Intelligent System for Breast Cancer Detection Using Mammographs

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Document Approval:
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1 INTRODUCTION

Breast cancer is the second most leading cause of death among women all over the world. There are multiple methods for detecting cancerous tissues such as, mammography, ultrasound, magnetic resonance imaging (MRI), breast-specific gamma imaging (BSGI) etc. It is hard to detect in initial stages using mammography since the cancerous tissues is not much different from the normal tissue. According to World Health Organization, most women develop breast cancer in the age bracket of 45-55. It is even harder to detect in young female due to extra dense breast tissues using mammography.

The rapid advancement of machine learning and especially deep learning continues to fuel the medical imaging community's interest in applying these techniques to improve the accuracy of cancer screening. This project is aimed to detect cancerous tumors from mammographs using a convolutional neural network (CNN). The model will be taking out a region of interest and detecting cancer within the region. The system basically incorporates deep learning computer aided detection system to help with early diagnose.

1.1. PURPOSE

Often doctors miss out in detecting the breast cancer from the mammographs, this can be because of weak eyesight or clouded judgement etc., so they need a second opinion. For this purpose. a portable breast cancer detector would be of great use to the doctors and surgeons. This would save time consulting another specialist and will always be accessible.
The project is being developed keeping in mind the current technologies and needs. The system is meant to be used commercial by doctors and surgeons. The app will be used to scan mammograms and give accurate results. The data is sent to the neural network after scanning, and the images are segmented and pooled at every layer giving a ROI. From the given ROI the model will give the user an output, detecting the any malignant or benign cancer tissues.

1.2. PRODUCT SCOPE

With the increasing automation nowadays, use of technology and artificial intelligence has started to grow. Hence forth, the medical imaging community has taken interest in incorporating the use of CAD systems. Such is our product. It uses an android application, which is the most used platform across the world. Android smartphones come at all prices and specifications and is readily available everywhere. Working inside the application is an AI model that gets the data and gives results within a few seconds, with increased accuracy and zero expense. Using deep learning algorithms, the model will detect cancer accurately and efficiently.

This product is targeted toward doctors and surgeons, who will use this application as a second opinion to their deductions. The doctors would not need to call upon other specialists or send patients to consult other specialists. This would save a lot of time and money of the patient as well as the doctors.

The product is eventually meant for commercial deployment and in later stages, the product can be upgraded and improved to include multiple types of cancers. It can later be developed into a desktop application and be used in cancer hospitals as a professional software.

Table 1: Terms used in this document and their description

Name	Description
CNN	Convolutional Neural Network
ROI	Region of Interest
TF	Tensor Flow

1.1 THE OVERALL DESCRIPTION

1.2 PRODUCT PERSPECTIVE

The product will run on an Android Smartphone. Since the application will be built on the android studio ,it would not run on the ios. The Smartphone with a good camera quality is recommended as it will be used to capture the mammograph image.

2.2. PRODUCT FUNCTIONS

In this section, we will be discussing the major functionalities of our application. The below-mentioned functionalities will be integrated into the final product with some changes if required.

Account:
After the user opens our app, the user must have to sign up the account. User can log in the desired application by filling the required information. After logging the account, the user should be able to use the options available in the application.
History:
After login into the account, the user uses the facilities available in the application. App has the history tab available in it. History tab has the record of the patient.
Feedback:

The doctor can give the feedback of the application's operations. The doctor will give the feedback of whether there is a bug or not in the application, whether the results are true or not.

New scan:
The new scan tab option can scan the mammographs and proceed the further procedure to the CNN model which is on the server.

Save scan:
After the scan is processed, the doctor then saves the scan with the patient credentials with the selection of the save scan button.

2.3. USER CHARACTERISTICS

The user of our product will be patients and surgeons. User will be able to use our app according to their desired needs. Patients would be able to upload and receive reports anytime. Breast cancer treatment will become easy to access in initial stages. Doctors can easily have their patients' history and can diagnose their disease by using patients scans and records.

2.4. CONSTRAINTS

- A fast internet connection will be necessary for timely response to the user.
- The users of the product know and understand the English language as the information and instructions displayed will be in English.
- The user cannot completely rely on the results of the application as this is the medical issue and we are assuming that the CNN model accuracy will not be 100% so , a second opinion will always be required .

2.5. ASSUMPTIONS AND DEPENDENCIES

- We are assuming that the user knows how to use the android mobile phone.
- The user can use the camera efficiently.
- The targeted user are professionals.
- The application will be used by doctor for consultation.
- The user must have knowledge about breast cancer.
- The user has a mammogram.
- The mobile phone has an internet connection.
- The mobile phone has a working camera.
- The smart phone should have enough storage for the application.

2 USER REQUIREMENTS

2.1 External Interface Requirements

2.1.1 User Interfaces

The client will be provided with a user-friendly android application. The user login/signup the application and after a successful login, the user is taken to the main activity. There are multiple options presented to be chosen from. If the user selects new scan option, they are sent to a new screen where the user is asked for basic patient credentials, i.e. Patient Id, age, gender. After the information is filled, the user is taken to scanning screen. After scanning the image is sent in the model and on a new screen the user receives an output.
In case the user wants to check old records, they would select the patient record option. This would take them to a new screen containing a list of patient names along with patient ID. Here the user can access old results of existing patients.

2.1.2 Hardware Interfaces

This system is not dependent on any highly specialized hardware when being used. As the user will only be interacting with the android application, they would only require an android smartphone with 2GB RAM, 500MB space and a recommended 5MP working camera.

2.1.3 Software Interfaces

This system will be accessed using an android application, where the user will be presented with multiple options to choose from. The main function is to scan the mammograph using the camera API. The resulting image will be fed to the neural network as input. The input image would be segmented and pooled after every layer and finally an output would be shown to the user.

2.1.4 Communication Interfaces

This system will be using **android studio** and **java** for application development. The AI model would be built using **TensorFlow and other Python libraries.** All records would be saved in a database developed in **Microsoft MySQL.** Every time the user wants to access previous patient records, the data would be accessed and viewed from the existing database.

3 Functional Requirements

Functional Requirement #	Functional Requirement Description
FR-1	The user must be able to register prior to professional use.
FR-2	Use of system must be preceded with a login screen.
FR-3	The user should have the ability to view and update old patient records.
FR-4	The user must be able to fill out all the patient credentials prior to scanning.
FR-5	The user must be able to scan the mammograms using camera API.
FR-6	The neural network must be able to receive input from the camera API and is also able to send back a correct output.
FR-7	The user should be able to see a final report after scan.
FR-8	User must be able to logout successfully.

3.1 Functional Requirements with Traceability information

Each requirement will have a separate table

Requirement ID	FR-1		Requirement Type	Functional requirement	Use Case #		UC-01
Status	New		Agreed-to	-	Baselined	-	Rejected	-
Parent Requirement #	None						
Description	The user must register into the system for using the application.						
Rationale	This is used to keep track of which user is logged in to the system and which data is accessible to the user.						
Source					Source Document	-	
Acceptance/Fit Criteria							
Dependencies	User should have knowledge of the information required by the system for registration.						
Priority	Essential	✓	Conditional	-	Optional	-	
Change History							

Requirement ID	FR-2		Requirement Type	Functional requirement	Use Case #		UC-01

Status	New		Agreed-to	-	Baselined	-	Rejected	-	
Parent Requirement #	FR-1								
Description	The user is taken to a login screen to login to their respective accounts.								
Rationale	This helps differentiate between different users and their saved data.								
Source					Source Document		-		
Acceptance/Fit Criteria									
Dependencies	The user should remember their login credentials.								
Priority	Essential	✓	Conditional	-	Optional	-			
Change History									

Requirement ID	FR-3		Requirement Type	Functional requirement		Use Case #		UC-02	
Status	New		Agreed-to	-	Baselined	-	Rejected	-	
Parent Requirement #	FR-2								
Description	User can save patient records and look them up using patient credentials.								
Rationale	This is in order to compare records with new scans and report patient progress.								
Source					Source Document		-		
Acceptance/Fit Criteria									
Dependencies	The user should know how to save patient records and access them.								
Priority	Essential	✓	Conditional	-	Optional	-			
Change History									

Requirement ID	FR-4		Requirement Type		Functional requirement		Use Case #		
Status	*New*		*Agreed-to*	-	*Baselined*	-	*Rejected*	-	
Parent Requirement #	FR-2								
Description	The user is asked for basic patient credentials prior to scanning mammograms and a patient ID is assigned if new patient. Else, old ID is used.								
Rationale	This assures that a certain record is easily accessible later and does not mix up with any other patient records.								
Source					Source Document		-		
Acceptance/Fit Criteria									
Dependencies	The user must know how to read and write								
Priority	*Essential*	✓	*Conditional*	-	*Optional*	-			
Change History									

Requirement ID	FR-5		Requirement Type		Functional requirement		Use Case #		UC-02
Status	*New*		*Agreed-to*	-	*Baselined*	-	*Rejected*	-	
Parent Requirement #	FR-2, FR-4								
Description	The user is then sent to a scan window where the mammogram is scanned.								
Rationale	Not all users will already have pictures of scans, so scanning on spot helps with the issue.								
Source					Source Document		-		
Acceptance/Fit Criteria									
Dependencies	The user should have a working camera and knowhow of how to take a picture.								
Priority	*Essential*	✓	*Conditional*	-	*Optional*	-			
Change History									

Requirement ID	FR-6			Requirement Type		Functional requirement		Use Case #		UC-02
Status	*New*		*Agreed-to*	-	*Baselined*	-	*Rejected*	-		
Parent Requirement #	FR-2, FR-5									
Description	The picture taken is sent to the neural network as input and an output is shown to the user in a new screen.									
Rationale	The neural network does all the processing on the image. After resizing, the input is convoluted, segmented, pooled and an ROI is set for next layer to work on as input. After the processing the neural network sends an output to the user.									
Source					Source Document		-			
Acceptance/Fit Criteria										
Dependencies	The image should not be blurry and be taken in ample amount of light.									
Priority	*Essential*		✓	*Conditional*	-	*Optional*	-			
Change History										

Requirement ID	FR-7			Requirement Type		Functional requirement		Use Case #		UC-02
Status	*New*		*Agreed-to*	-	*Baselined*	-	*Rejected*	-		
Parent Requirement #										
Description	After the neural network has processed the data and formed an output, user should be able to see a final report.									
Rationale	The output is to second the user deductions and provide a quick check.									
Source					Source Document		-			
Acceptance/Fit Criteria										
Dependencies	The user should be able to read and have knowledge of mammograms.									
Priority	*Essential*		✓	*Conditional*	-	*Optional*	-			
Change History										

Requirement ID	FR-8		Requirement Type	Functional requirement		Use Case #		UC-02
Status	*New*		*Agreed-to*	-	*Baselined*	-	*Rejected*	-
Parent Requirement #								
Description	User must be able to logout successfully after operations are completed.							
Rationale	After no more work is needed the user should logout of the application.							
Source				Source Document	-			
Acceptance/Fit Criteria								
Dependencies	User must know what the logout button is.							
Priority	*Essential*	✓	*Conditional*	-	*Optional*	-		
Change History								

4 Nonfunctional Requirements & Software System Attributes

In systems engineering and requirements engineering a non-functional requirement is requirement that specifies the criteria that can be used to judge the operation of a system rather than specifies behavior. They are often referred to as quality attributes of a system. Below mentioned are the non-functional requirements of Intelligent System for Breast Cancer Detection Using Mammograms

1. **Performance**:
   The performance of the system should be up to the mark. The way system performs the whole process, should not be turbulent.

2. **Reliability:**
   The output generated should be reliable in every aspect; from scanning the mammogram to getting the proper output.

3. **Availability**:
   Availability includes the requirement of a computer system that can only run an android smartphone. Just a device with android OS is needed.

4. **Portability**:
   The android application is portable if the android smartphone in which it is desired to run has enough resources to run an android application.
5. **Dependability**:
   There is certain pre-requisite for the Mammograph scan to work. The user must have enough knowledge of how to operate android smartphone.

4.1 Performance Requirements

Performance requirements define how well the **system** performs certain functions under specific conditions. Examples are speed of response, throughput, execution time and storage capacity.
The speed of response for this system totally depend on the speed of the internet connection .

5 USE CASES: (Diagrams)
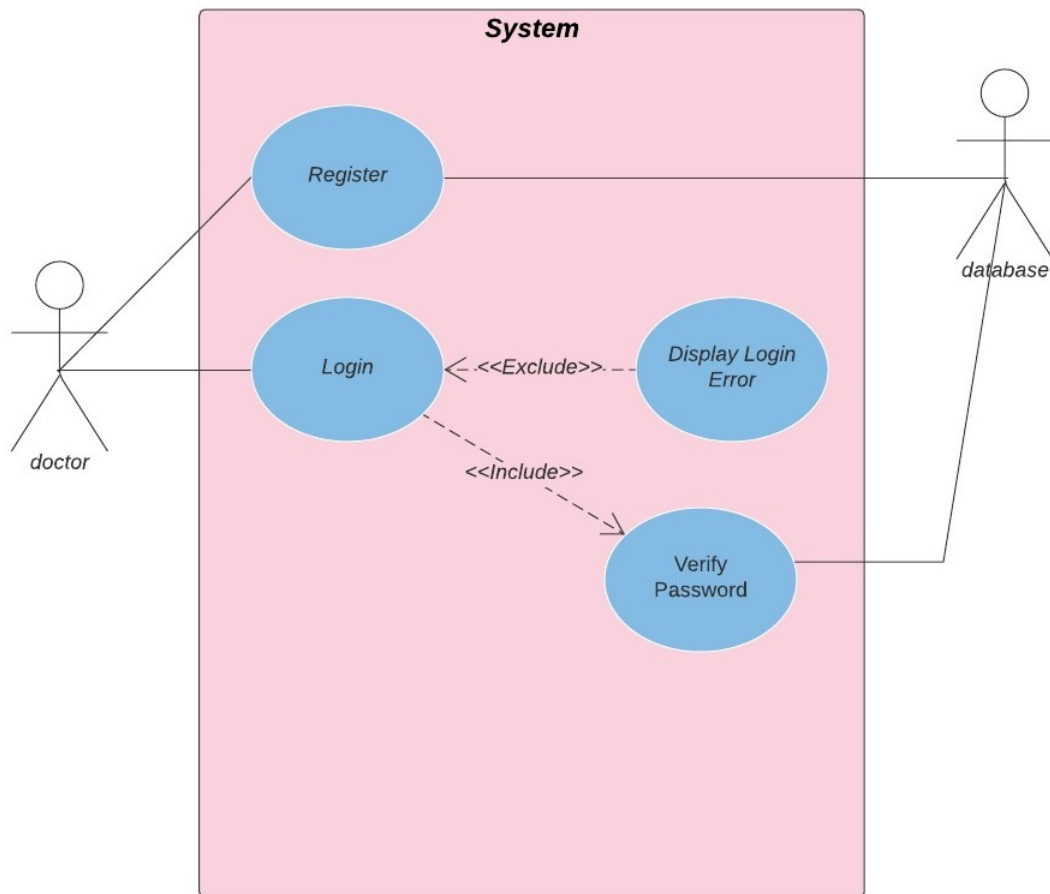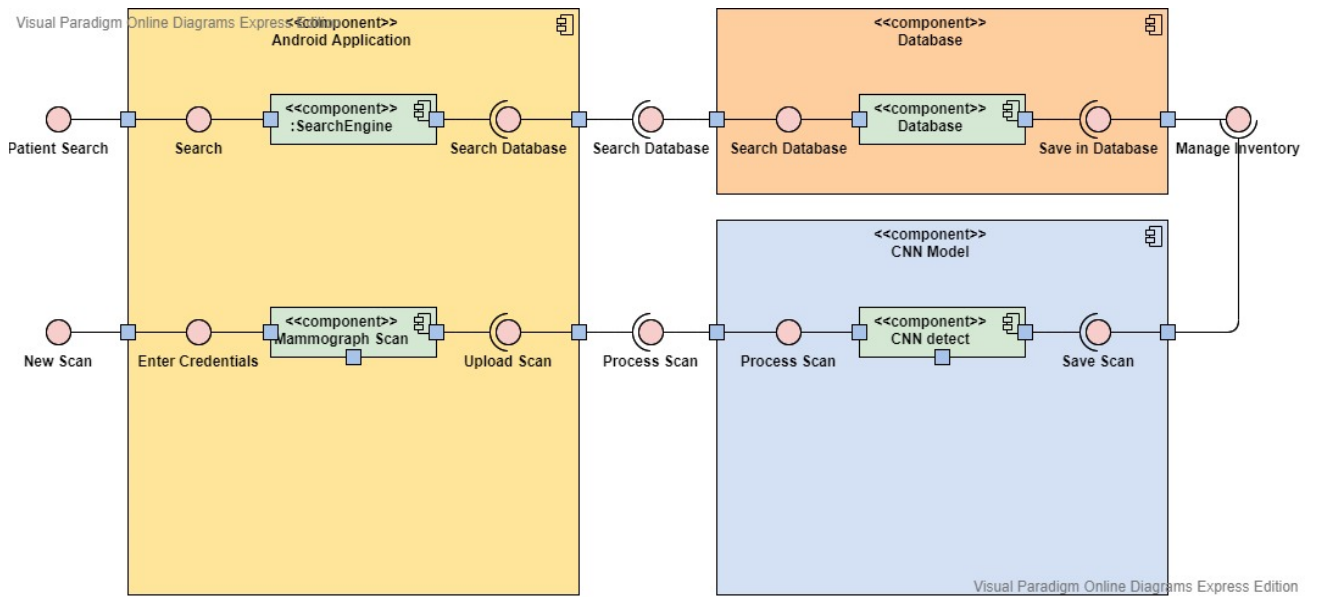

UC-01: Login Use Case
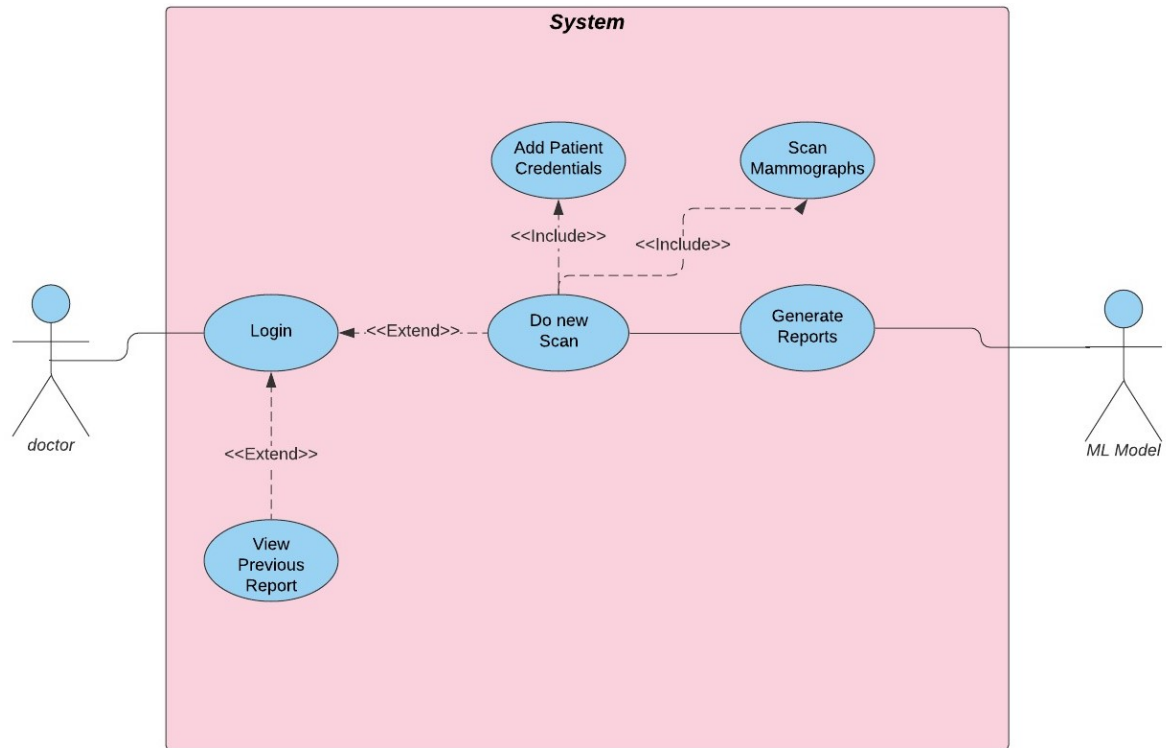
UC-02:Overall Application use case

6 UML Diagrams

- ## Component Diagram

• **Activity Diagram**

Activity diagram

Salman Ahmad | November 13, 2020
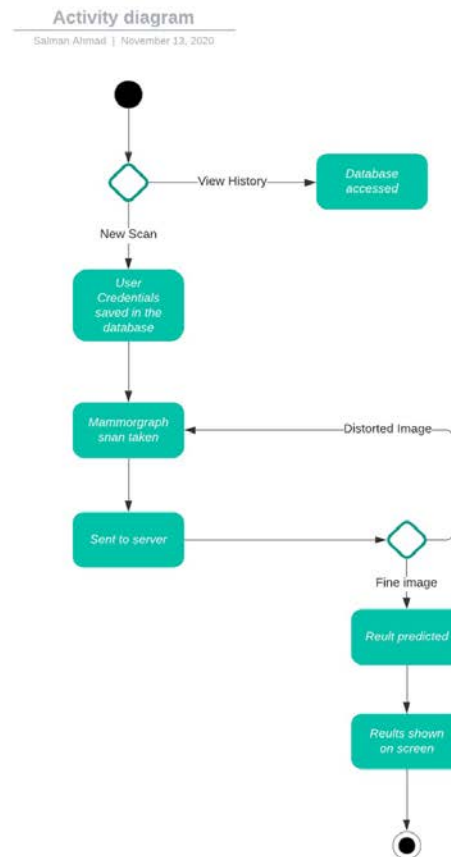
- ## Sequence Diagram
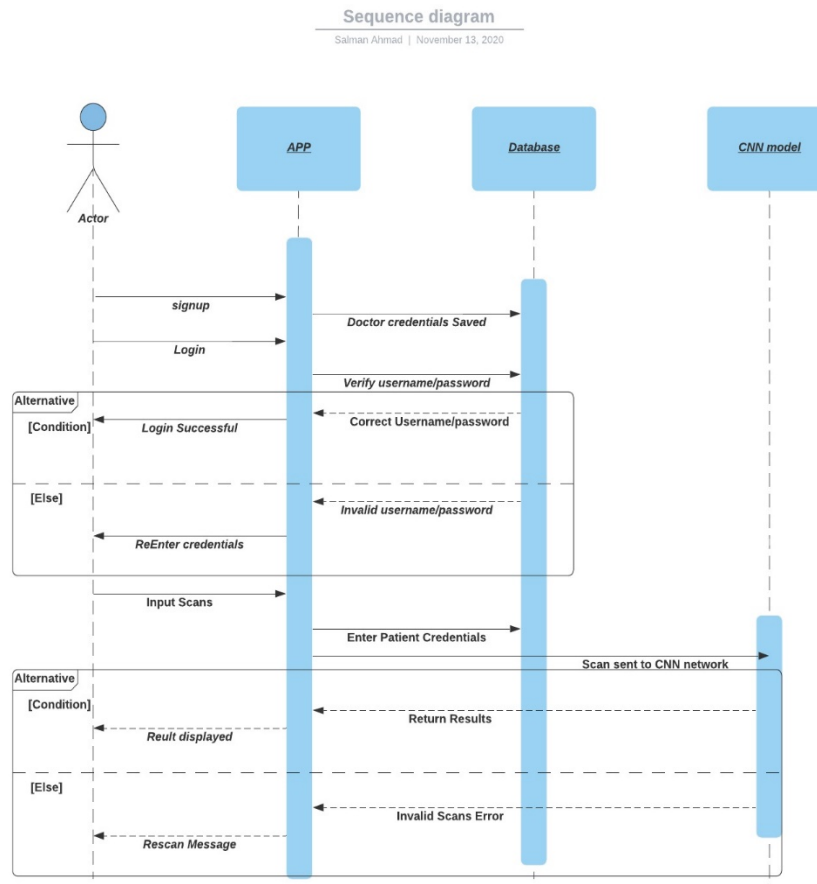
- ### Deployment Diagram

- **Package Diagram**