**Medical consulting application**

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***Mohammad Sofan***

**Abstract**

Musculoskeletal disorders are a significant health concern, and automated diagnosis using deep learning can aid in early detection and treatment. This project focuses on classifying radiographs of seven body parts (shoulder, elbow, finger, hand, humerus, wrist, and forearm) from the MURA dataset as normal or abnormal using a Convolutional Neural Network (CNN) based on DenseNet-169. Transfer learning is employed to leverage the pre-trained features of DenseNet-169, improving model efficiency and generalization. A single model is trained, with checkpoints saved at each epoch. The five models with the lowest validation loss are selected for ensembling to enhance prediction robustness. To address class imbalance, a custom data generator incorporating class weighting and data augmentation is utilized. The model’s performance is evaluated using accuracy, precision, recall, F1-score, and Cohen's Kappa. To make the model accessible, a Python API and a web-based interface are developed, enabling seamless interaction with the classification system. This approach demonstrates the potential of deep learning in musculoskeletal diagnosis, paving the way for more efficient and accessible medical imaging solutions.

**Chapter 1**

**Introduction**

**1.1 Introduction**

Musculoskeletal disorders (MSDs) represent a significant global health challenge, affecting individuals of all ages and contributing to disability and reduced quality of life. These conditions often require early diagnosis and intervention to prevent further complications. Radiographic imaging is a common diagnostic tool for MSDs, but manual interpretation of radiographs by radiologists can be time-consuming, subjective, and prone to inter-observer variability. Therefore, automating the diagnostic process using deep learning techniques has the potential to enhance diagnostic accuracy, consistency, and efficiency. Deep learning, particularly Convolutional Neural Networks (CNNs), has shown remarkable success in various medical imaging tasks. The MURA (Musculoskeletal Radiographs) dataset, one of the largest publicly available musculoskeletal radiograph datasets, serves as an ideal benchmark for developing automated diagnostic systems. This project aims to classify radiographs of seven body parts—shoulder, elbow, finger, hand, humerus, wrist, and forearm—as normal or abnormal using a CNN based on DenseNet-169.

**1.2 Project Scope**

This project aims to develop a web application that enables users to classify one or multiple radiograph images of seven body parts—shoulder, elbow, finger, hand, humerus, wrist, and forearm—as normal or abnormal. The targeted users include doctors, medical staff, and individuals seeking a preliminary assessment of their radiographs. By providing an intuitive and accessible interface, the system allows users to obtain an initial indication of potential abnormalities before consulting a medical professional. This tool is designed to assist in early detection, facilitate decision-making, and enhance accessibility to musculoskeletal diagnostic insights.

**1.3 Problem Specification**

Musculoskeletal disorders are a significant health concern, requiring timely and accurate diagnosis for effective treatment. Radiographic imaging is a key diagnostic tool, but interpreting these images can be complex and requires specialized medical expertise. Patients may seek an initial understanding of their radiographs before consulting a doctor, yet without medical training, interpreting these images accurately is challenging. Additionally, medical professionals often face a high workload, making preliminary screening tools valuable for optimizing their workflow.

This project addresses these challenges by developing an AI-powered web application that serves as a **first-step screening tool** for musculoskeletal radiographs. Using a deep learning model (DenseNet-169) trained on the MURA dataset, the system classifies radiographs of seven body parts—shoulder, elbow, finger, hand, humerus, wrist, and forearm—as **normal or abnormal**. The goal is to provide users, including doctors, medical staff, and individuals, with an initial assessment before seeking professional medical consultation.

Key objectives of the system include:

* **Providing individuals** with a preliminary indication of potential abnormalities before consulting a doctor.
* **Assisting radiologists and medical staff** by offering an AI-powered pre-screening tool to support clinical decision-making.
* **Enhancing accessibility** to musculoskeletal assessments, particularly in areas with limited medical resources.

This project does not replace manual interpretation by radiologists but acts as a complementary tool to facilitate early detection and streamline the diagnostic process.

**1.4 Goals and Objectives**

Providing customers with convenience and quickness while also considering their conditions in situations where they cannot physically contact a doctor or pharmacy is our app goal.

First, immediately find the user's nearest open pharmacy in a couple of minutes.

Second, saving user time by allowing him to contact a pharmacy and ask whether they have the medicine he needs, due to the fact that not all pharmacies carry every medicine.

Third, consulting several doctors and pharmacies, as well as evaluating it via the Internet. These goals are to provide as much support as we can to all users.

**1.5 Motivation**

The purpose behind our project is to help people medically, meet their needs and consider their circumstances. Though there are online apps available,none of them could give users the ability to communicate with different doctors and pharmacies via the Internet or direct them to the closest pharmacy that carries the medicine they need. For this reason, we decided to start our project in order to give users the services that previous applications were unable to offer.

**1.6 System Requirement**

* **High Level Language Java**
* **External Database**
* **Android Studio**

**1.7 Project Plan and Schedule**

Start at the end of February 2023 and expected to be finished by the start of May 2023.

* **Analysis,** Start Date: 28/2, End Date: 7/4
* SWOT Analysis
* Project Planning
* **Information Collection,** Start Date: 8/4, End Date: 16/5
* Client Requirement
* Market Requirement
* **Selecting Tools,** Start Date: 18/5, End Date: 21/6
* OS Environment
* High Level Language
* Framework
* Platform
* **Writing,** Start Date: 22/6, End Date: 15/7
* Documentation
* **Implementation,** Start Date: 16/7, End Date: 1/9
* Build Database
* Construct Model
* Create Modules
* Interface Designing
* **Final Phase,** Start Date: 2/9, End Date: 15/9
* QA Testing
* Feedback
* Maintain

**1.8 Outline of the Project**

The six Chapters of the medical consulting app project are as follows: The project scope, system requirements, objectives, and project strategy are discussed in Chapter 1's introduction. The second chapter discusses literature and methodology, discusses the distinction between the present and proposed systems, and covers feasibility studies. System analysis, system design, and requirements including requirement gathering, requirement research, and requirement structure are all covered in Chapter 3. System UML design is the step that is covered in Chapter 4. The system's conclusion and upcoming work are presented in Chapter 5.

**Chapter Two**

**Dataset**

**2.1 Introduction**

To build an application for detecting musculoskeletal disorders, it was necessary to use a dataset classified into normal and abnormal to develop the model. One of the most widely used datasets for this purpose is the **MURA (Musculoskeletal Radiographs) dataset**, which contains a large collection of X-ray images labeled as normal or abnormal.

MURA, developed by researchers at Stanford University, consists of radiographic images from different anatomical regions, including the shoulder, elbow, wrist, hand, finger, hip, knee, and ankle. It is one of the largest public datasets for musculoskeletal abnormality detection and serves as a benchmark for deep learning models in medical imaging.

By leveraging MURA, researchers can train and evaluate machine learning models to automate musculoskeletal disorder diagnosis, improving diagnostic accuracy and assisting radiologists in clinical decision-making. The dataset plays a crucial role in advancing artificial intelligence applications in medical imaging, particularly in the field of musculoskeletal radiology.

**2.2 Dataset Overview**

MURA consists of **40,561 X-ray images** collected from **14,863 patient studies** at **Stanford Hospital**. The dataset covers **seven anatomical regions**: shoulder, elbow, wrist, hand, finger, hip, and knee. Each study contains **one or more X-ray images** of the same region, taken from different angles. The images are labeled as **Normal** or **Abnormal** by expert radiologists, ensuring high-quality annotations.

The dataset is originally in **DICOM format** but has been converted into **PNG** for public release, making it easily accessible for machine learning applications. Image resolutions vary, but they are generally high-quality, allowing for detailed analysis of musculoskeletal structures. The dataset includes variations in lighting, contrast, and positioning, making it a valuable resource for developing AI models that can generalize well across different imaging conditions.

### **2.3 **Challenges and Variability in MURA****

MURA presents several real-world challenges that make it an excellent dataset for developing **robust AI models**:

* **Variability in Imaging Conditions**: Differences in X-ray machine settings, patient positioning, and exposure levels.
* **Diverse Patient Demographics**: Covers a wide range of ages, body types, and musculoskeletal conditions.
* **Multiple Views per Study**: Some studies contain **multiple X-rays from different angles**, requiring AI models to analyze and aggregate information across images.
* **Class Imbalance**: The dataset contains **more normal cases than abnormal cases**, which requires careful handling during model training to avoid bias.

**2.4 Feasibility Study**

Through this application, it is possible to benefit by displaying advertisements to users in addition to the annual subscriptions provided to doctors and pharmacies (so that some services will be exclusive by paying an amount of money annually).

**2.5 Methodology (SDLC)**

Surveys, interviews, and comparisons have all been used to study the use of pharmacy and doctor online consultation applications. While surveys and interviews are typically used to gather data on patient experiences and opinions, comparing means evaluating the effectiveness of the applications in contrast to conventional in-person consultations

**Chapter Three**

**System Analysis and Design**

The analysis and design of an online doctor and pharmacy consultation system are critical phases in the software development life cycle. They provide a clear understanding of the current system and its limitations and services as the basis for designing a new and improved system that meets the needs of the users. The design of an online doctor and pharmacy consultation system must take into account the unique needs users. It must also provide a secure platform for communication between patients and medical professionals, including secure messaging, video consultations, and prescription management.

**3.1 Requirements discovery**

These methods were used by the team members to better understand the system requirements throughout the requirements discovery process. Activities for identifying requirements included:

1. Contact customer: We talked to different pharmacists to find out more about their requirements and recommendations, such as adding a page to the app where they can show their medication discounts.
2. Online research: We use search engines to find information about online doctors and pharmacies consultation systems and came across <https://www.healthgrades.com/>, <https://www.goodrx.com/health> we read reviews and ratings from other patients to get an idea of the quality of service provided.
3. Ask for Recommendations: We've seen our friends, family members, and colleagues ask for their recommendations, and they seem happy to have such a convenient app, but their recommendation was to have a secure communication with their medical professional and pharmacist because private is important in these topics.
   * 1. **Functional Requirements**
4. Online chatting: The system should provide a secure channel for patients to communicate with medical professionals via messaging and video consultations.
5. Patient Feedback: The application should let users to provide feedback about their experiences with doctors and pharmacies and the application itself. This can help to improve the quality of the service and build trust among users.
6. Location: Instead of wasting time looking for an open pharmacy, an application may provide users with the closest one using maps
7. Offers: Doctors and pharmacists should be able to display their products and offers to customers.

**3.1.2 Non-Functional Requirements**

1. Usability: The application should be easy to use. The process of interacting with medical professionals should be straightforward.
2. Security and Privacy: The application should have strong security measures in place to protect users' personal and medical information.
3. Availability of medical professionals: A sufficient number of medical professionals and pharmacies who are ready to offer consultations at any time should be included in the application. Moreover, users should have the option of selecting their chosen medical specialist based on their specialization.
4. Performance: The system should be able to handle a large number of simultaneous users and provide fast response times

**3.2 Requirements classification and organization**

Medical consulting app is divided into the 4 increments as follows:

1. First increment: Registration, may focus on implementing basic features such as patient, doctors, and pharmacist registration.
2. Second increment: Increments may focus on more advanced features such as Online chatting and Location Finding.
3. Third increment: Patient Feedback, this increment focuses on user feedback and experience, which is important for the application's success.
4. Fourth increment: Adding a page to the app where pharmacist and doctors can show their medication discounts and offers.

**3.3 Requirements prioritization and negotiation**

As we noted from above, this system divided into 4 increments: Registration, Online chatting and Location Finding, Patient Feedback, Medication discounts page:

1. Registration, since this increment focuses on implementing basic features, it should be prioritized first to ensure that patients are registered to the application and share their personal and medical information so doctors and pharmacist can view it.
2. Online chatting and Location Finding, this increment builds on the basic features of the first increment and provides more advanced features which is allowing each patient to view the closest pharmacies according to their information that was entered by them. Additionally, provides users with a place for searching for any doctor or pharmacy using their name, location, and specialization to communicate with them. It should be prioritized second.
3. Patient Feedback, the application will let users to provide feedback about their experiences with doctors and pharmacies and the application itself. It should be prioritized third.
4. Page for medication discounts: While adding a page for medication discounts is important, it may be less critical than the other increments. Therefore, it could be prioritized last.

**3.4 Requirements specification**

* **Online Chatting:**

1. The system should provide an online chatting feature that enables patients to communicate with doctors or pharmacists.
2. The chatting feature should be secure, private, and only accessible to the patient and the doctors or pharmacists.

* **Location of Closest Pharmacy:**

1. The system should allow patients to enter their location or allow the system to access their current location.
2. The system should provide a list of the closest pharmacies to the patient's location.
3. The list of pharmacies shall include information such as pharmacy name and address.

* **Patient Feedback:**

1. The system should provide a feature that allows patients to provide feedback on their experiences with doctors, pharmacists, and the application itself.
2. The feedback feature should be easy to use, secure, and only accessible to the patients.
3. The system should store patients’ feedback and make it available to the system administrators for analysis and improvement.

**3.5 Requirements Validation**

The following approaches we used to validate the requirements:

1. Acceptance testing: This could be by asking a group of users and collecting feedback on their experience with the online chatting feature. This would help to ensure that the feature is easy to use, reliable, and meets the needs of the users.
2. Usability testing: Checking the accuracy of the location data could be tested by comparing it with data from other sources, such as Google Maps.
3. Perspective-based reading: Every use case is looked through individually by every team member.

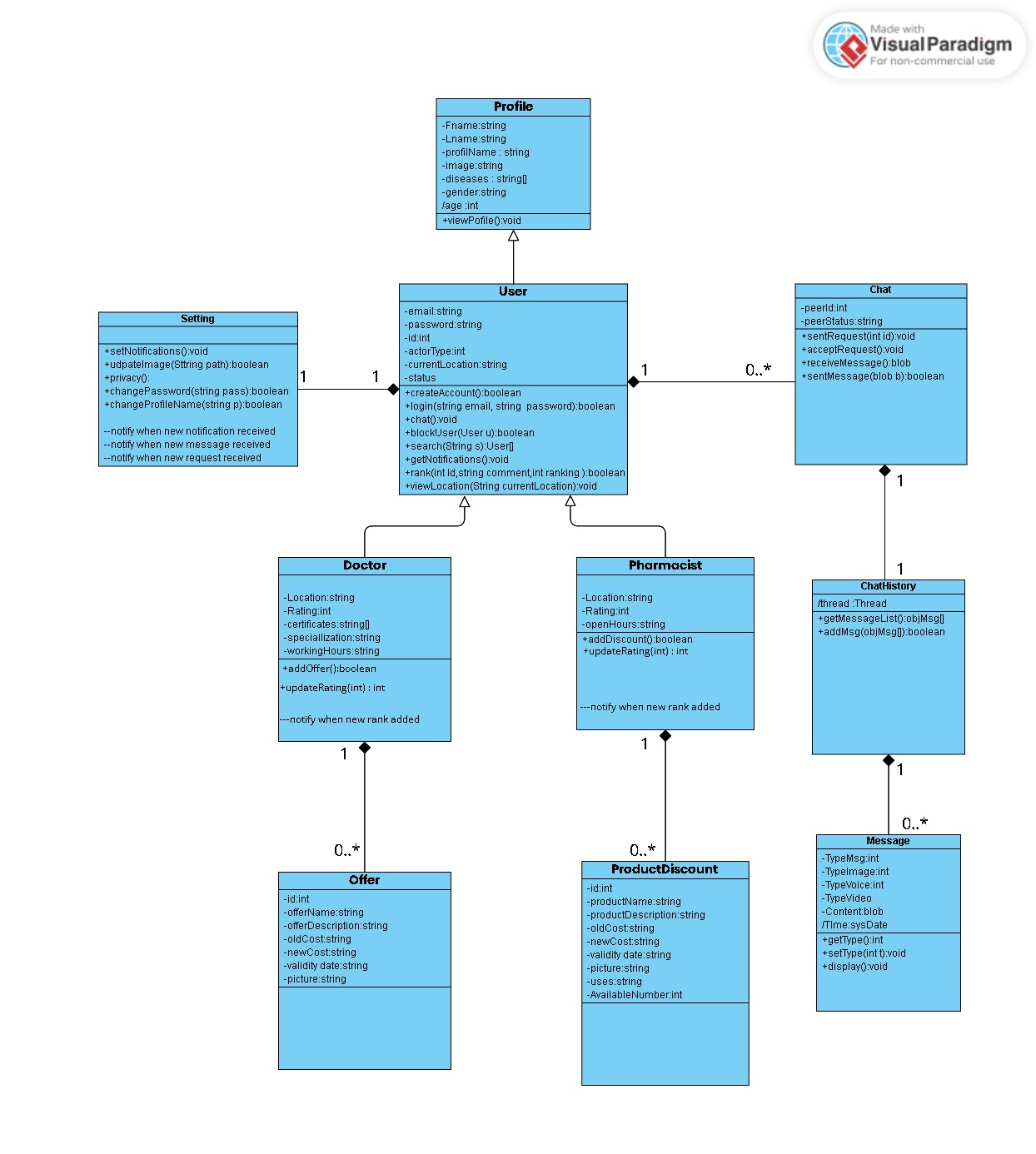
**3.6 Requirements management**

Melon was developed using Agile method, so any changing in requirements has four possibilities. First, collecting and clearly outlining the system's requirements. Second, reviewing the requirements to ensure they are complete and consistent. Third, any changes to the requirements should be reviewed before implementation to ensure that they do not affect other requirements. Fourth, ensuring that the requirements have been met through testing and verification techniques.

**Chapter Four**

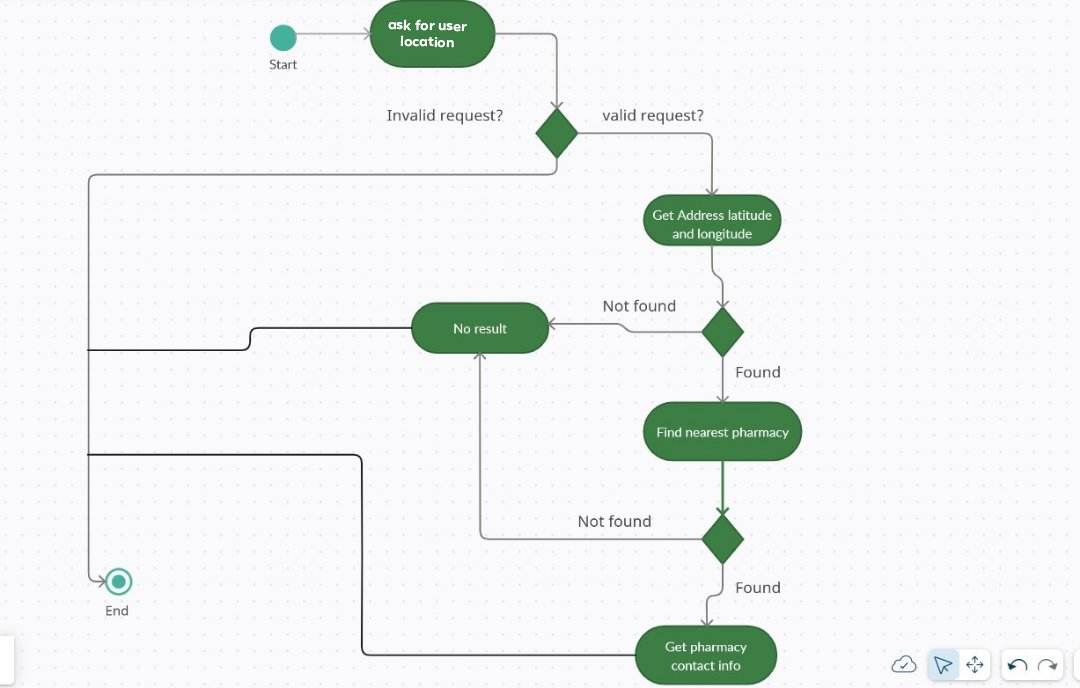
System UML Design

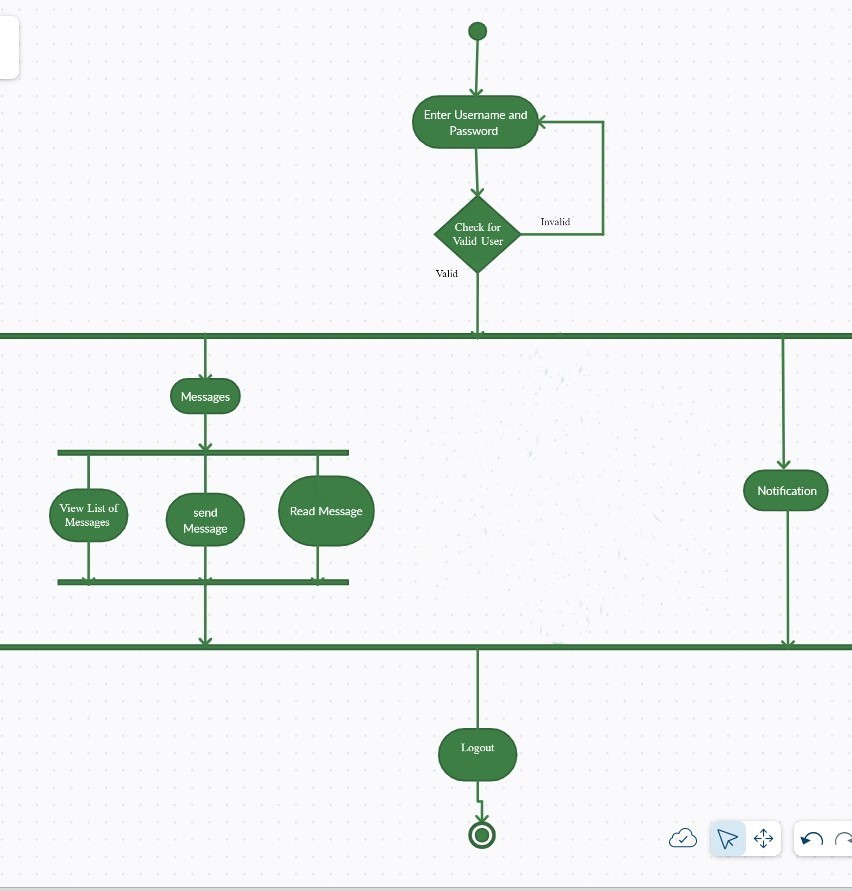
1. Use case
2. Class diagram



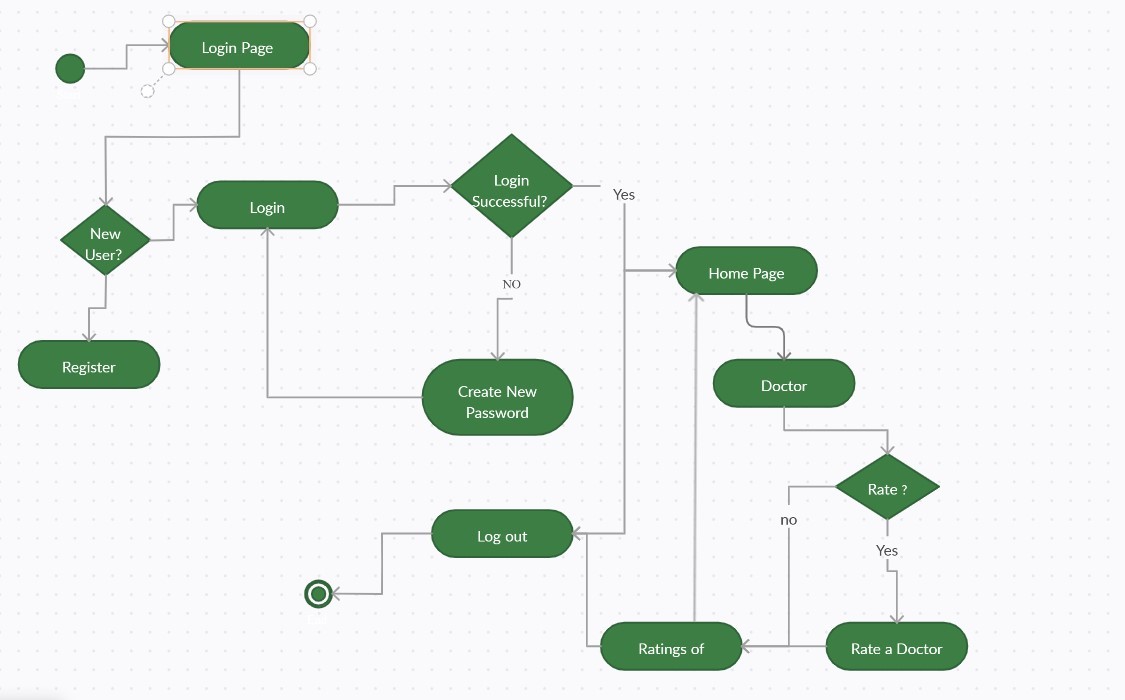
1. Activity diagram

Nearest pharmacy



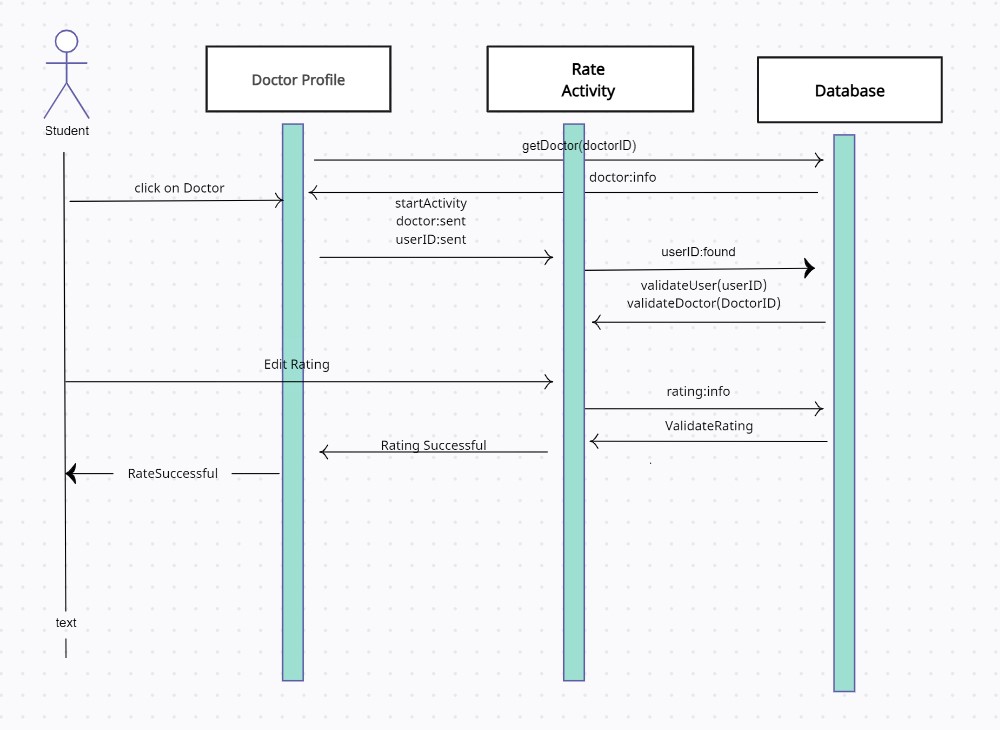
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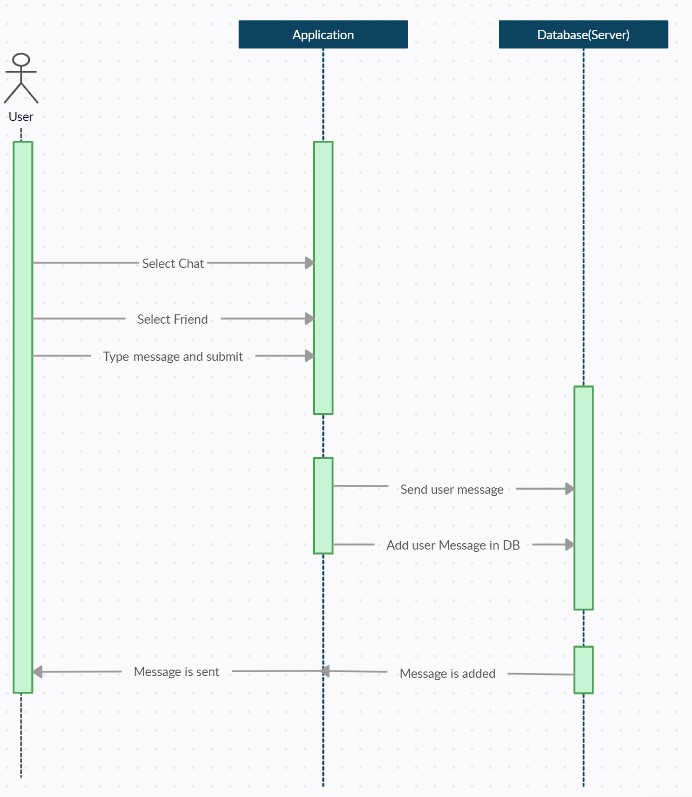
Chatting

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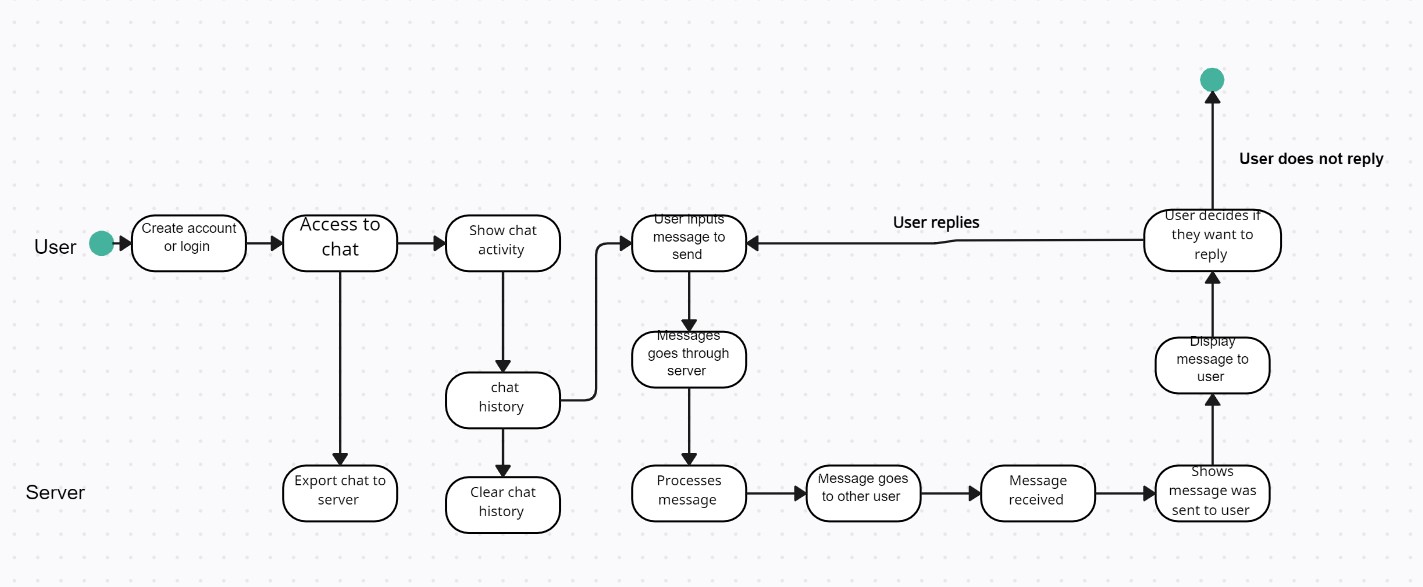
**Rating**

1. Sequence Diagram





1. State Diagram



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