

# CSIT 321 – Final Year Project

Deep Learning based COVID-19 X-ray Image Classification

Group - FYP-23-S3-07

## System Requirement Specification

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## Contents

|   |    |
|---|----|
| 1. Introduction .....   | 3  |
| 1.1 Purpose .....   | 3  |
| 1.2 Objectives of the project .....                             | 3  |
| 1.3 Target Audience .....                                       | 3  |
| 2. Overall Description .....                                    | 4  |
| 2.1 Website Design.....   | 4  |
| 2.2 Website Features .....                                      | 5  |
| 2.3 Operating Environment.....                                  | 6  |
| 2.4 Design and Implementation Constraints.....                  | 6  |
| 3. System Features .....  | 7  |
| 3.1 Account Features.....                                       | 7  |
| 3.1.1 Login.....  | 7  |
| 3.1.2 Logout .....  | 7  |
| 3.1.3 Create Account .....                                      | 7  |
| 3.2 User: Doctor .....  | 8  |
| 3.2.1 Upload image for analysis .....                           | 8  |
| 3.2.2 View analysis report.....                                 | 8  |
| 3.2.3 Write comments for patients.....                          | 8  |
| 3.2.4 Submit comment/report .....                               | 9  |
| 3.2.5 View previously submitted report .....                    | 9  |
| 3.2.6 Edit comment for previously submitted report. ....        | 9  |
| 3.2.7 Make report available to the corresponding patient .....  | 9  |
| 3.2.8 Make report unavailable to the corresponding patient..... | 10 |
| 3.3 User: Patient.....  | 10 |
| 3.3.1 View analysis report and comment from doctor .....        | 10 |
| 3.3.2 Save analysis report .....                                | 10 |
| 3.3.3 Print analysis report .....                               | 11 |
| 4. System Design .....  | 12 |
| 4.1 Use Case Diagram .....                                      | 12 |
| 4.2 Use Case Description .....                                  | 13 |
| 4.4 Functional Requirements.....                                | 20 |
| 4.4.1 Data Collection.....                                      | 20 |
| 4.4.2 Preprocessing .....                                       | 20 |
| 4.4.3 Model Development .....                                   | 20 |

|  |    |
|--|----|
| 5.4.4 Model Evaluation .....                 | 20 |
| 4.4.5 User Interface .....                   | 21 |
| 4.4.6 User Experience: Lung Detection.....   | 21 |
| 4.4.7 User Experience: Lung Recognition..... | 21 |
| 4.4.8 Privacy and Security: .....            | 21 |
| 4.5 NON-FUNCTIONAL REQUIREMENTS.....         | 21 |
| 4.5.1 Performance .....                      | 21 |
| 4.5.2 Usability.....                         | 21 |
| 4.5.3 Reliability.....                       | 22 |
| 4.5.4 Security.....                          | 22 |
| 4.5.5 Compliance.....                        | 22 |
| 4.5.6 Maintainability.....                   | 22 |

# 1. Introduction

## 1.1 Purpose

The purpose of this documentation for this project is to provide a detailed and comprehensive outline of the functional and non-functional requirements that govern the development, implementation, and operation of the COVID-19 diagnosis system.

It serves as a blueprint that guides the entire development team, including designers, developers, and testers, in understanding the project's objectives, functionalities, constraints, and performance expectations. It also serves as a reference document for the team, ensuring that all parties involved have a clear understanding of the system's scope, features, and expected outcomes.

Additionally, it acts as a basis for validation and verification activities, allowing for systematic testing and evaluation to ensure that the system meets the specified requirements and fulfills its intended purpose of enhancing the accuracy and efficiency of COVID-19 diagnosis.

## 1.2 Objectives of the project

The project aims to develop an advanced Machine Learning model for more accurate and efficient COVID-19 diagnoses. We analyze existing deep learning models in medical imaging to inform our approach. The enhanced model will utilize cutting-edge techniques in neural networks and image processing to extract detailed information from COVID-19-related medical images. This will assist healthcare professionals and the public in making informed decisions for timely interventions and detection. While the model provides a useful benchmark, consulting a healthcare professional or using alternative testing methods is still recommended for confirmation.

## 1.3 Target Audience

The project is tailored for healthcare professionals, specifically doctors, who will upload X-ray images for diagnosis using the model. Patients will have access only to view the reports generated by the doctor. Medical related personnel such as healthcare professionals will benefit from the model more from the accuracy and the speed of detection, enabling them to make well-informed decisions and improve patient care.

## 2. Overall Description

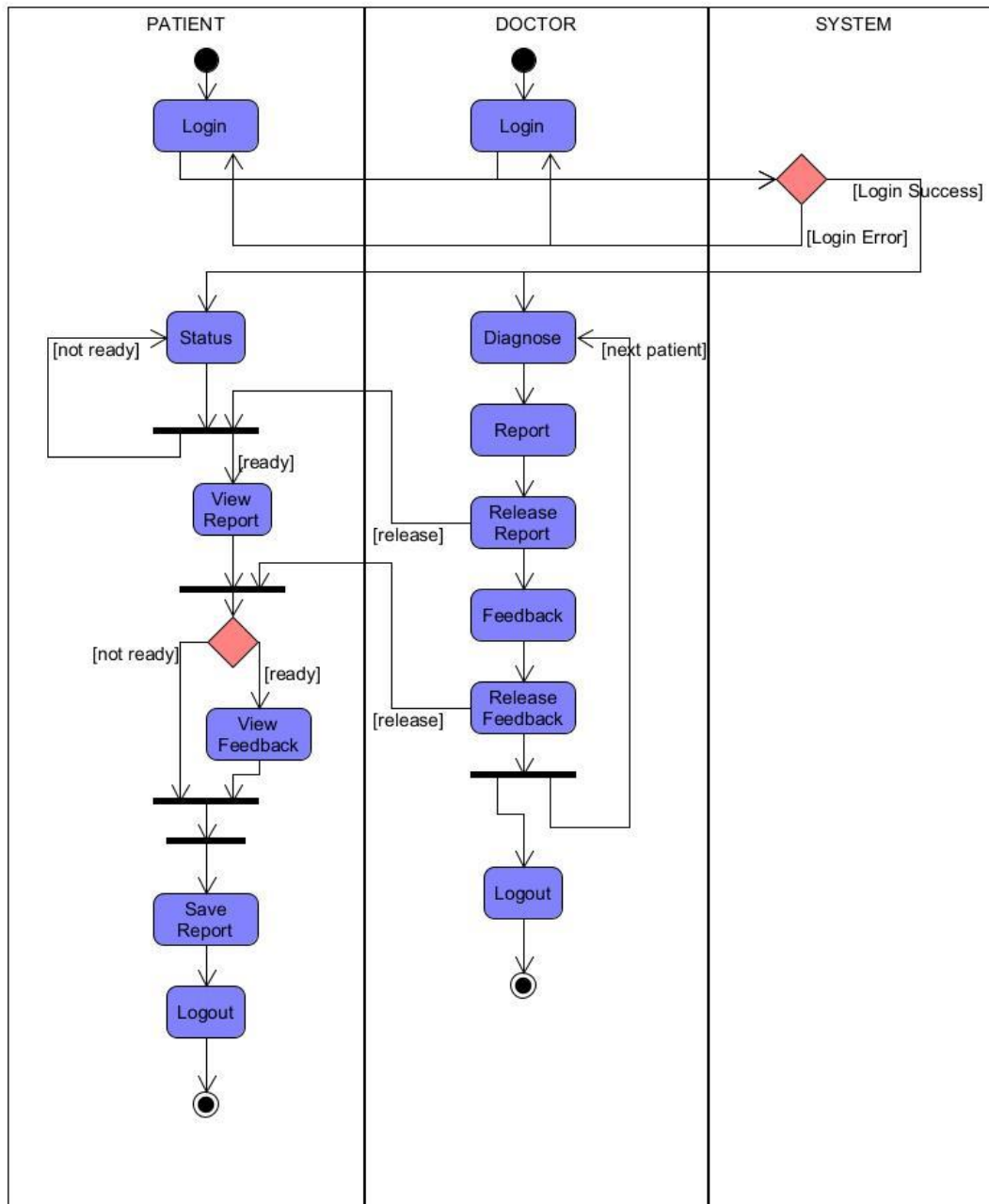
### 2.1 Website Design

This project centers around the development of a specialized website aimed at streamlining the process of COVID-19 diagnosis using advanced Machine Learning techniques, specifically a Convolutional Neural Network (CNN) model. The website's primary purpose is to provide a platform for healthcare professionals, particularly doctors, to upload X-ray images for accurate and efficient diagnosis.

Once uploaded, the images will be processed by the CNN model, which leverages cutting-edge neural network and image processing techniques to extract relevant information and patterns. The resulting diagnosis will be made available to the doctor through the platform. Additionally, patients will have access to view the generated reports, ensuring transparency and accessibility in healthcare delivery.

This initiative aims to significantly enhance the diagnostic accuracy and efficiency in identifying COVID-19 cases, ultimately contributing to improved healthcare outcomes in the midst of the global health crisis. It provides a valuable tool for healthcare professionals while maintaining a patient-centric approach by enabling them to access their own reports for informed decision-making.

## 2.2 Website Features



### 2.3 Operating Environment

| <b>NO</b> | <b>Operating Environment</b>           |
|-----------|--|
| 1         | Computer with web browser installed    |
| 2         | Smart phone with web browser installed |

### 2.4 Design and Implementation Constraints

| <b>NO</b> | <b>Design and Implementation Constraints</b>  |
|-----------|---|
| 1         | Users needs full internet access  |
| 2         | Users need to have access to a computer or smart phone                                  |
| 3         | User needs to have sufficient computer/smart phone knowledge to use the system smoothly |

### 3. System Features

#### 3.1 Account Features

##### 3.1.1 Login

**Description:**

The system should allow registered users to log in securely.

**Functional requirements:**

- Users can log in with their registered username and password.
- System should verify user credentials for authentication.
- Users must receive an error message if they provide incorrect login details.

##### 3.1.2 Logout

**Description:**

The system should allow registered users to log out securely.

**Functional requirements:**

- Users can log out if their accounts are secure.
- After logging out, the system should clear the user's session and ensure they cannot access restricted features without logging in again

##### 3.1.3 Create Account

**Description:**

The system should allow users to create accounts securely.

**Functional requirements:**

- Users can create a new account by providing a self-defined username, a password, selecting their role, and other required information.
- The system should validate the uniqueness of the username to prevent duplicate accounts.
- Users must receive an error message when not all required fields are filled in.



### 3.2 User: Doctor

#### 3.2.1 Upload image for analysis

**Description:**

Doctors should be able to upload an X-ray image for analysis.

**Functional requirements:**

- Doctors can press a button and choose a X-ray file from the local storage for the algorithm to analyse.
- The doctor needs to fill in the patient ID to which the X-ray belongs, ensuring that the results correspond to the correct patient.
- Doctor need to press the analyse image button to start the analysis process.

#### 3.2.2 View analysis report

**Description:**

Doctors are able to view the report of the X-ray analysis.

**Functional requirements:**

- Doctor need to press generate report button to generate a report containing the outcome.

#### 3.2.3 Write comments for patients

**Description:**

Doctors are able to write additional comments from the patient.

**Functional requirements:**

- Doctors can type his/her comments in the comment box provided

#### 3.2.4 Submit comment/report

**Description:**

Doctors are able submit the report and comments for storage on the database.

**Functional requirements:**

- After viewing the report, the doctor needs to click on the submit button to save the comments and the results from the analysis.

#### 3.2.5 View previously submitted report

**Description:**

Doctors are able to view the reports they have submitted previously.

**Functional requirements:**

- Click the pen icon on the main page to view the report of a patient.

#### 3.2.6 Edit comment for previously submitted report.

**Description:**

Doctors are able to edit the comments of the reports they have submitted previously.

**Functional requirements:**

- Click the pen icon on the main page to go into the report of a patient.
- Edit the comments in the comment box.
- Press the submit button.

#### 3.2.7 Make report available to the corresponding patient

**Description:**

Doctors are able to release the report to the patient so the patient can carry out further actions.

**Functional requirements:**

- Click the check box in the release column for the report doctor wish to release.

### 3.2.8 Make report unavailable to the corresponding patient

**Description:**

Doctors are able to make the report unavailable to the patient.

**Functional requirements:**

- Clicked the checked check box in the “Release” column for the report doctor wish to make unavailable.

## 3.3 User: Patient

### 3.3.1 View analysis report and comment from doctor

**Description:**

Patients are able to view the report and doctor’s comment which the doctor released.

**Functional requirements:**

- Patient need to click on the eye icon under “Actions” column in the main page.

### 3.3.2 Save analysis report

**Description:**

Patients are able to save the analysis report.

**Functional requirements:**

- Patient need to click on “Print and Save” button on the view report page.
- A PDF will be auto shown to display the report content.

### 3.3.3 Print analysis report

**Description:**

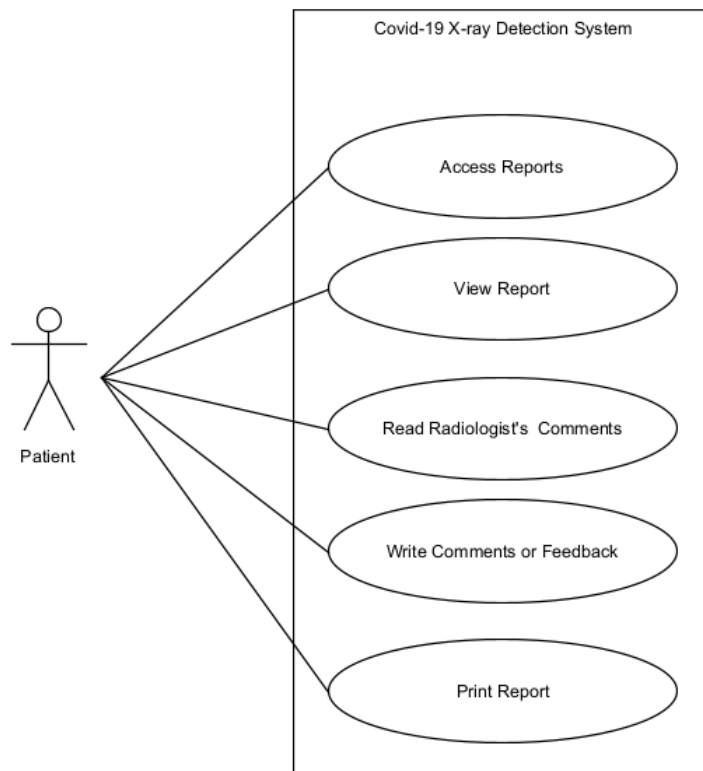
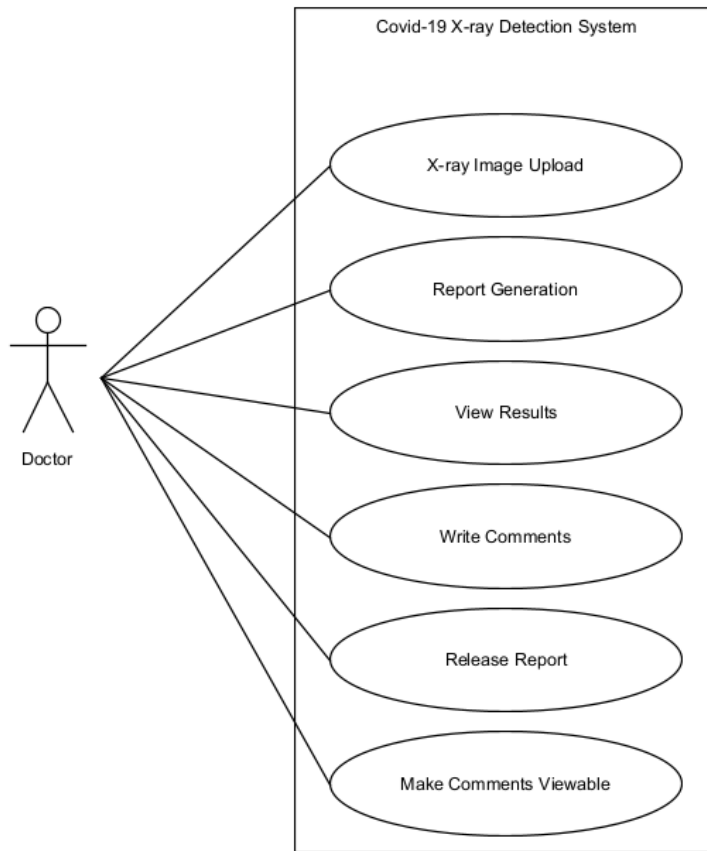
Patients are able to print the analysis report.

**Functional requirements:**

- Patient need to click on “Print and Save” button on the view report page.
- A PDF will be auto shown to display the report content.
- User can choose to download the report.

## 4. System Design

### 4.1 Use Case Diagram



## 4.2 Use Case Description

|  |              |
|--|--------------|
| <b>Use Case Name: X-ray Image Upload</b>   | <b>ID: 1</b> |
| <b>Stakeholders and goals:</b> Doctor aims to upload X-ray images of patients to the website so that the backend model can diagnose COVID-19 based on the X-ray images.  |              |
| <b>Description:</b> Doctor uploads X-ray images of patients for COVID-19 diagnosis. The uploaded images will be processed by the backend model, which will generate a diagnosis report indicating whether the X-ray suggests COVID-19 or not.  |              |
| <b>Actors:</b> Doctor  |              |
| <b>Trigger:</b> The doctor accesses the website and initiates the process of uploading X-ray images.   |              |
| <b>Preconditions:</b> <ul style="list-style-type: none"><li>• The doctor has a valid account registered on the website.</li><li>• The doctor has relevant X-ray images of patients stored on their device for upload.</li></ul>  |              |
| <b>Normal flow:</b> <ol style="list-style-type: none"><li>1. The doctor selects the option to upload X-ray images for COVID-19 diagnosis.</li><li>2. The website prompts the doctor to choose the relevant X-ray images from their local storage.</li><li>3. The website processes the uploaded X-ray images and forwards them to the backend model.</li></ol> |              |
| <b>Sub-flows:</b> None   |              |
| <b>Alternative/Exceptional flows:</b> None   |              |

|   |              |
|---|--------------|
| <b>Use Case Name: Report Generation</b>   | <b>ID: 2</b> |
| <b>Stakeholders and goals:</b> Doctor wants the machine learning model to generate a report with the COVID-19 diagnosis result based on X-ray images, enabling accurate communication of findings to the patient.   |              |
| <b>Description:</b> Doctor uses the machine learning model to analyse the uploaded X-ray images and generate a detailed report with the COVID-19 diagnosis result. The generated report will indicate whether the X-ray images suggest a positive or negative diagnosis for COVID-19, providing valuable information for accurate communication with the patient. |              |

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| <b>Actors:</b> Doctor  |
| <b>Trigger:</b> The doctor initiates the process of generating the COVID-19 diagnosis report after uploading the X-ray images.   |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The doctor has successfully uploaded X-ray images of the patient to the website.</li> <li>• The uploaded X-ray images have been processed by the backend model.</li> </ul>  |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>1. The doctor chooses the X-ray image for which they want to generate the COVID-19 diagnosis report.</li> <li>2. The machine learning model processes the selected X-ray image and generates a detailed report with the COVID-19 diagnosis result.</li> </ol> |
| <b>Sub-flows:</b> None   |
| <b>Alternative/Exceptional flows:</b> None   |

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|--|--------------|
| <b>Use Case Name: View Results</b>   | <b>ID: 3</b> |
| <b>Stakeholders and goals:</b> Doctor wants to view the results of the machine learning model's analysis of X-ray images, enabling them to make a diagnosis based on the provided information.   |              |
| <b>Description:</b> Doctor accesses the machine learning model's results, which are generated based on the analysis of uploaded X-ray images. The results will provide valuable information to the doctor, assisting them in making an accurate diagnosis for the patient. |              |
| <b>Actors:</b> Doctor  |              |
| <b>Trigger:</b> The doctor initiates the process of viewing the results of the machine learning model after it has analyzed the X-ray images.  |              |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The doctor has successfully uploaded X-ray images of the patient to the website.</li> <li>• The uploaded X-ray images have been processed by the backend machine learning model.</li> </ul>                 |              |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>1. The doctor chooses the X-ray image for which they want to view the machine learning model's results.</li> </ol>  |              |

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| 2. The website displays the results of the machine learning model's analysis for the selected X-ray image. The results may include the COVID-19 diagnosis (positive/negative) and any additional insights or details obtained from the model. |
| <b>Sub-flows:</b> None  |
| <b>Alternative/Exceptional flows:</b> None  |

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| <b>Use Case Name: Write Comments</b>   | <b>ID: 4</b> |
| <b>Stakeholders and goals:</b> Doctor wants the ability to write comments or feedback on the generated report to provide additional insights or explanations to the patient regarding their COVID-19 diagnosis.  |              |
| <b>Description:</b> Doctor accesses the generated report and being able to write comments or feedback to improve the COVID-19 diagnosis. The doctor may include additional details, recommendations, clarifications, or treatments in their comments to improve the patient's understanding of the diagnosis.  |              |
| <b>Actors:</b> Doctor  |              |
| <b>Trigger:</b> The doctor accesses the generated report and initiates the process of writing comments or feedback.  |              |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The doctor has reviewed the machine learning model's results for the patient's X-ray image.</li> <li>• The doctor has the necessary permissions to add comments to the report.</li> </ul>   |              |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>1. The doctor chooses the generated report for which they want to write comments or feedback.</li> <li>2. The doctor enters their comments or feedback in a designated input area in the report. The comments may include additional insights, explanations, or recommendations related to the COVID-19 diagnosis.</li> </ol> |              |
| <b>Sub-flows:</b> None   |              |
| <b>Alternative/Exceptional flows:</b> None   |              |



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|---|--------------|
| <b>Use Case Name: Release Report</b>  | <b>ID: 5</b> |
| <b>Stakeholders and goals:</b> Doctor releases the generated report and their comments to the patient, enabling the patient to review the COVID-19 diagnosis results.   |              |
| <b>Description:</b> Doctor finalizes the report and comments they have written and releases this report to the patient. The patient will be able to access the report and comments on the website to understand their COVID-19 diagnosis.   |              |
| <b>Actors:</b> Doctor   |              |
| <b>Trigger:</b> The doctor completes writing the comments on the report and initiates the process of releasing the report and comments to the patient.  |              |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The doctor has successfully written comments on the generated report.</li> <li>• The patient has a valid account registered on the website.</li> </ul>   |              |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>1. The doctor reviews and finalizes the comments on the generated report to ensure accuracy and completeness.</li> <li>2. The doctor chooses the patient to whom they want to release the report and comments.</li> <li>3. The doctor initiates the release of the report and comments to the selected patient.</li> </ol> |              |
| <b>Sub-flows:</b> None  |              |
| <b>Alternative/Exceptional flows:</b> None  |              |

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|---|--------------|
| <b>Use Case Name: Make Report Viewable</b>  | <b>ID: 6</b> |
| <b>Stakeholders and goals:</b> Doctor wants to make their reports viewable to the patient, enabling the patient to gain additional insights on their COVID-19 diagnosis.  |              |
| <b>Description:</b> Doctor finalizes the comments and feedback they have written on the patient's diagnosis report. The doctor then releases these comments with the report to make them viewable to the patient. |              |
| <b>Actors:</b> Doctor   |              |
| <b>Trigger:</b> The doctor completes writing comments and feedback on the patient's diagnosis report and initiates the process of releasing these comments to the patient.  |              |

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| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The doctor has a valid account registered on the website.</li> <li>• The doctor has successfully written comments and feedback on the patient's diagnosis report.</li> </ul>                              |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>1. The doctor will review the patient's diagnosis report to ensure accuracy and appropriateness.</li> <li>2. The doctor initiates the process to make the report viewable to the selected patient.</li> </ol> |
| <b>Sub-flows:</b> None   |
| <b>Alternative/Exceptional flows:</b> None   |

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|---|--------------|
| <b>Use Case Name: Access Reports</b>  | <b>ID: 7</b> |
| <b>Stakeholders and goals:</b> Patient wants to check the status of their diagnosis report to track the progress and know when it becomes available for review.   |              |
| <b>Description:</b> Patient accesses the website to check the status of their COVID-19 diagnosis report. The status indicates whether the report is still under analysis or completed.  |              |
| <b>Actors:</b> Patient  |              |
| <b>Trigger:</b> The patient accesses the website and initiates the process of checking the status of their COVID-19 diagnosis report.   |              |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The patient has a valid account registered on the website.</li> <li>• The doctor has released the diagnosis report and comments for the patient.</li> </ul>  |              |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>3. The patient opens their web browser and logs in to their account on the website.</li> <li>4. The patient accesses their dashboard and navigates to the section where diagnosis reports are stored.</li> <li>5. The website displays the status of the COVID-19 diagnosis report, indicating whether it is still under analysis or completed.</li> </ol> |              |
| <b>Sub-flows:</b> None  |              |
| <b>Alternative/Exceptional flows:</b> None  |              |

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|--|--------------|
| <b>Use Case Name: View Report</b>  | <b>ID: 8</b> |
| <b>Stakeholders and goals:</b> Patient wants to view the report released by the doctor to determine if the X-ray indicates COVID-19 or not.  |              |
| <b>Description:</b> Patient views the COVID-19 diagnosis report on the website. The report contains the results of the analysis performed by the doctor on the uploaded X-ray images, providing the patient with information about whether the X-ray indicates a positive or negative diagnosis for COVID-19.  |              |
| <b>Actors:</b> Patient   |              |
| <b>Trigger:</b> The doctor completes and releases the diagnosis report to the patient.   |              |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The patient has a valid account registered on the website.</li> <li>• The doctor has generated and released the COVID-19 diagnosis report for the patient.</li> </ul>   |              |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>1. The patient opens their web browser and logs in to their account on the website.</li> <li>2. The patient accesses their dashboard and navigates to the section where diagnosis reports are stored.</li> <li>3. The patient chooses the specific COVID-19 diagnosis report they wish to view from the available list.</li> <li>4. The website displays the COVID-19 diagnosis report, and relevant information provided by the doctor.</li> </ol> |              |
| <b>Sub-flows:</b> None   |              |
| <b>Alternative/Exceptional flows:</b> None   |              |

|  |              |
|--|--------------|
| <b>Use Case Name: Read Doctor's Comments</b>   | <b>ID: 9</b> |
| <b>Stakeholders and goals:</b> Patient wants to read the comments or feedback written by the doctor on their diagnosis report to gain a better understanding of the diagnosis.   |              |
| <b>Description:</b> Patient accesses the diagnosis report and reads the comments or feedback provided by the doctor. The comments may contain additional insights, explanations, or recommendations related to the COVID-19 diagnosis, helping the patient comprehend their medical condition more thoroughly. |              |

|   |
|---|
| <b>Actors:</b> Patient  |
| <b>Trigger:</b> The doctor writes and releases the comments, making them available for the patient to access.   |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The patient has a valid account registered on the website.</li> <li>• The doctor has generated and released the COVID-19 diagnosis report for the patient.</li> </ul>  |
| <b>Normal flow:</b> <ol style="list-style-type: none"> <li>1. The patient opens their web browser and logs in to their account on the website.</li> <li>2. The patient accesses their dashboard and navigates to the section where diagnosis reports are stored.</li> <li>3. The patient chooses the specific COVID-19 diagnosis report they wish to view from the available list.</li> <li>4. The website displays the diagnosis report along with the comments written by the doctor for the patient to read and understand the diagnosis in more detail.</li> <li>5. A textbox will be displayed for the patient to write their comment and will be feedbacked to the doctor.</li> </ol> |
| <b>Sub-flows:</b> None  |
| <b>Alternative/Exceptional flows:</b> None  |

|   |               |
|---|---------------|
| <b>Use Case Name:</b> Print Report  | <b>ID:</b> 10 |
| <b>Stakeholders and goals:</b> Patient wants to print a report of their COVID-19 diagnosis to have a hard copy for further analysis and reference   |               |
| <b>Description:</b> Patient accesses the diagnosis report and initiates the process of printing the report. Patient can print the report to keep for their records or share with other healthcare provider for further analysis and evaluation. |               |
| <b>Actors:</b> Patient  |               |
| <b>Trigger:</b> Patient decides to print the COVID-19 diagnosis report after accessing the report on the website.   |               |
| <b>Preconditions:</b> <ul style="list-style-type: none"> <li>• The patient has a valid account registered on the website.</li> <li>• The doctor has generated and released the COVID-19 diagnosis report for the patient.</li> </ul>            |               |

**Normal flow:**

1. The patient opens their web browser and logs in to their account on the website.
2. The patient accesses their dashboard and navigates to the section where diagnosis reports are stored.
3. The patient clicks on the "Print" button, signaling their intent to print the diagnosis report.

**Sub-flows:** None**Alternative/Exceptional flows:** None

#### 4.4 Functional Requirements

##### 4.4.1 Data Collection

- Collect reliable and relevant datasets for COVID-19 related data that contains X-rays or CT scans images.
- Ensure high-quality data is collected to train and test the machine learning models effectively.

##### 4.4.2 Preprocessing

- Perform data preprocessing procedures to handle missing values, noise, or outliers in the collected data.
- Normalize the data to ensure that different data types and formats are compatible for training and testing the machine learning models.
- Perform feature extraction from the collected data to represent them in a suitable format for the machine learning model.

##### 4.4.3 Model Development

- Build a machine learning model for COVID-19 diagnosis using lung detection and recognition techniques.
- Train and test the models on a public available dataset (e.g., Kaggle) and make sure the results are meeting the standard and requirements.

##### 5.4.4 Model Evaluation

- Evaluate the accuracy, sensitivity, specificity, and F1 score of the model.
- Conduct relevant testing to ensure the models are meeting the standard and requirements.

#### 4.4.5 User Interface

- Create an intuitive and user-friendly web interface for seamless interactions.
- Design a webpage where users can upload their images and view diagnosis results.

#### 4.4.6 User Experience: Lung Detection

- Provide users with a lung detection feature to identify the uploaded images are showing the lungs correctly.
- Display the original image with detected lung regions highlighted.
- Allow users to adjust the detected regions manually if necessary.

#### 4.4.7 User Experience: Lung Recognition

- Enable lung recognition functionality to predict COVID-19 diagnosis.
- Process the uploaded images through the machine learning model for lung recognition.
- Present the diagnosis results along with the scores achieved by the model and any other relevant information.

#### 4.4.8 Privacy and Security:

- Implement secure user registration and authentication mechanisms to protect sensitive data.
- Ensure user data is encrypted and securely stored.

### 4.5 NON-FUNCTIONAL REQUIREMENTS

#### 4.5.1 Performance

- The website should provide quick responses to user actions, such as image uploads and diagnosis requests, with minimal latency.
- The system should handle an increasing number of users and image processing requests without significant performance degradation.
- The website should be capable of processing multiple diagnosis requests concurrently, ensuring efficient use of computational resources.

#### 4.5.2 Usability

- The website must be user-friendly and easy to navigate, allowing users to interact with the system effortlessly.
- Ensure the website is responsive across various devices and screen sizes for a consistent user experience.

#### 4.5.3 Reliability

- Implement robust error handling mechanisms to gracefully handle unexpected scenarios and provide helpful error messages to users.
- Regularly backup user data and model parameters to prevent data loss in case of system failures.

#### 4.5.4 Security

- Ensure all user data, including uploaded medical images, is encrypted during transmission and storage to protect user privacy.
- Token-based authentication can be implemented to ensure the users will be identified and direct to the respective dashboard.
- Access to the machine learning model is strictly not allowed to users.

#### 4.5.5 Compliance

- Comply with relevant data protection regulations (e.g., GDPR) and obtain consent from users to collect and process their data.
- Ensure the machine learning model and website is only for educational purpose only and not liable for any outcome of the results.

#### 4.5.6 Maintainability

- Use version control systems (e.g., Github, Google Colab) to manage changes to the model and track updates.
- Maintain clear and comprehensive documentation for the code and machine learning model to help in future development and troubleshooting.