for a check again after 18 months[4].

This process described above is conducted in public and private health centers in Turkey, Additionally, there are public health centers called KETEM that are only designated for the periodic checks of mammography, colon cancer, and HPV. KETEM provides imaging and analysis of the result for free [5]. Furthermore, in the current system, KETEM buys mammography analysis services from private image analysis companies. However, in the current system, based on the observations of the doctors and nurses in the field, it is known that there are significant delays(2-3 months), which is creating disapprobation of the clients and creating health risks. To sum up, in the current system, mammography analysis requires effort, takes time, and takes money.

There are a couple of private competitors that are also aiming to take part in the atomization of mammography analysis. The application has no direct competitors but indirect competitors. Those indirect competitors can be classified into two main application areas, which are the second medical opinion market and the doctor assistance market. Whereas, our application is the combination of these services. and providing an end-to-end product.

Companies that are providing second opinions in mammography analysis and operating in Turkey:

- **Hastalar Soruyor:** Hastalar Soruyor is a web-based application that provides patients with several services, which can be listed as consulting a doctor, analyzing medical test results, getting a second doctor's opinion, and making an appointment with a doctor. For these services, patients are asked to make payment, which is determined before each service [6].

- **Medicopin.com:** Medicopin is a healthcare service that connects users with top medical experts worldwide, allowing them to share health concerns and receive expert evaluations via personalized video recordings or face-to-face consultations with doctors through Medicopin.com. It aims to provide users not only with reliable medical advice but also the peace of mind needed during severe health issues while offering ongoing support for a stress-free healthcare experience [7].

Companies that are providing doctor assistance in mammography analysis and operating in Turkey:

3 **Screen Point Transpara:** Screen Point Transpara is a product that aims to make early detection using machine learning methods for breast cancer. Additionally, it is FDA-cleared for use on all major 2D and 3D mammography systems. According to their research, they have a similar recall, cancer detection rate, and false positive rate compared to the standard double-checking. They currently provide services to the local private oncology clinics in İstanbul [8].

4 **ICTerra:** ICTerra's effort in AI is framed in oncology and radiology. They have a project to classify mammograms using XAI. Their main target in the market is the governmental agencies and hospitals. The details of the project and benchmarks of the model are not shared publicly [9].

5 **Siemens Syngo Breast Care:** Siemens is one of the leading companies in the imaging machine manufacturing industry. Additionally, they developed software that is integrated into the imaging mammography machine [10].

6 Proposed System

Overview

This section will explain detailed information about how we built the MediXAI application. In general, our design is based on two main features of our application: time-saving for the patients and the doctors and extended accuracy with the help of XAI.

Functional Requirements

The following functional requirements are for the **patients**:

- The Turkish users must register/log in using their TR Identity No. The foreign users must register/log in using their Passport No.
- The user can upload/remove medical images in the .dcm format they want to be assessed by specifying when the image is taken.
- The user can see his/her already uploaded medical images.
- The user can request an assessment for diagnosis based on the selected medical images.
- The user can see the final diagnosis and take a report for that based on the images they uploaded.
- The user can see the optimal steps for the final diagnosis, such as making an appointment with an oncologist or requiring no further action.
- The user can see their old diagnosis decisions.
- The user can make payments for the medical image assessments with their preferred payment type and card.
- The user can add/remove the preferred payment type and card.

The following functional requirements are for the **doctors**:

- The user can register/log in using their username and password. (More would be required for registration, such as certificates.)
- The user can see the waiting medical image assessments.
- The user can access old images and diagnoses of the patient they assess.
- The user can see the explainable AI (XAI) diagnosis of the medical image they assess.

- The user can make an assessment and decide on the final diagnosis.
- The user can add notes and his/her suggestions to the final diagnosis and further steps.
- The user can see his/her accuracy rate compared to the XAI diagnoses.
- The user can see his/her income from assessing medical images.
- The user can add/remove bank account information.

The following functional requirements are for **doctors and patients**:

- The user can edit his/her profile.
- The user can delete his/her profile.

Non-functional Requirements

The non-functional requirements are analyzed under five sections.

6.1.1 Usability

The mobile application and web-based platform will feature an intuitive and user-friendly interface with a learning curve not exceeding 30 minutes for new users. Being a user-friendly application means users can achieve their planned operations as quickly as possible. For this reason, medical image uploading can be done in three clicks, and XAI explanations to the doctors will be accessible in two clicks. The system will support Turkish, English, and Arabic languages.

6.1.2 Reliability

The system is aimed to maintain a minimum uptime of 99% to ensure 24/7 availability. We will implement our system in a way that it is fault-tolerant. The system will implement robust encryption and access control mechanisms to ensure data integrity and prevent unauthorized access. We will integrate KPSPublic Web Service[11] into our system to enable users to register and sign in to our system with TR ID No and hence enhance security. The system will recover from failures within 5 minutes and maintain core functionality even with faults. The system will follow GDPR[12] and KVKK [13] regulations in private data management.

6.1.3 Performance

Medical image uploads, processing, and assessment will have response times of 2 seconds, 5 seconds, and 3 seconds, respectively. The system will support a 200% increase in concurrent users without a decrease in response time. The system will ensure a minimum data transfer speed of 10 MBps for medical image uploads. System resource utilization will be at most 70% of available CPU and memory to ensure optimal performance.

6.1.4 Supportability

This application will initially be developed as a cross-platform mobile application on the patient side and a web application on the doctor side. For the upcoming releases, the application scope can be extended as a web application on the patient side, and new features can be added. System updates and maintenance will be scheduled during off-peak hours to minimize disruption, and the process will not exceed 1 hour. The system will provide a full suite of documentation, including FAQs, troubleshooting guides, and system architecture documentation, accessible from the user interface for patients and doctors.

6.1.5 Scalability

The system will automatically scale resources to accommodate a 100% increase in concurrent users within 5 minutes. Load balancing mechanisms will evenly distribute incoming requests across available servers to prevent overload and optimize performance. We aim to develop our application so that our ML model is usable across many platforms, including other applications, such as integration to e-Nabız [14].

Pseudo Requirements

MediXAI will have a mobile application for patients and a web application for doctors. Both applications will be implemented by using Flutter (also Dart)[15]. Firebase will be used to authenticate and store data, as well as the BaaS.

● Flutter version is v3.16.1, which are the environment variables.

● Android Studio[16], Visual Studio Code[17], and FlutterFlow[18], Firebase Console[19] are used for Flutter and Firebase development.

● Users will be authenticated by entering their phone numbers via SMS. However, their full phone number will never be stored completely on the database. The encrypted version of the phone number will be saved. It increases the complexity of the authentication, but at the same time, it increases the anonymity since the phone numbers can not be readable from the database

● Firebase Analytics[20] will be used to track user flow in the app to get more information about users' behaviors. Moreover, possible bugs will be followed from here.

● All the external APIs and other data will be fetched through our server side. The reason for this, some APIs have keys that we do not prefer to embed into the mobile application since reverse engineering can reveal them.

● FlutterFlow[18] is used for UI design for mobile applications.

● The mobile application will be deployed to both App Store[21] and Play Store[22].

● The web application will be deployed on the web using Firebase's hosting service.

● Git[23] and GitHub[24] are used for the version control system.

● Trello[25] and GitHub Issues[26] will be used for project management.

● Telegram[27] will be used for communication among the group.

● Each team member has to open a new branch while adding a new feature or

fixing one.

● For each pull request, each member assigns a new reviewer. If he doesn't assign a reviewer, the GitHub Actions bot will assign a reviewer.

● Issue templates are prepared for new feature requests, bug reports, and an available custom issue template.

System Models

If it is desired for any reason, such as resolution issues, our diagrams can be seen at https://github.com/MediXAI/Diagrams.

6.1.6 Scenarios

Name: Upload Mammography Image

Participating Actor: Patient

Entry Condition:
Patient has the medical image from the medical image center or e-nabiz

Exit Condition:

Image uploaded to the servers.

Flow of Events:

1. Patient uploads her image from a medical image center or e-nabiz to the device that she is using the system on.
2. Patient logs into the system.
3. Enters Request Analysis Section
4. From the start analysis section, she uploads the image to the system.

Special Requirements:

The personal information and medical data about the patient should be kept securely.

Name: Mammography Analysis

Participating Actor: Patient, First Doctor, Second Doctor, Explainable ML Model

Entry Condition:
Patient has the medical image from the medical image center or e-nabiz and uploads it to the System.

Patient made the payment.

Exit Condition:

Mammogram analysis created.

Flow of Events:

1. Uploaded mammography is assigned to the waiting list of first doctors.
2. The doctor who is available and wants to analyze the image selects the mammogram from the waiting list.
3. The image is removed from the waiting list and moved to the pending list.

4. The first doctor analyzes the mammogram, assigns the bi-rad classification label, writes the explanation about the analysis, and writes notes about the further required steps(e.g., ultrasound, biopsy)
5. Explainable ML Model analyzes the image and adds explanations.
6. If the two analysis labels match the report is shown to the patients.
7. Otherwise, the third doctor makes the final analysis, taking the first doctor's and the ML model's decision into account.
8. The patient can see the final analysis report and the necessary actions to take.

Special Requirements:

The personal information and medical data about the patient should be kept securely.

Name: Purchase Medical Analysis

Participating Actor: Patient, Bank

Entry Condition:
Patient uploads the medical image to the system.

Patient has sufficient money to purchase analysis.

Patient has a bank account.

Exit Condition:
Patient's money transferred from the

1. Flow of Events:
Patient uploads the image to the system
2. Enters make payment section
3. Choose the payment type and make the payment.
4. The bank transfers the patient's money to the systems account.
5. The system checks the payment success

Special Requirements:

Bank account information has to be kept securely.

Name: Withdraw Money

Participating Actor: Doctor, Bank

Entry Condition:
Doctor has a bank account in the system.

Doctor has the money in the Account.

Exit Condition:
The money in the doctors transferred to doctor's bank account.

Flow of Events:

1. The doctor enters to the income section.
2. Checks his/her income.
3. Enters withdraw section.
4. Checks bank account information, adds/removes/edits bank account.

5. Specifies an amount to withdraw and the bank account.
6. The bank transfers the money from the system's account to the doctor's account.

Special Requirements:

The bank account information should be kept securely.

Name: Register to the System with TC ID Number

Participating Actor: User

Entry Condition:
User should have a TC ID Number

Exit Condition:
Creation of the profile

Flow of Events:

1. User enters the signup section.
2. Select the user type: Doctor, Patient.

Then, upload the necessary documents and information.

3. The patient additionally adds information about her medical history.

Special Requirements:

The personal information should be kept securely.

6.1.7 Use-Case Model

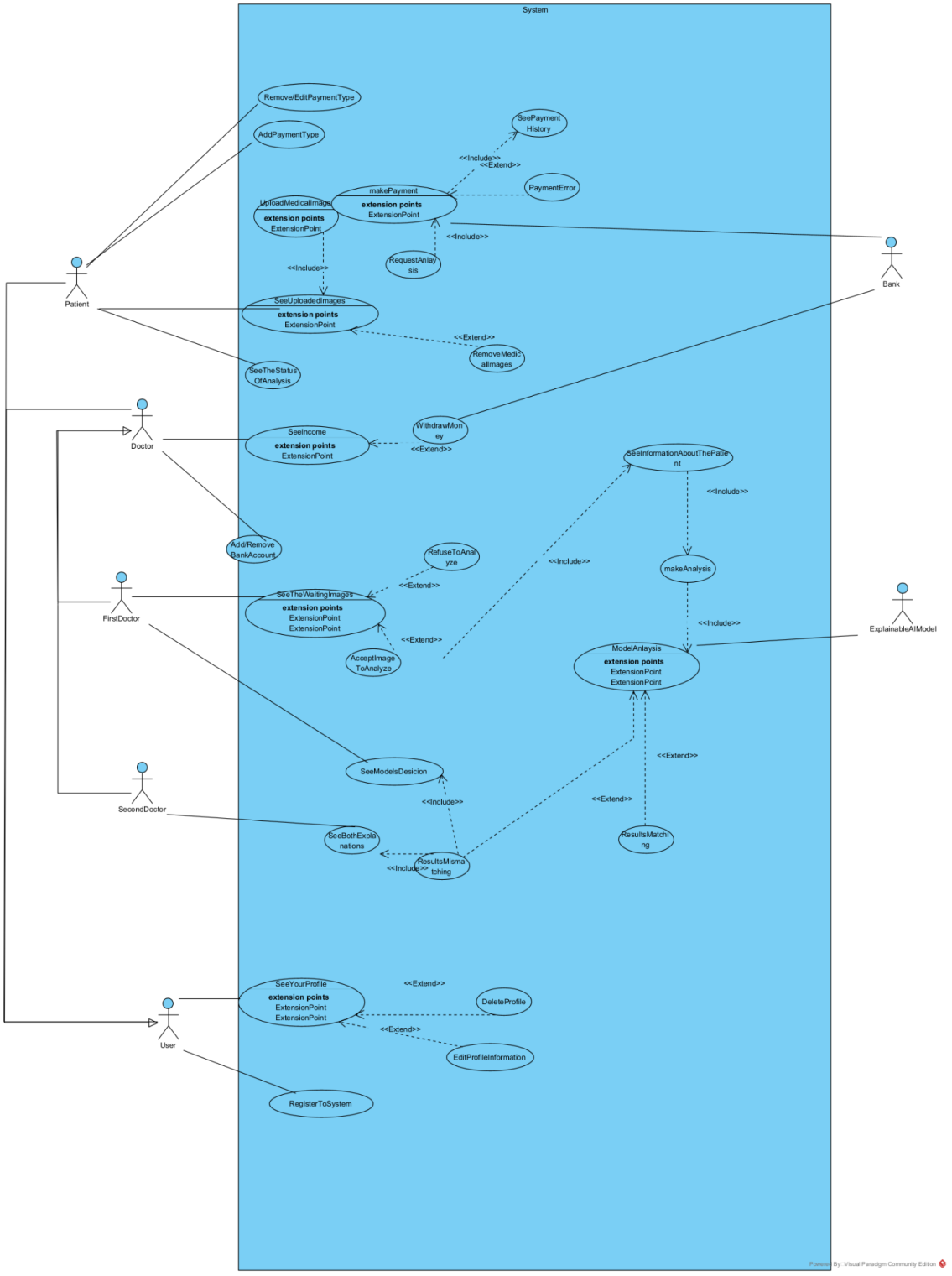


Figure 1: Use Case diagram of MediXAI

6.1.8 Object and Class Model

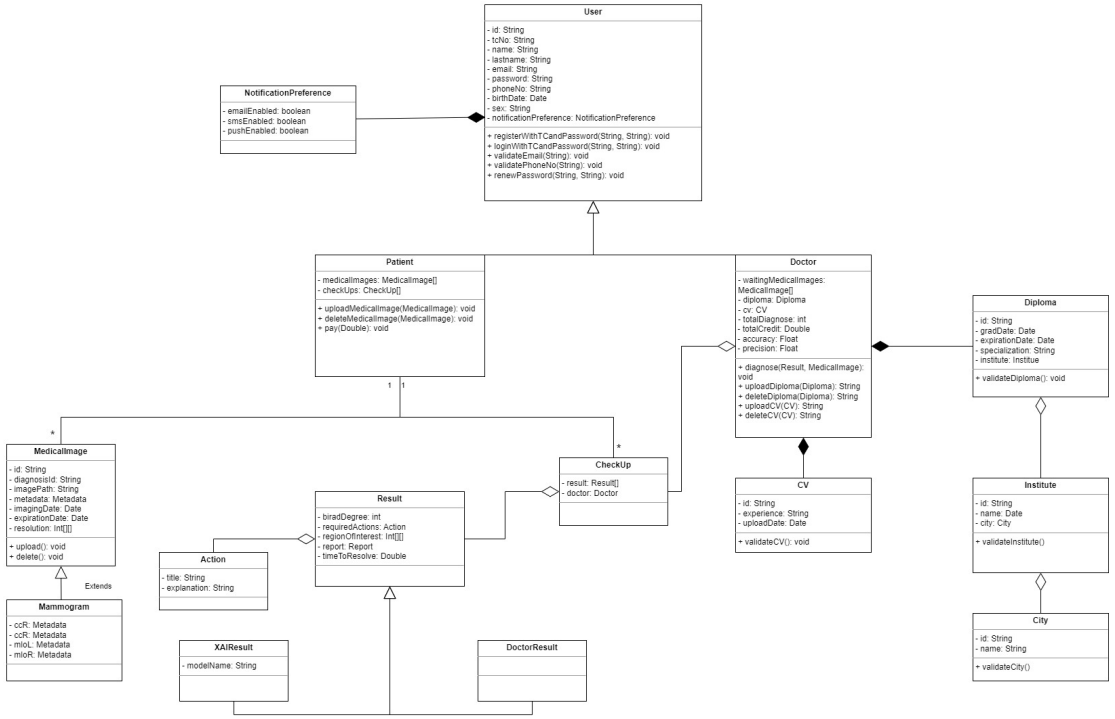


Figure 2: Class diagram of MediXAI

6.1.9 Dynamic Models

6.1.9.1 State Diagram

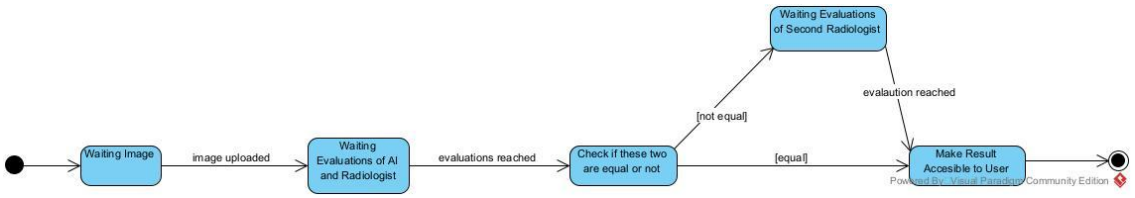


Figure 3: State Diagram of MediXAI

6.1.9.2 Activity Diagrams

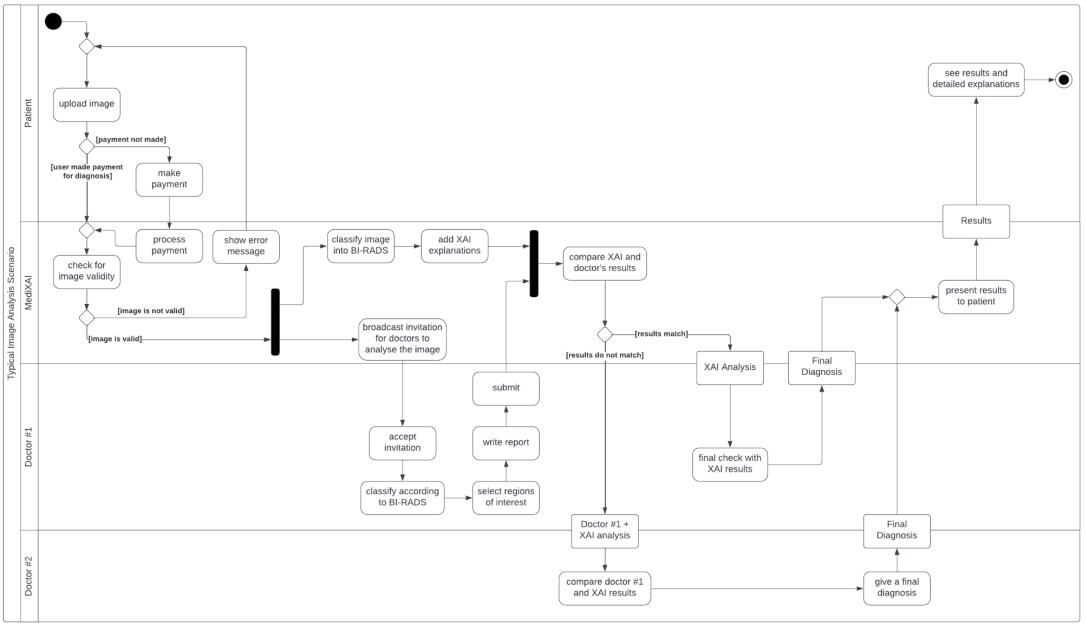


Figure 4: Activity Diagram for A Typical Image Analysis Scenario

In the above diagram, the process of a typical mammogram diagnosis is shown. The user uploads the image. After multiple verifications (image validity, payment…), the image is sent to the first doctor. The doctor analyzes it and gives the BI-RADS classification. If the classification matches the ML classification, the ML results are shown to the doctor along with the XAI explanations. The doctor does some last checks and reports the results. When the results of the ML model and the 1st doctor do not match, the diagnosis made by both the 1st doctor and the ML model are sent to a second doctor. The second doctor will compare those results and give a final decision. The decision then will be considered as the final diagnosis and will be sent to the patient.

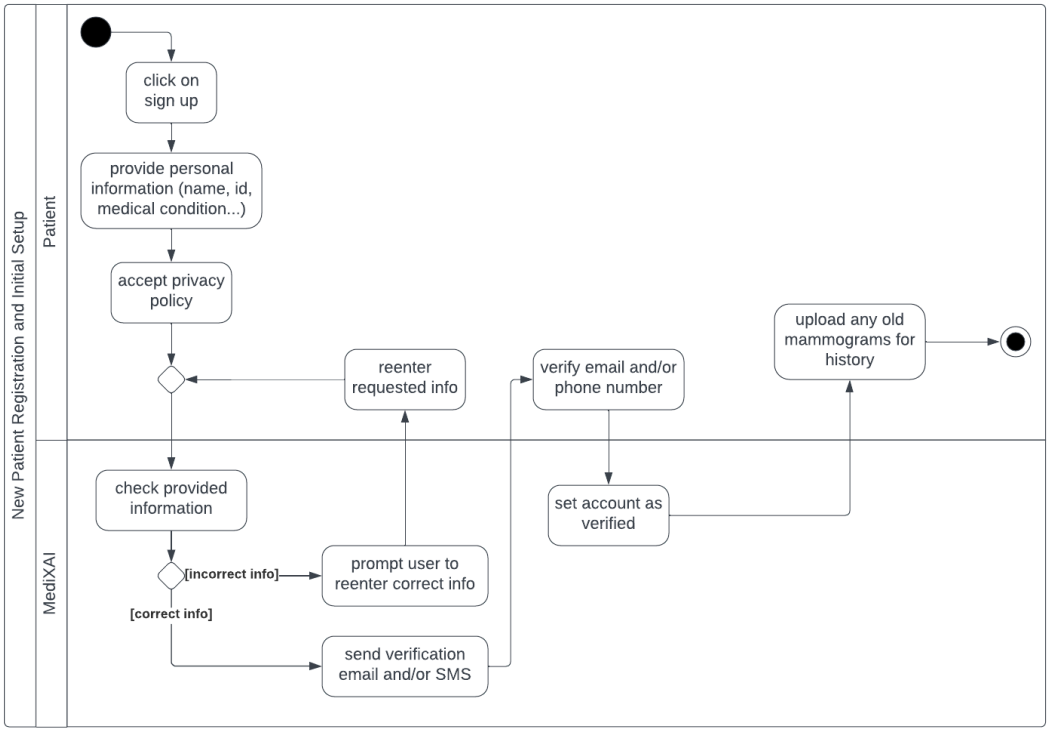


Figure 5: Activity Diagram: New Patient Registration and Initial Setup

In the above diagram, the process of a new user registration is described. The user enters personal info, which will be checked for any invalid info. The user's email and phone numbers will be verified by sending a verification code. The user will then be able to upload old mammograms to their account to serve as history for doctors to look at and use when they start their first diagnosis. Note that these old images will not be analyzed by the doctors. They will only be used as context and history for them to go back to if necessary in later encounters.

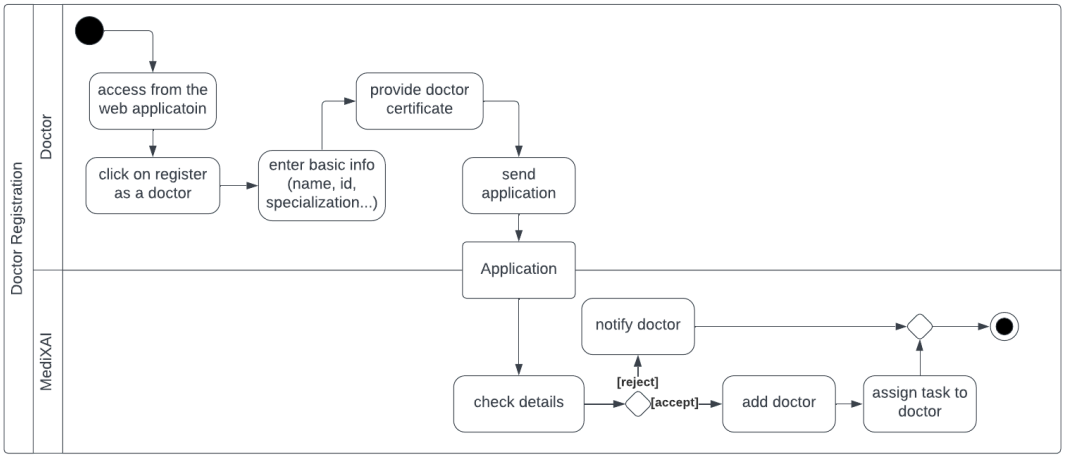


Figure 6: Activity Diagram: Doctor Registration

In the above diagram, the process of registering a doctor is described. The doctors will be able to create new accounts from the web application. After entering their personal info, the

system will check if they are real doctors and it will check the validity of other details. To check if they are real doctors, the official website of the Turkish Ministry of Health will be used [28]. This will allow the system to detect whether it is a real doctor registering or not. After verifying all the information, the doctor will be added to the system, and tasks can be assigned to them.

6.1.9.3 Sequence Diagrams

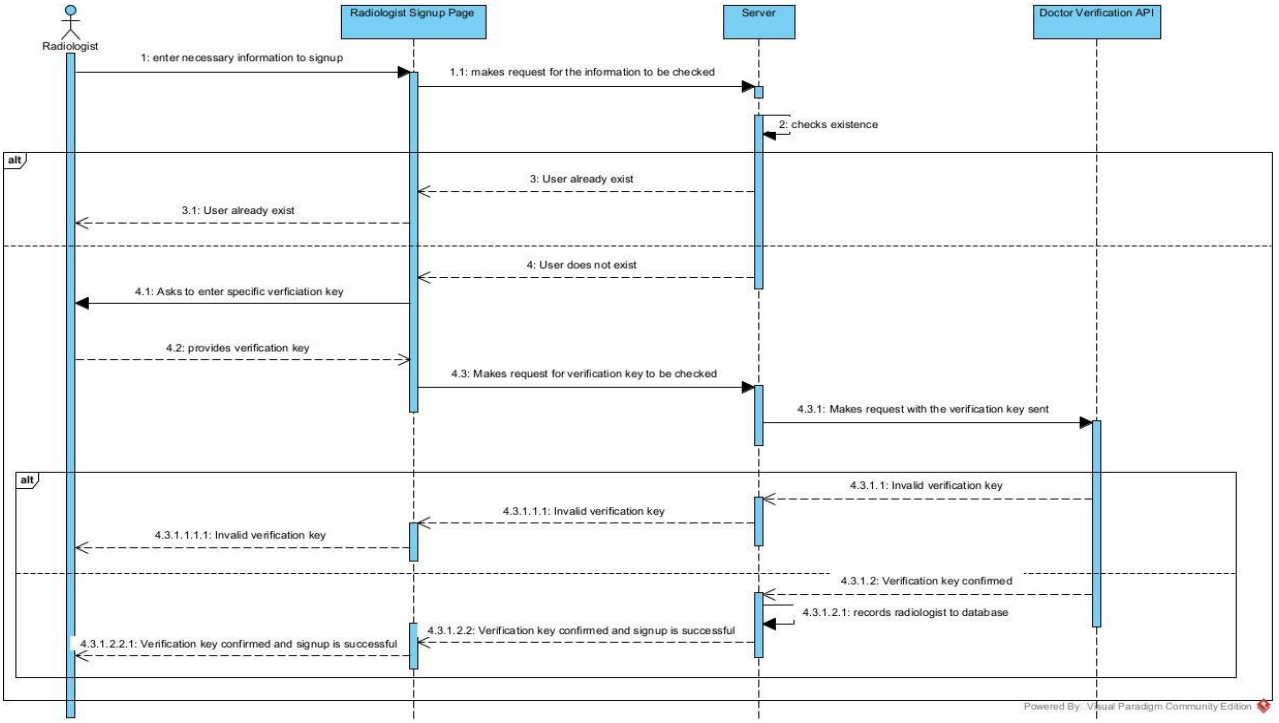


Figure 7: Sequence Diagram: Doctor Registration

In the above diagram, the process of registering a doctor is shown. The doctors will be able to create new accounts from the web application through the radiologist sign up page. After entering their personal info, the server will check if they are real doctors and refuse or confirm the registration accordingly.

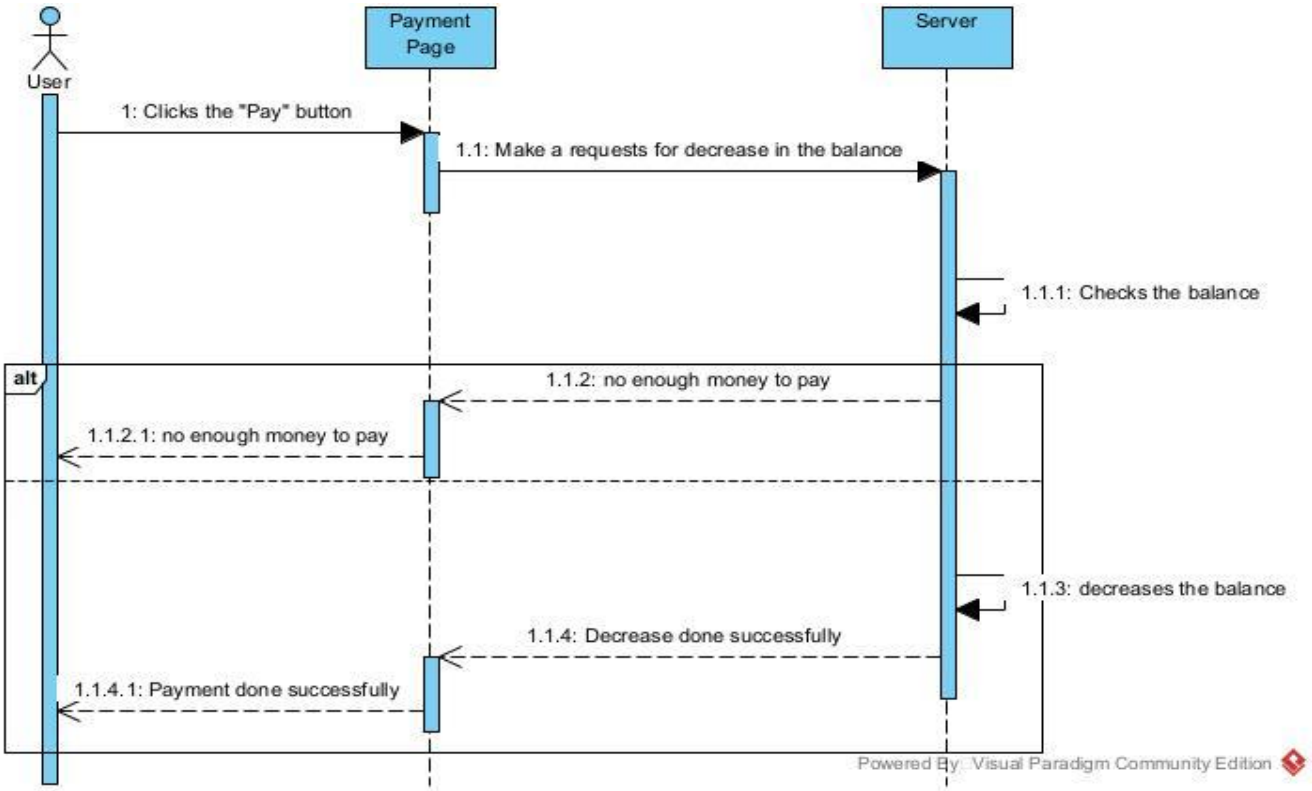


Figure 8: Sequence Diagram: Payment

In the above diagram, the process of payment is shown. The user will be able to pay the price of the service he is getting through the payment page. After sending a payment request, the server will check if the payment is done in collaboration with the bank API.

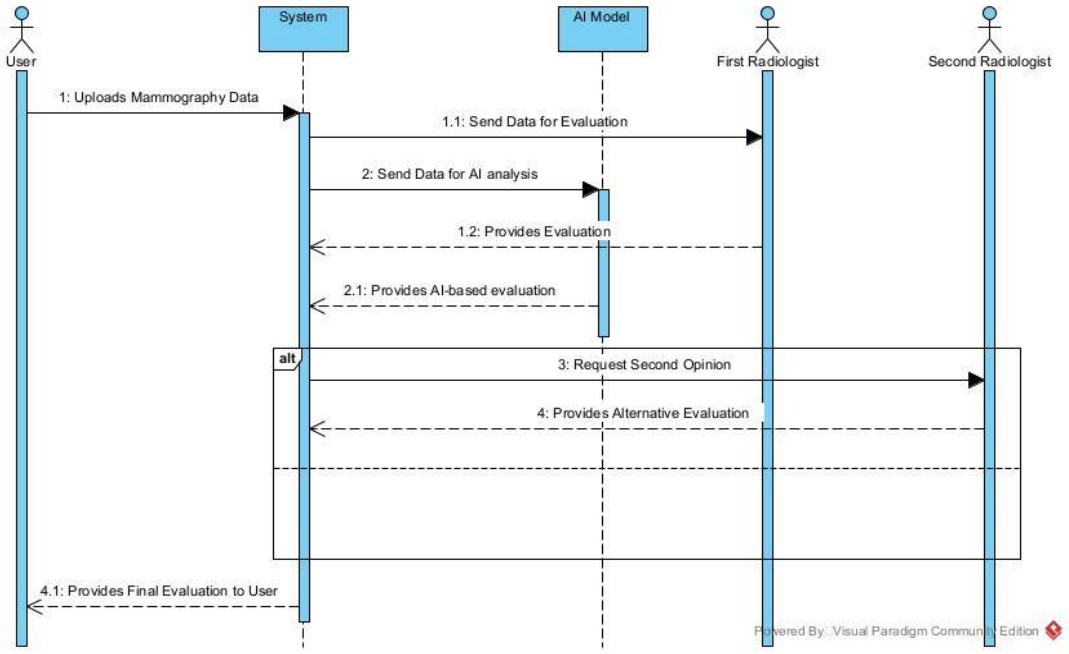
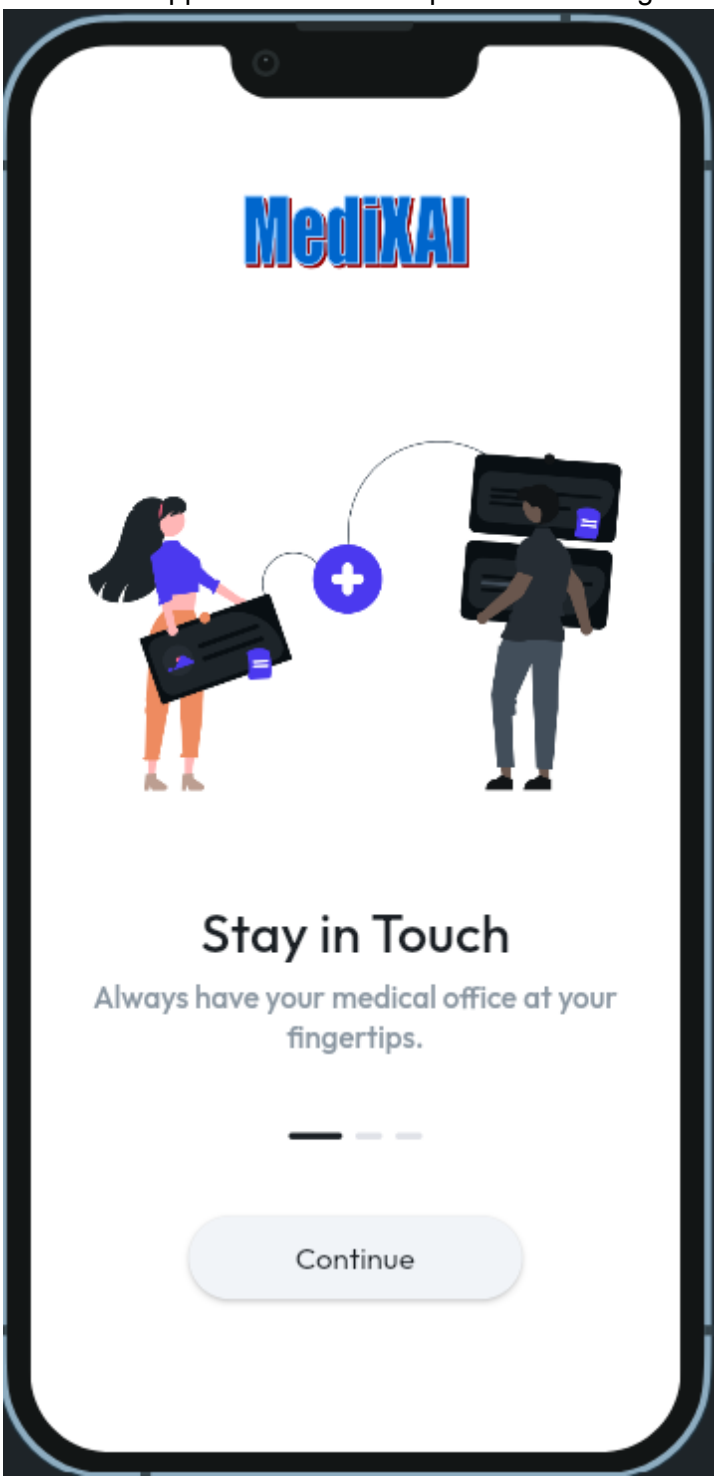


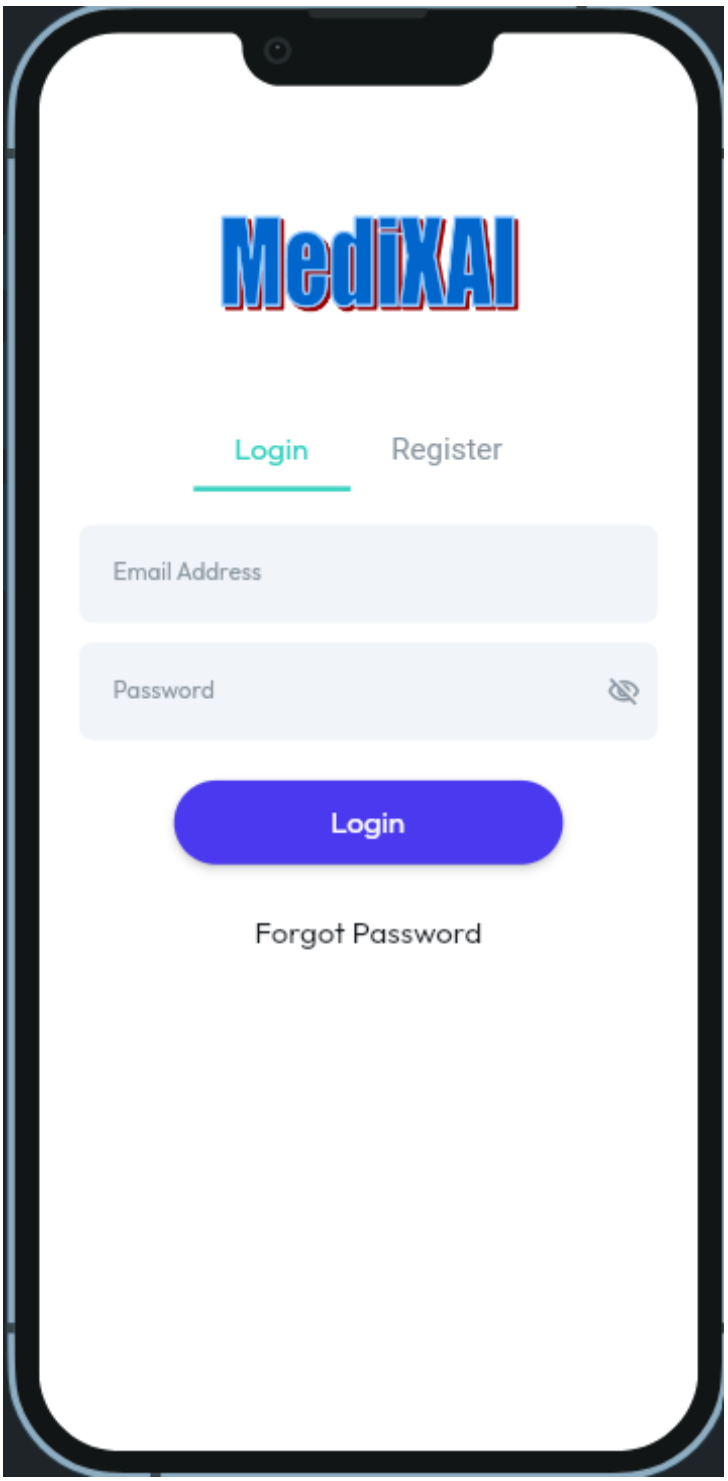
Figure 9: Sequence Diagram: Data upload and diagnosis

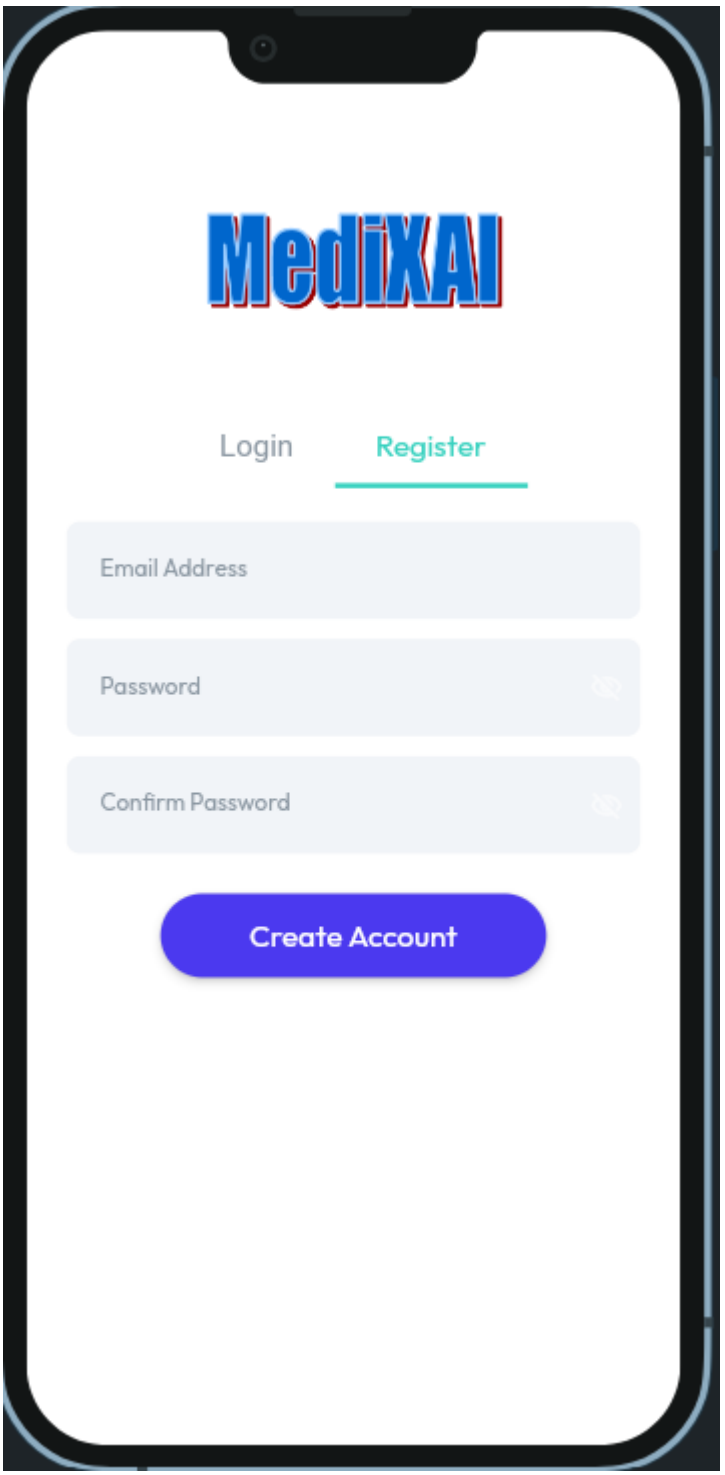
In the above diagram, the process of mammogram analysis is shown. The user will be able to upload medical images. After that, the image analysis request will be sent to both the AI model and the second doctor. After they respond according to the results system directs the image to the doctor or directly returns the analysis result to the user.

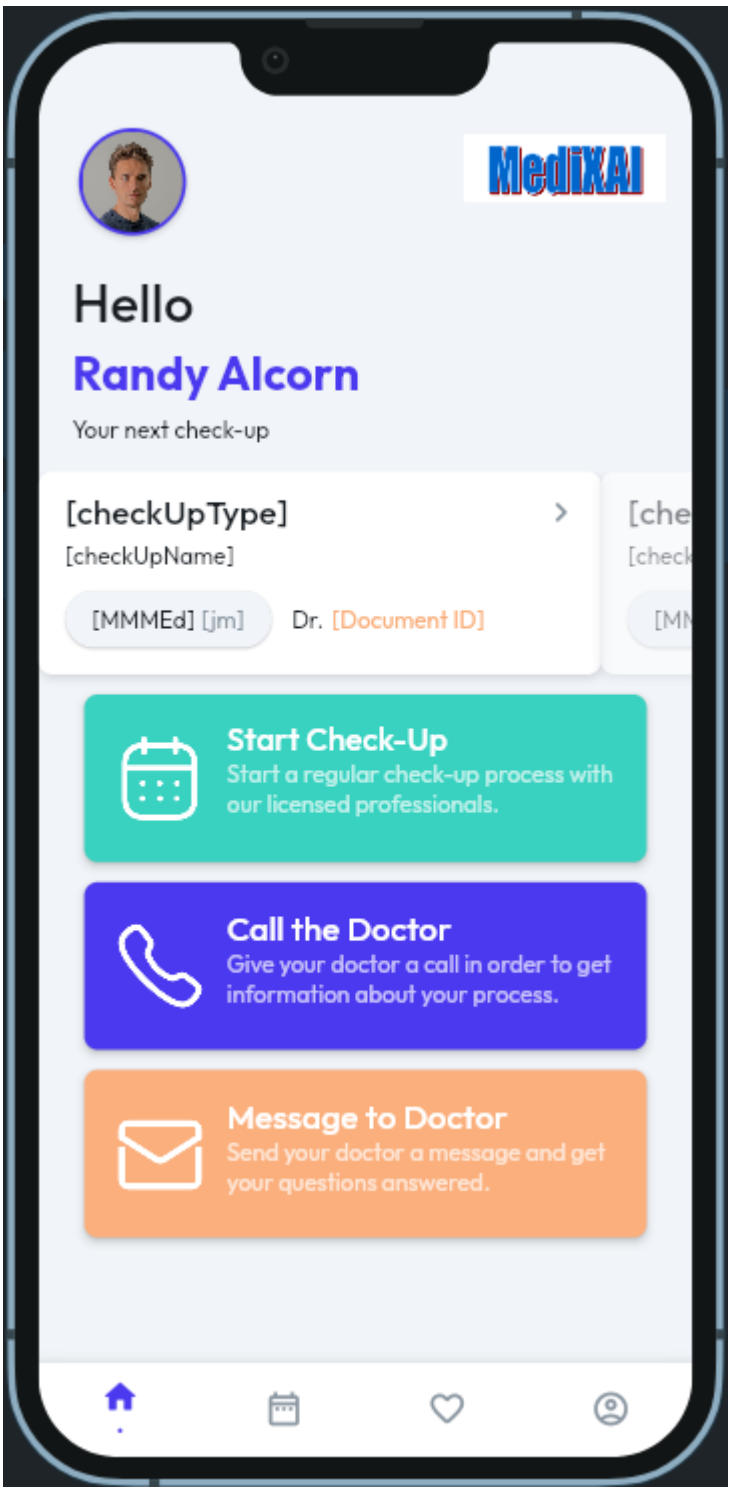
6.1.10 User Interface

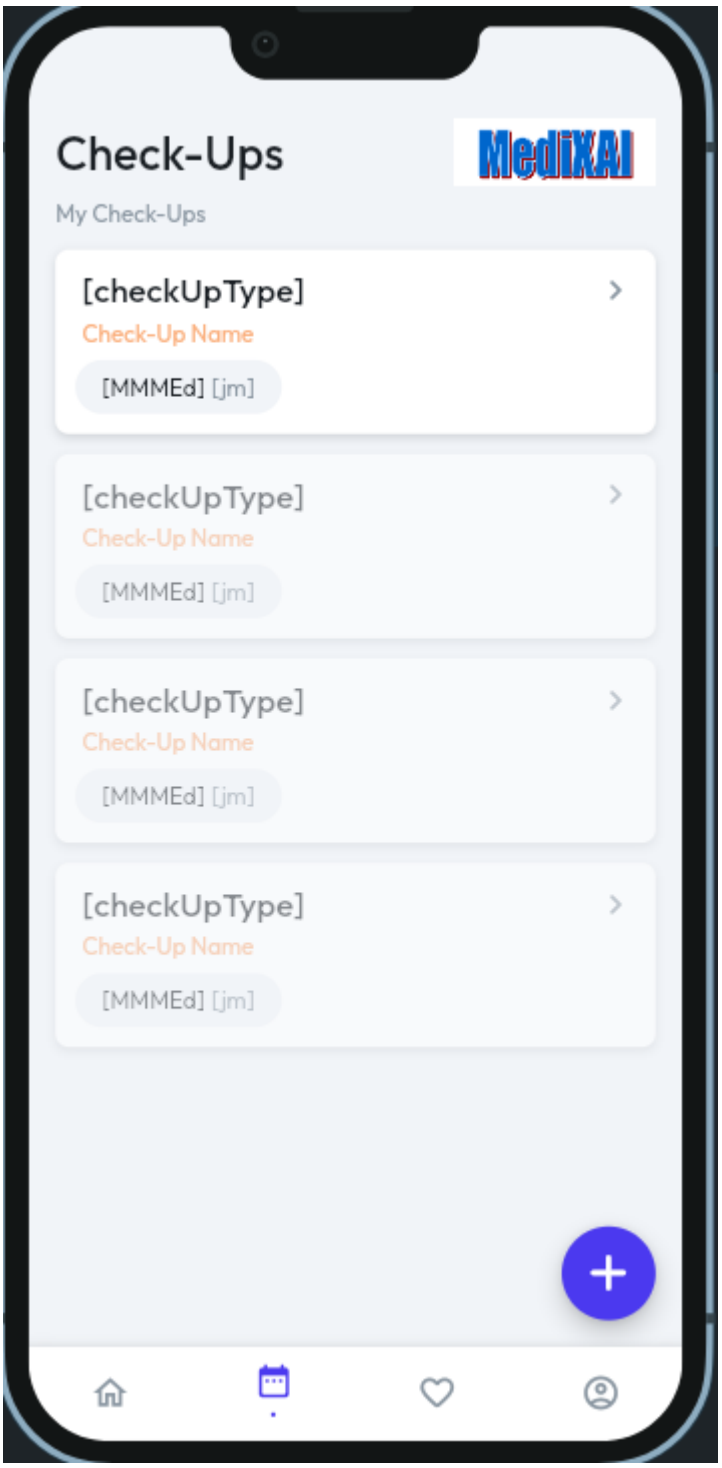
The mobile application UI for the patient's side is given below.




MediXAI
Login
Register
Email Address
Password
Login
Forgot Password


MediXAI
Login
Register
Email Address
Password
Confirm Password
Create Account


MediXAI
Hello
Randy Alcorn
Your next check-up
[checkUpType]
[checkUpName]
[MMMEd] [jm]
Dr. [Document ID]
Start Check-Up
Start a regular check-up process with our licensed professionals.
Call the Doctor
Give your doctor a call in order to get information about your process.
Message to Doctor
Send your doctor a message and get your questions answered.


Check-Ups
MediXAI
My Check-Ups
[checkUpType]
Check-Up Name
[MMMEd] [jm]
[checkUpType]
Check-Up Name
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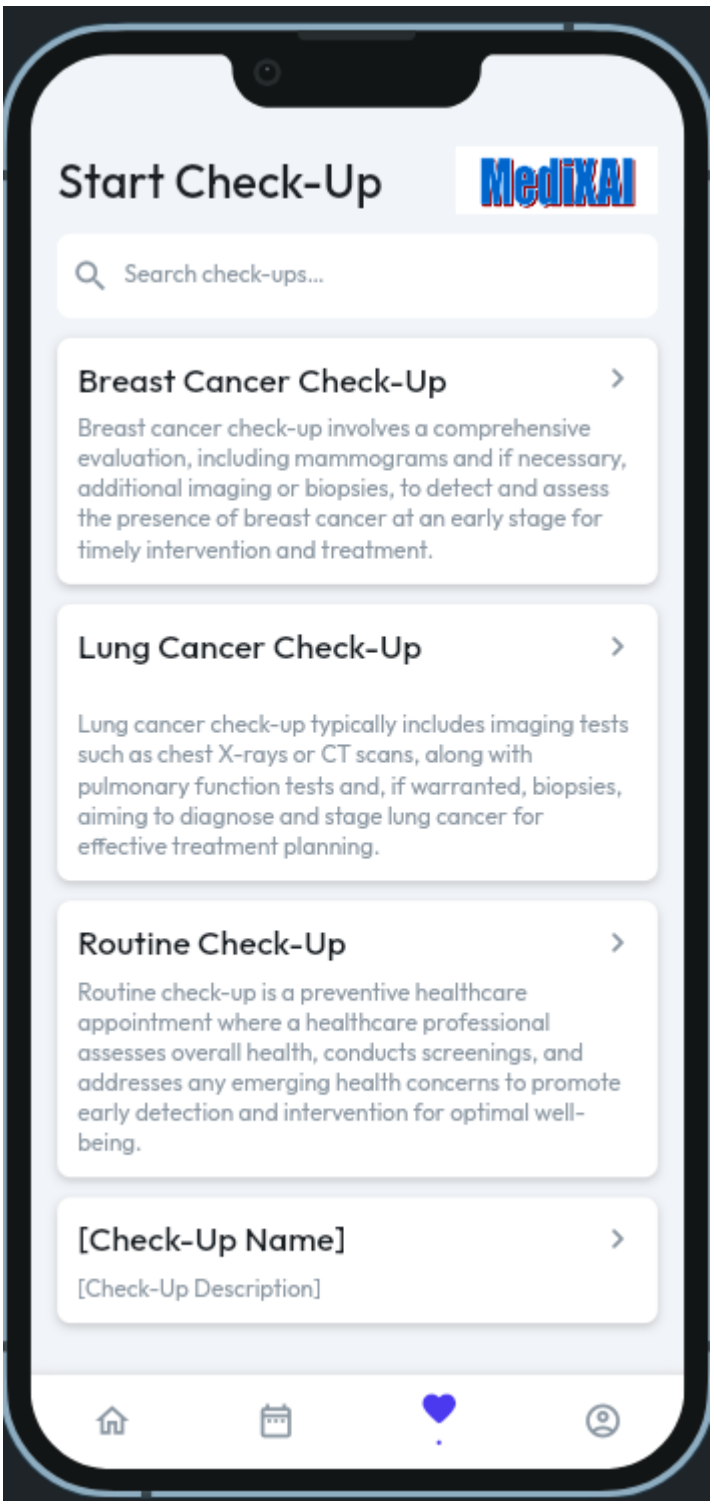
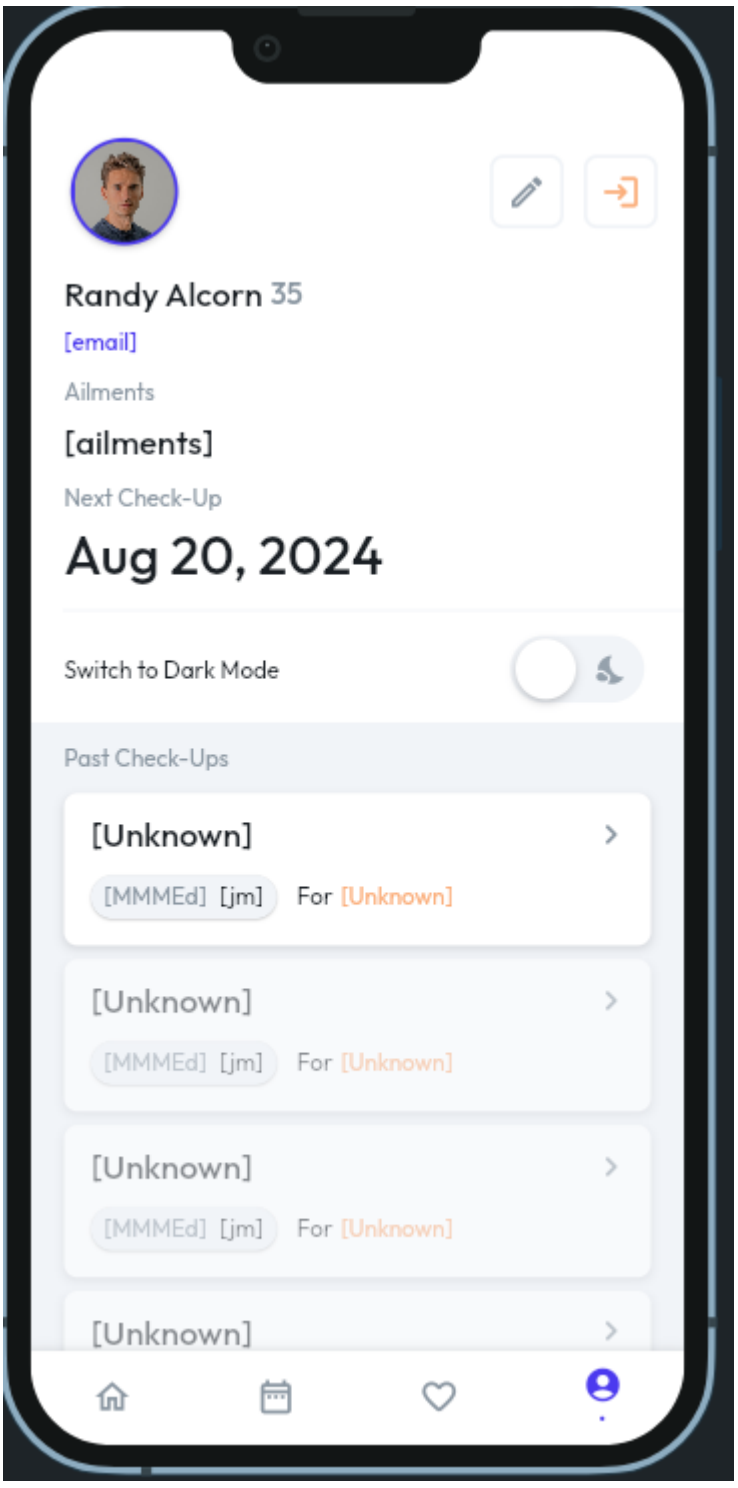
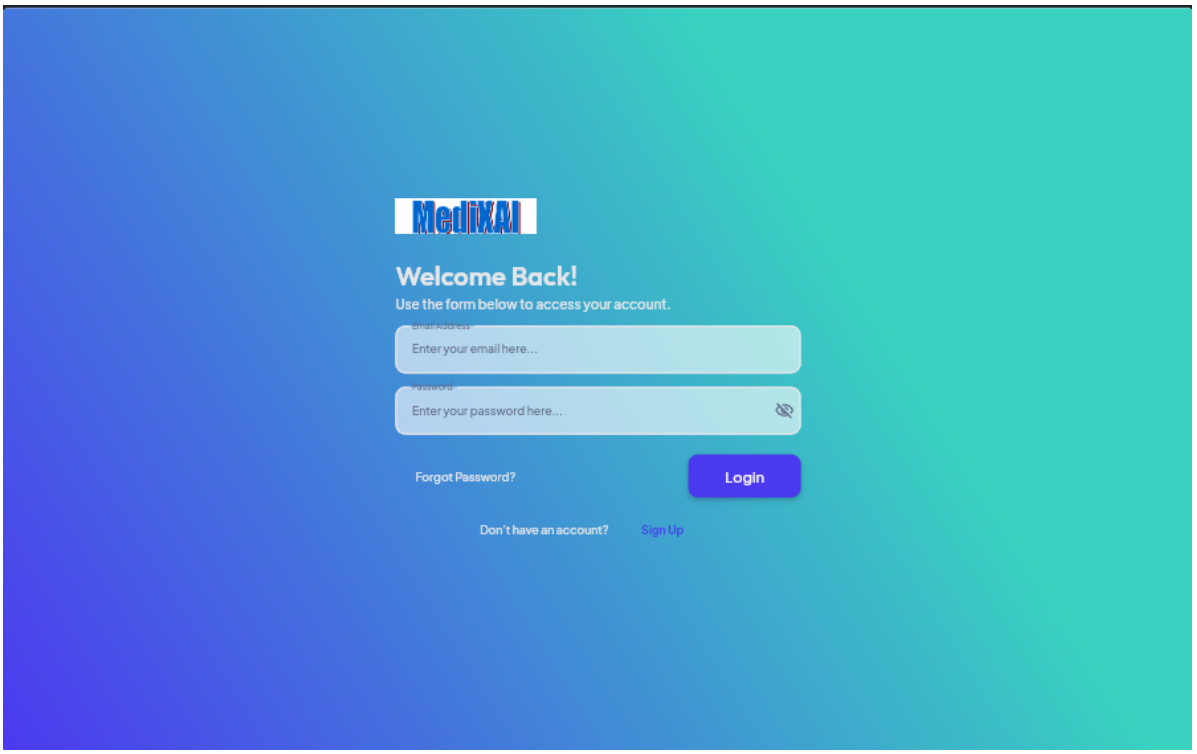
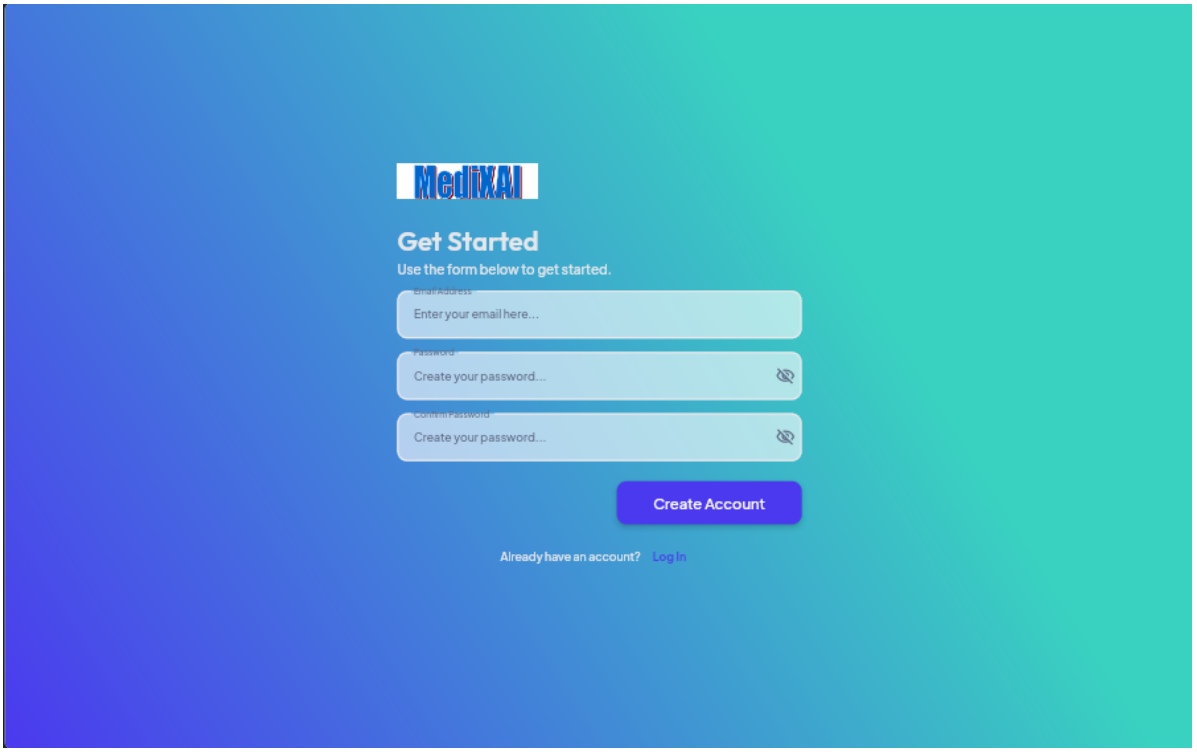
Check-Up Name
[MMMEd] [jm]

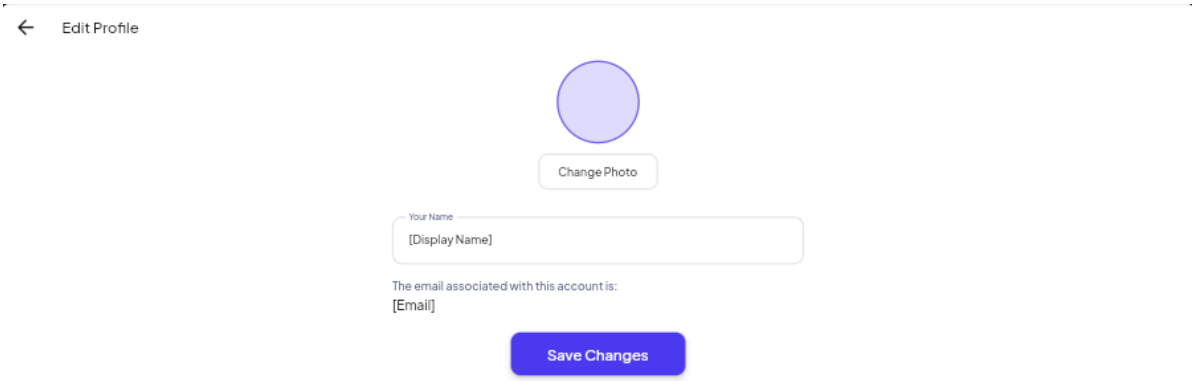

Start Check-Up
MediXAI
Search check-ups...
Breast Cancer Check-Up
Breast cancer check-up involves a comprehensive evaluation, including mammograms and if necessary, additional imaging or biopsies, to detect and assess the presence of breast cancer at an early stage for timely intervention and treatment.
Lung Cancer Check-Up
Lung cancer check-up typically includes imaging tests such as chest X-rays or CT scans, along with pulmonary function tests and, if warranted, biopsies, aiming to diagnose and stage lung cancer for effective treatment planning.
Routine Check-Up
Routine check-up is a preventive healthcare appointment where a healthcare professional assesses overall health, conducts screenings, and addresses any emerging health concerns to promote early detection and intervention for optimal well-being.
[Check-Up Name]
[Check-Up Description]

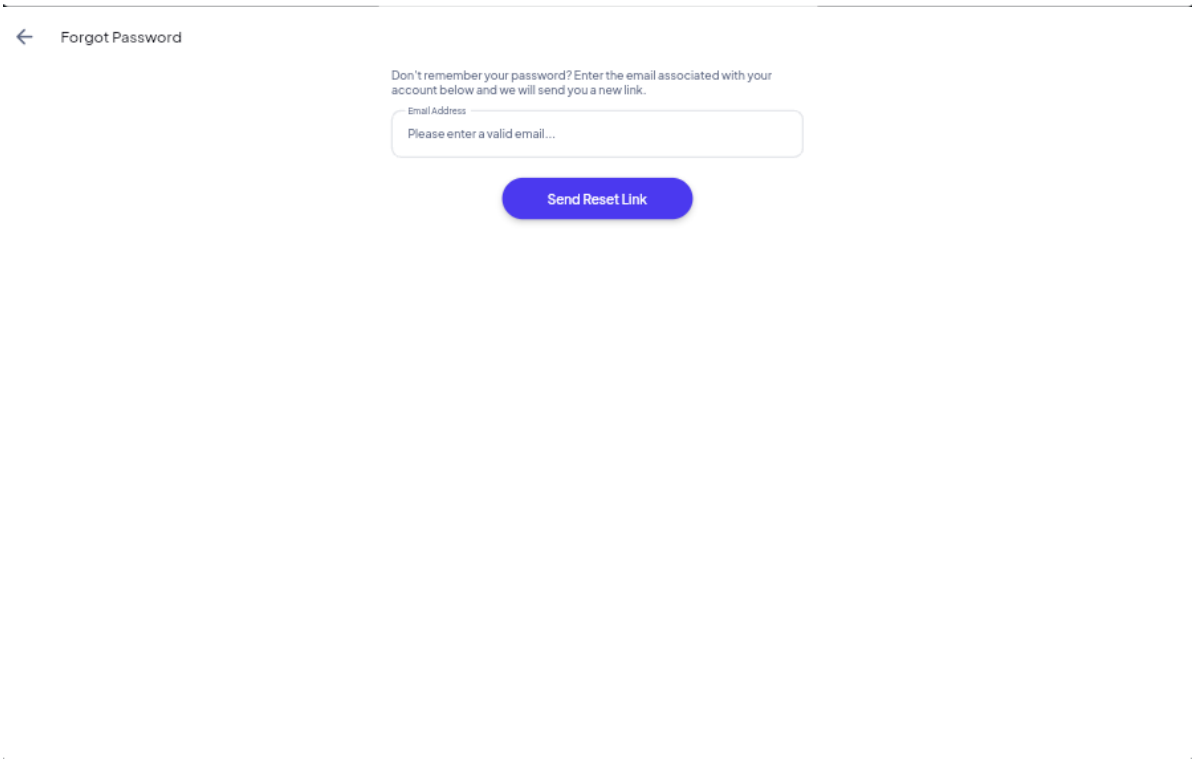

Randy Alcorn 35
[email]
Ailments
[ailments]
Next Check-Up
Aug 20, 2024
Switch to Dark Mode
Past Check-Ups
[Unknown]
[MMMEd] [jm] For [Unknown]
[Unknown]
[MMMEd] [jm] For [Unknown]
[Unknown]
[MMMEd] [jm] For [Unknown]
[Unknown]

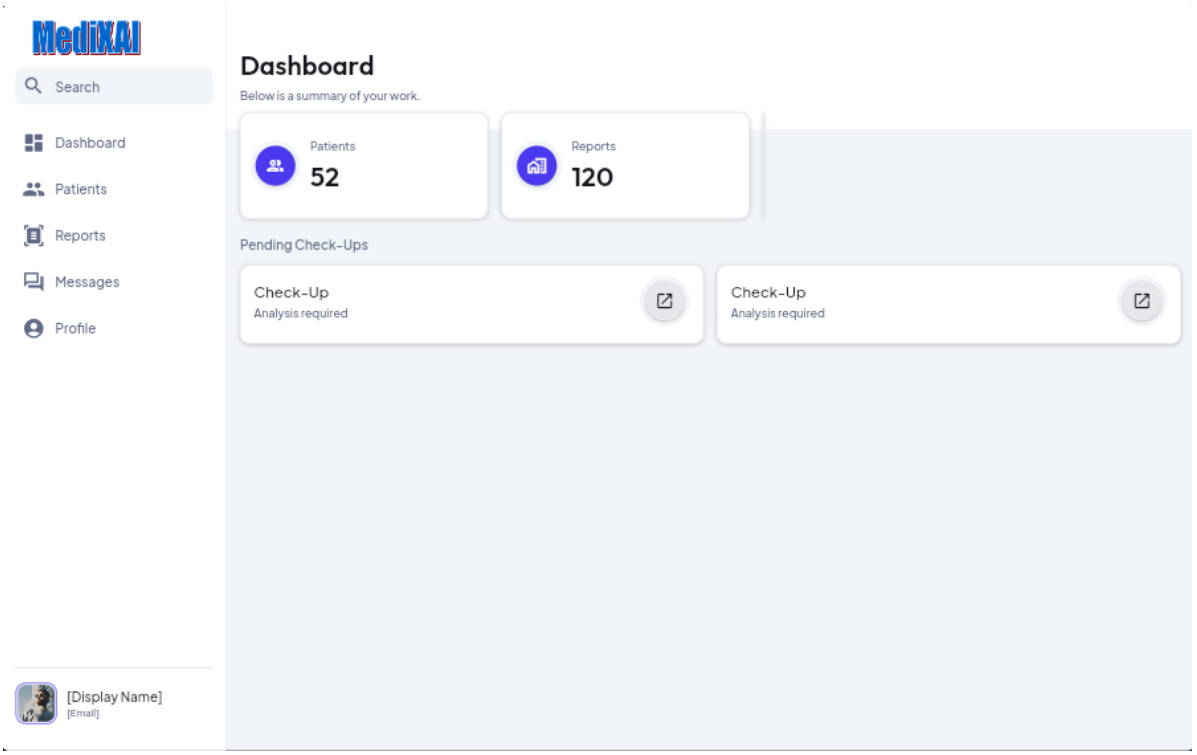
The web application UI for the doctor's side is given below.

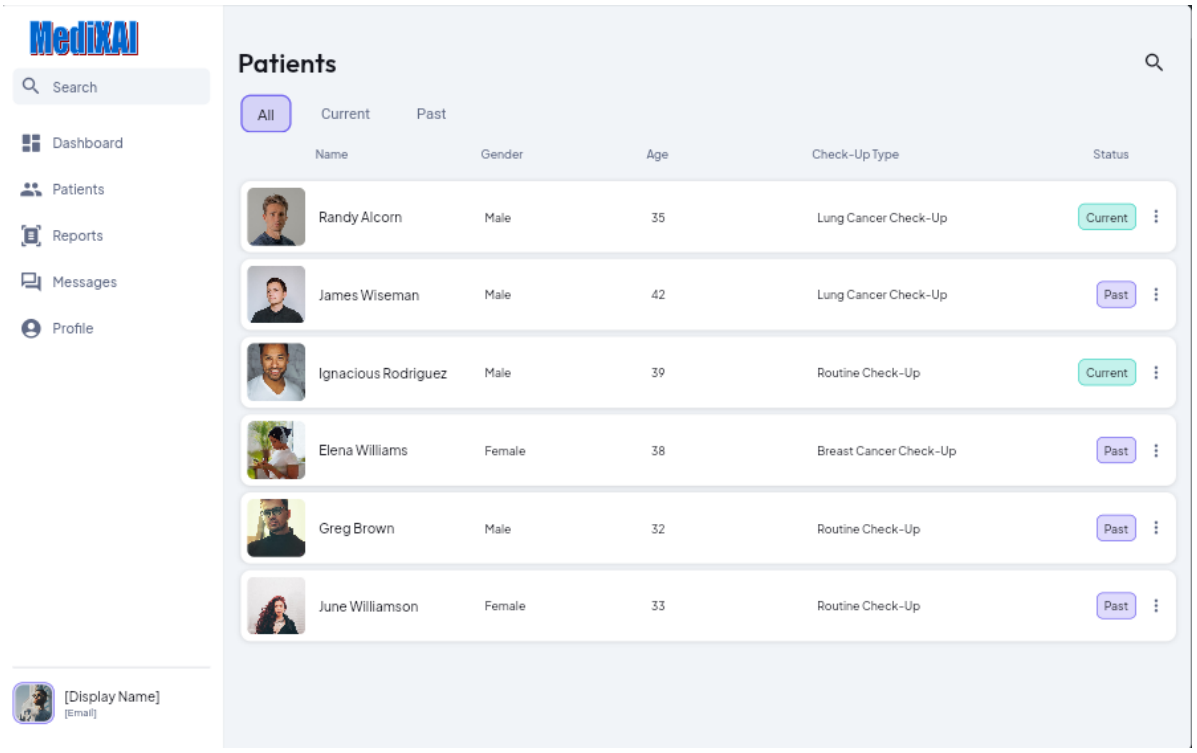


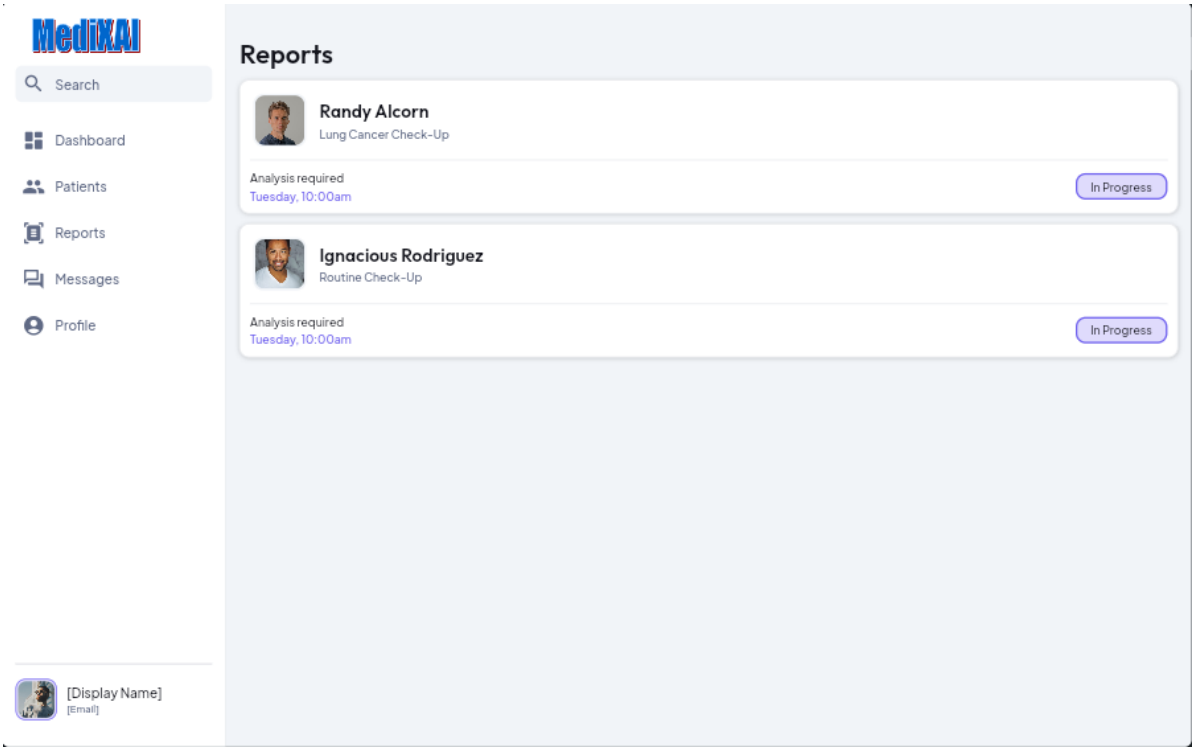


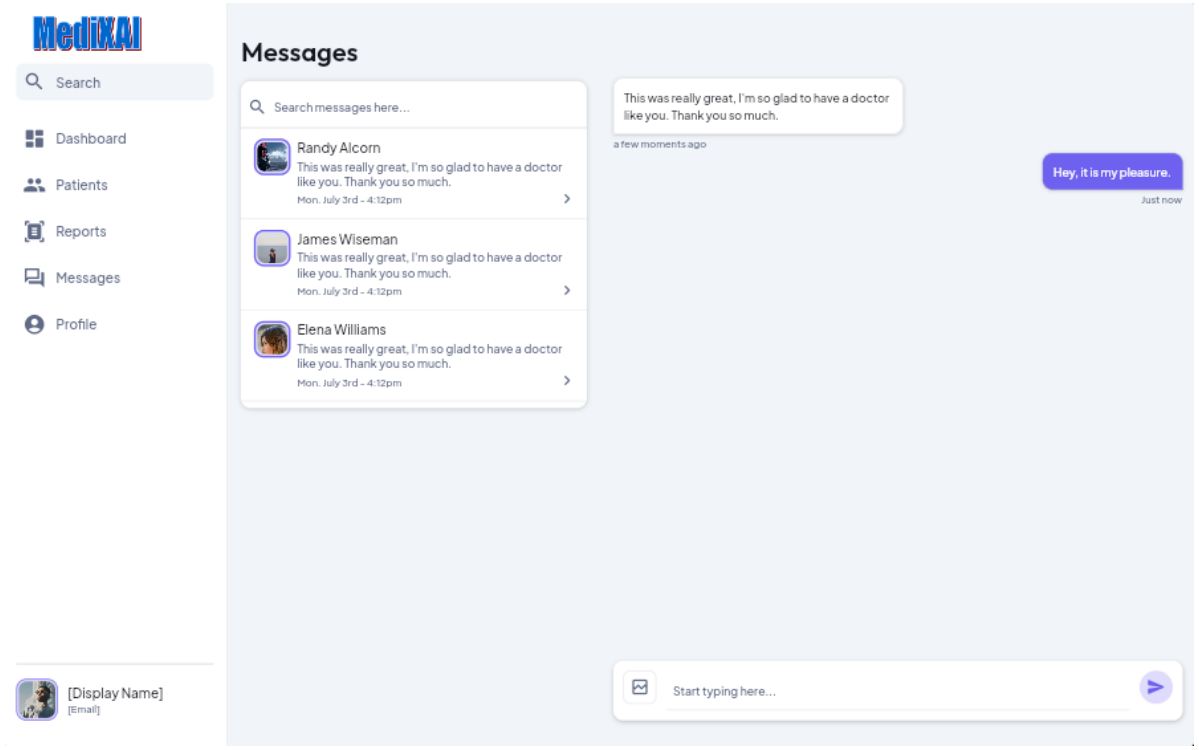

Edit Profile
Change Photo
Your Name
[Display Name]
The email associated with this account is:
[Email]
Save Changes

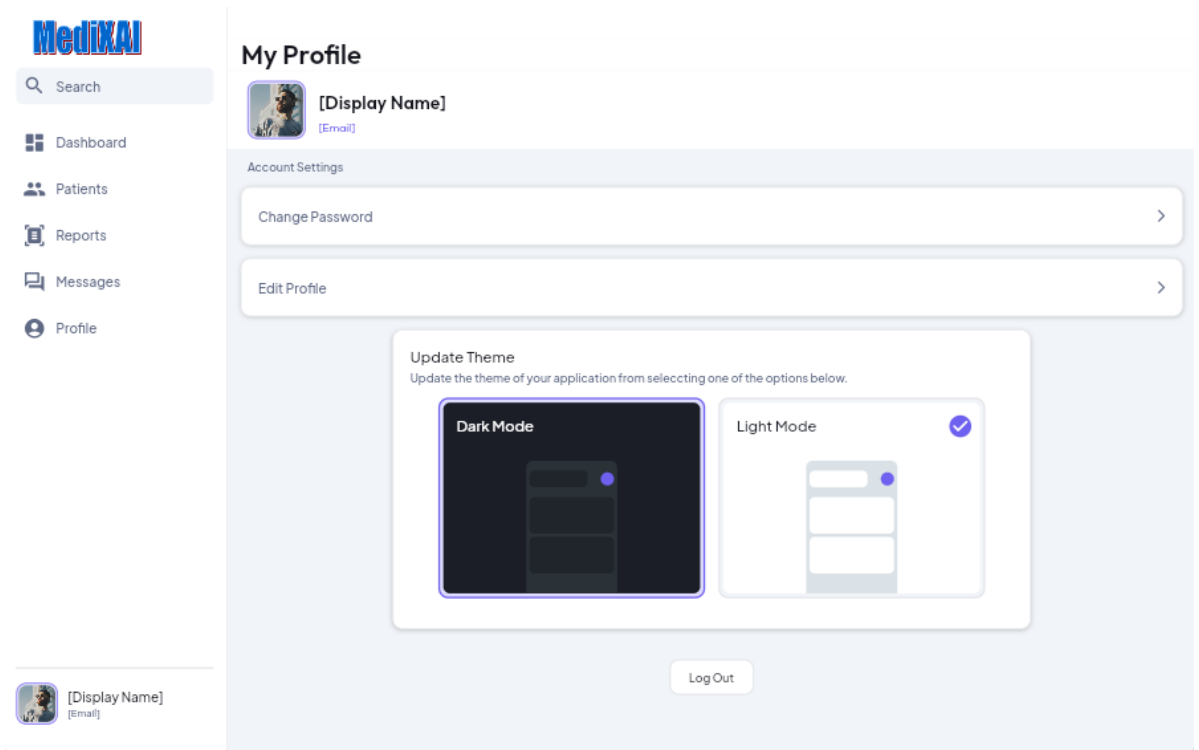

Forgot Password
Don't remember your password? Enter the email associated with your account below and we will send you a new link.
Email Address
Please enter a valid email....
Send Reset Link


MediXAI
Search
Dashboard
Patients
Reports
Messages
Profile
[Display Name]
[Email]
Dashboard
Below is a summary of your work.
Patients
52
Reports
120
Pending Check-Ups
Check-Up
Analysis required
Check-Up
Analysis required


MediXAI
Search
Dashboard
Patients
Reports
Messages
Profile
[Display Name]
[Email]
Patients
All
Current
Past
Name
Gender
Age
Check-Up Type
Status
Randy Alcorn
Male
35
Lung Cancer Check-Up
Current
James Wiseman
Male
42
Lung Cancer Check-Up
Past
Ignacious Rodriguez
Male
39
Routine Check-Up
Current
Elena Williams
Female
38
Breast Cancer Check-Up
Past
Greg Brown
Male
32
Routine Check-Up
Past
June Williamson
Female
33
Routine Check-Up
Past


MediXAI
Search
Dashboard
Patients
Reports
Messages
Profile
[Display Name]
[Email]
Reports
Randy Alcorn
Lung Cancer Check-Up
Analysis required
Tuesday, 10:00am
In Progress
Ignacious Rodriguez
Routine Check-Up
Analysis required
Tuesday, 10:00am
In Progress





7 Other Analysis Elements

Consideration of Various Factors in Engineering Design

In the engineering design of our breast cancer control project, various considerations have been given to several critical factors to ensure the system's efficacy, fairness, and security. First of all, we still try to find a comprehensive dataset that contains diverse demographics to

avoid biases towards specific races or demographics. Secondly, the design involves implementing an AI-human decision-making mechanism where both the radiologist and the artificial intelligence independently determine the BI-RADS level from uploaded mammogram images, ensuring unbiased decision-making. This approach comes from the idea that exposing the radiologist to the AI decision beforehand might introduce bias to the radiologist's mind, potentially leading to misinterpretation. Furthermore, in cases where the initial assessments of AI and the first radiologist conflict, a second radiologist is consulted to resolve discrepancies. Thirdly, it is certain that AI returning its results only as categories and their corresponding probabilities will not help radiologists comprehend why AI gives a specific decision. Addressing this issue, we consider that we can use explanaible AI, which shows its decision details. Finally, to prevent fraudulent entries, an important measure has been integrated into the registration process. Prospective radiologists must authenticate their credentials using a verification key specific to medical professionals. Thus, we will utilize a verification API to validate their legitimacy before they gain access to the platform. As a result, these considerations collectively form the foundation of our engineering design, prioritizing inclusivity, accuracy, and security within our breast cancer diagnostic system.

Risks and Alternatives

Risks:

Depending on the external conditions, there are potential risks associated with our application.

- The first risk is that our ML model's predictions may not give accurate results because of a lack of fully accurate data, such as the patient's medical history that cannot be predicted before.
- The second potential risk involves our response time being dependent on the promptness of doctors' responses. The duration for the application to reach a final diagnosis is notably influenced by the doctors' performance. Since this cannot be foreseen in advance, our date for finalizing results remains uncertain.

Alternatives:

Additionally, the current solution gives the most accurate possible predictions. We trained our model with several public and private datasets. Our model predicts based on

- age of the patients,
- the number of births,
- medical history of the patient,
- changes from the last mammogram image taken.

Our application assigns doctors based on their expertise and availability.

Project Plan

	Effect level	Effect

Access to good datasets	High	This will affect the accuracy of the ML mode which will affect the overall diagnosis process
The costs of training the ML model	Medium	If the cost is high, it can be an obstacle due to the limited budget available
The cost of hosting the services	High	The services (database, storage, web server…) are hosted online, which means that the cost will be continuous if it exceeds our expectations it might cause some difficulties in the design stage.
New competitors appearing	Medium	In the case where new competitors appear during the design stage, the project's success might be affected

Table 1: Factors that can affect analysis and design

	Likelihood	fect on the project	B Plan Summary
Accuracy of the ML lel might not be as as desired (95%)	m		people from the software o the ML team and give more or fine-tuning and optimizatior
ot working as ted		m	sider the algorithms used for AI can be implemented in forms, we will try other forms chniques.
nline servers not able to handle the ining process as ted			ge the provider (go to Amazor ample) the provider is currently e
se not being able to e all backend tasks			those tasks to Flutter frontenc sible, otherwise host a ementary program on the s to complete the missing es

Table 2: Risks

WP#	Work package title	Leader	Members involved
WP1	ML model	Ahmet	Ahmet, Mustafa
WP2	XAI model	Mustafa	Ahmet, Mustafa
WP3	UI design	Ömer	Ömer
WP4	Backend architecture design	Mahmut	Mahmut
WP5	Frontend implementation	Ömer	Ömer, Mahmut
WP6	Backend implementation	Omar	Omar, Mahmut
WP7	Project website	Omar	Omar
WP8	Project Specification Document	Ömer	Ahmet, Mahmut, Mustafa, Omar, Ömer
WP9	Analysis and Requirement Report	Mahmut	Ahmet, Mahmut, Mustafa, Omar, Ömer

Table 3: List of work packages

WP 1: *ML Model*			
Start date: *01/11/2023* **End date:** *15/02/2024*			
Leader:	*Ahmet*	**Members involved:**	*Mustafa*
Objectives: *Design a ML model that can classify mammograms according to the BI-RADS scale. The model should have an accuracy of at least 95%.*			
Tasks: ***Task 1.1 Collect data*:** *The ML model needs to train on labeled images. Those images have to be collected from various databases on the internet.* ***Task 1.2 Preprocess the dataset*:** *The collected data should be analyzed and filtered based on specific criteria so that it can be later combined into a balanced and meaningful dataset to train the model on* ***Task 1.3 Train the initial model*:** The initial model will be trained on the data collected and the performance will be monitored ***Task 1.4 Fine tune the model*:** *The model has to be fine-tuned for early breast cancer detections to increase accuracy.*			
Deliverables ***D1.1:** Well-balanced and diverse dataset* ***D1.2:** Accurate ML model for BI-RADS classification* ***D1.3:** Fine-tuned ML model that performs well with early screenings*			
WP 2: *XAI Model*			
Start date: *15/02/2024* **End date:** *01/04/2024*			
Leader:	*Mustafa*	**Members involved:**	*Ahmet*
Objectives: *Develop a model that can provide explainability and interpretability. Both the doctors and the developers should be able to understand how the model works. The ambiguity of ML models should be eliminated as much as possible.*			
Tasks: ***Task 2.1 Search for the most suitable approach*:** *XAI can be implemented in many ways. I is just a concept. The most suitable way for our use case should be investigated.* ***Task 2.2 Get a suitable dataset*:** *XAI will require a slightly different dataset with selections o regions of interest and explanations if possible.* ***Task 2.3 Train the model*:** *Train the model with the obtained dataset.* ***Task 2.4 Increase accuracy*:** *The model should be tested, and if the accuracy is not good enough, it should be increased.*			
Deliverables			

D2.1: *Develop a good XAI approach* ***D2.2:*** *Suitable dataset for XAI* ***D2.3:*** accurate *XAI model*

WP 3: *UI Design*			
Start date: *25/11/2023* **End date:** *01/12/2023*			
Leader:	Ömer	**Members involved:**	
Objectives: *Design the mockups for the mobile application that will be used by the patients and the web application that will be used by the doctors.*			
Tasks: ***Task 3.1 Design mobile app pages*****:** *Those mobile app pages will be used by the patients to upload their mammograms and follow the diagnosis steps and results.* ***Task 3.2 Design web app pages*****:** *The web app pages will be used by doctors to analyze mammograms and give their diagnoses to the patients.*			
Deliverables ***D3.1:*** *Fully developed mobile app pages using FlutterFlow* ***D3.2:*** *Fully developed web app pages using FlutterFlow*			

WP 4: Backend architecture design			
Start date: *25/11/2023* **End date:** *01/12/2023*			
Leader:	*Mahmut*	**Members involved:**	
Objectives: Develop a *design plan of a full architecture for the backend (database, services, storage…)*			
Tasks: ***Task 4.1*** **Identify the necessary features that need to be used in Firebase:** Give a list of features to be used in the backend so that the backend team can work on them later. ***Task 4.2 Come up with a design*****:** *Those different features should be brought together in a design that will define the end-to-end backend structure*			
Deliverables ***D4.1:*** *List of technologies and features to be used* ***D4.2:*** *End-to-end backend design*			

WP 5: Frontend implementation			
Start date: *01/12/2023* **End date:** *15/12/2023*			
Leader:	Ömer	**Members involved:**	*Mahmut*
Objectives: *Have a fully working frontend with all the pages implemented*			
Tasks: ***Task 5.1 Implement Mobile Application frontend*****:** *The mobile application will be used by the patients.* ***Task 5.2 Implement the web application frontend*****:** *The web application will be used by the doctors.*			
Deliverables ***D5.1:*** *FlutterFlow mobile application UI implementation and backend integration* ***D5.2:*** *FlutterFlow web application UI implementation and backend integration*			

WP 6: Backend implementation			
Start date: *01/12/2023* **End date:** *15/12/2023*			
Leader:	*Omar*	**Members involved:**	*Mahmut*

Objectives: *Develop a fully working backend with database, authentication…*
Tasks: ***Task 6.1 Design the Firebase database*:** *The database will hold all the application's data other than files* ***Task 6.2 Develop the authentication on Firebase*:** *Authentication will be used to log in users (Doctors and patients)* ***Task 6.3 Set up Firebase storage to store all files*:** *The storage will be used to store files like mammograms, images, pdf reports…* ***Task 6.4 Set up messaging on Firebase*:** *Messaging will be used between patients and doctors*
Deliverables ***D6.1:*** *Firebase database* ***D6.2:*** *Firebase Authentication system* ***D6.3:*** *Firebase storage* ***D6.4:*** *Firebase messaging*

WP 7: Project website			
Start date: *01/10/2023* **End date:** *10/10/2023*			
Leader:	*Omar*	**Members involved:**	
Objectives: *The website will serve as the project description page and the place for reports and other project related information*			
Tasks: ***Task 7.1 Get a domain from Google*:** *The domain will be used to reach the website online* ***Task 7.2 Set up an HTTPS server*:** *set up an HTTPS server to host the website and use Google Cloud DNS to link the domain to the public ip address of the server*			
Deliverables ***D7.1:*** *Website accessible from the internet*			

WP 8: Project Specification Document			
Start date: *01/11/2023* **End date:** 17/11/2023			
Leader:	*Ömer*	**Members involved:**	Ahmet, Mustafa, Omar, Mahmut
Objectives: *Complete the project specification document*			

Tasks: ***Task 8.1 Introduction:*** ***Task 8.2 Description*** ***Task 8.3 High Level System Architecture & Components of Proposed Solution*** ***Task 8.4 Implementation Constraints*** ***Task 8.5 Economic Constraints*** ***Task 8.6 Ethical Constraints*** ***Task 8.7 Professional and Ethical Issues*** ***Task 8.8 Standards*** ***Task 8.9 Functional Requirements*** ***Task 8.10 Non-Functional Requirements*** ***Task 8.11 Market & Competitive Analysis*** ***Task 8.12 Academic Analysis***
Deliverables ***D8.1:*** Project Specification Document

WP 9: Analysis and Requirement Report			
Start date: *01/12/2023* **End date:** *07/12/2023*			
Leader:	*Mahmut*	**Members involved:**	Ahmet, Mustafa, Omar, Ömer
Objectives: *Complete the Analysis and Requirement Report*			
Tasks: ***Task 9.1 Introduction*** ***Task 9.2 Current System*** ***Task 9.3 Functional Requirements*** ***Task 9.4 Nonfunctional Requirements*** ***Task 9.5 Pseudo Requirements*** ***Task 9.6 Scenarios*** ***Task 9.7 Use Case Model*** ***Task 9.8 Object and Class Model*** ***Task 9.9 Dynamic Models*** ***Task 9.10 User Interface - Navigational Paths and Screen Mock-ups*** ***Task 9.11 Constraints*** ***Task 9.12 Standards*** ***Task 9.13 Risks and Alternatives*** ***Task 9.14 Project Plan*** ***Task 9.15 Ensuring Proper Teamwork*** ***Task 9.16 Ethics and Professional Responsibilities*** ***Task 9.17 Planning for New Knowledge and Learning Strategies***			
Deliverables ***D9.1:*** *Analysis and Requirement Report*			

Ensuring Proper Teamwork

The implementation of the project is divided into two parts which are software development and ML model development. Work distribution in our team is shown in Table 4.

Software Development	ML Model Development
Omar, Mahmut, Ömer	Ahmet, Mustafa

Table 4: Work Distribution

We schedule weekly meetings and additional smaller meetings as necessary to assess our progress, identify upcoming tasks, and allocate responsibilities to each team member. This strategy ensures the continuity of effective teamwork.

Ethics and Professional Responsibilities

All the data that is accessed during the training of the machine learning model is obtained from publicly available databases that consist of medical images taken from patients who consented for their data to be used for medical and academic purposes. Additionally, some of the data is obtained by legal agreements with organizations' ethics commissions. Moreover, we will implement the model in a way that prevents the reconstruction of the training data or any part of it.

At the registration stage, consent of the users will be taken to process and store user data in our system. We will only keep the necessary data in our servers, and all other data will be stored in the user device as much as possible. All the stored data will be protected by encrypting them and securing our servers. The users will have the option to choose how long the data stays on our servers. Users are also asked for permission to use their data to further train our model (for feedback learning). We will authenticate the users before uploading any data to the system by checking their identity. We might cooperate with some companies that are specialized in the relevant field; for this, we will need to sign a Non-Disclosure Agreement (NDA).

Another significant issue with computer-assisted systems is the potential bias in diagnosis due to the lack of diversity in training datasets. Models trained predominantly on data from certain ethnic groups or body types may not perform equally well across all populations. This disparity can lead to less accurate diagnoses for underrepresented groups, raising concerns about equity in healthcare. Ensuring that these models are trained on diverse and inclusive datasets is an important issue for us and we are trying to train our models using datasets as diverse as possible for Turkish society.

Using machine learning models in critical domains like healthcare is a sensitive issue. The problem with classical models is that they act as a "black box"; it is not possible to understand the reasoning behind the classification. This poses an ethical issue since relying on a model that might misdiagnose a case without understanding how it made its decision might put patients' lives in danger. Therefore, we will include an XAI model to make it clear to doctors how the model diagnosed the case. This XAI model can provide text explanations and highlight relevant locations in the image.

Planning for New Knowledge and Learning Strategies

We try to gain knowledge in various areas to realize our project:

1. Explainable AI using Transformers
2. How the breast cancer diagnosis process works in Turkey, and what institutions are responsible for this process
3. FlutterFlow for Frontend
4. Firebase for Backend

In order to learn all this new knowledge, we use a wide range of learning strategies:

1. Scientific Articles
2. Blogs
3. Youtube
4. Physically visiting the responsible institutions and talking with their workers

8 Glossary

Term	Definition
XAI	Explainable Artificial Intelligence
HIPAA	Health Insurance Portability and Accountability Act
KETEM	Cancer Early Diagnosis, Screening and Education Center
BI-RADS	Breast Imaging-Reporting and Data System
API	Application Programming Interface
UI	User Interface

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