HAEMATOLOGY APP

Capstone Project Report

END SEMESTER EVALUATION

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ABSTRACT

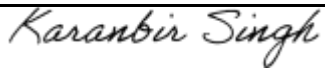
Our project is divided into three broad domains – pathology, blood bank and data visualization. For the pathology domain. The pathologist will be able to upload microscopic image and get it tested for malaria and leukemia by ML algorithms or classify blood cells. In blood bank domain, the blood donor would be able to register online for blood donation and blood receiver will be able to place a request for blood online by uploading supporting medical documents. For data visualization domain, the user will be able to view real-time data related to infectious diseases like malaria and blood cancer etc.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled

Haematology app is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr Palika Chopra during 6th semester (2020).

Date: July 31, 2021

Roll No.	Name	Signature
101803235	KARANBIR SINGH	
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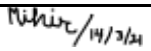
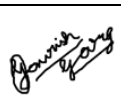
101803521	MIHIR KUMAR	
101803621	GAURISH GARG	

Counter Signed By

Dr Palika Chopra

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We are also thankful to Dr Maninder Singh, Head, Computer Science and Engineering Department, entire faculty and staff of Computer Science and Engineering Department, and also our friends who devoted their valuable time and helped us in all possible ways towards successful completion of this project. We thank all those who have contributed either directly or indirectly towards this project.

Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us and we admire their determination and sacrifice.

Date: July 31, 2021

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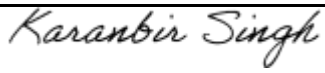
101803235	KARANBIR SINGH	
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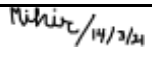
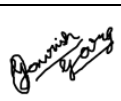
101803521	MIHIR KUMAR	
101803621	GAURISH GARG	

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LIST OF ABBREVIATIONS

CAD	**Computer Aided Design**
CNN	**Convolutional Neural Network**
CSS	**Cascading Style Sheets**
DFD	**Data Flow Diagram**
HTML	**Hypertext Markup Language**
IEEE	**Institute of Electrical and Electronics Engineers**
JS	**JavaScript**
KNN	**K Nearest Neighbors**
SRS	**Software Requirements Specification**
UML	**Unified Modelling Language**
WBS	**Work Breakdown Structure**
ML	**Machine Learning**

1. INTRODUCTION

1.1. Project Overview

This project aims at building a web application for pathological studies and testing. The user shall be provided with the facility of uploading microscopic images by the application to check for malarial infection or blood cancer. If the user wishes, the cells shall be classified into 4 broad categories: - eosinophils, monocytes, lymphocytes or neutrophils for pathological studies by the application. The image classification algorithms will be used by the application to check whether the given sample is infected with malaria and blood cancer or classification of cell types into 4 broad categories which are eosinophils, monocytes, lymphocytes or neutrophils.

A suitable interface for blood donation management system shall be provided by the application in which the user can request for blood from nearby blood banks and make online payment as per the blood group of the patient. The transfusion details shall also be stored in the system which mentions that which blood group can receive blood of which group. Real time infection data and number of deaths due to malaria and blood cancer shall also be visualised by the application to help prevent and diagnose malarial infection early and correctly.

The User-Interface for uploading the image and choosing an option for checking blood cancer or malaria and classification shall be developed using HTML/CSS/JS along with node.js and express.js and MongoDB for server-side rendering. The diseases from the blood sample shall be detected using image classification algorithms along with the OpenCV library. The detailed process of automated checking for malarial/blood cancer infection is indicated in Figure 1.

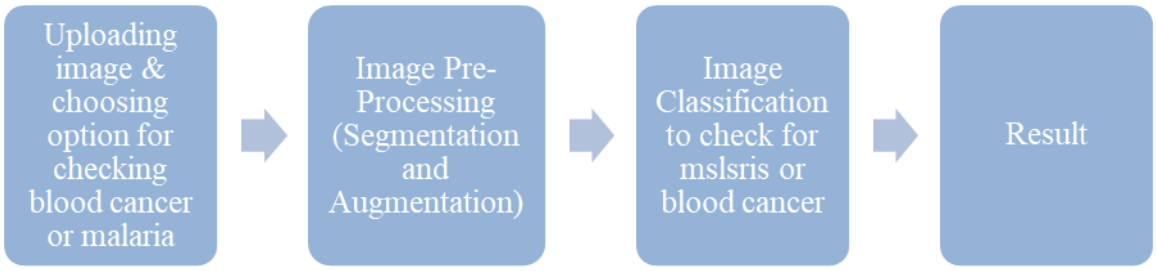


FIGURE 1 Detection of blood diseases (malaria/leukemia) using ML Models

If s/he wishes, the cells shall be classified into 4 broad categories: - eosinophils, monocytes, lymphocytes or neutrophils for pathological studies by the application. The image classification algorithms will be used by the application to check whether the given sample is infected with malaria and blood cancer or classification of cell types into 4 broad categories which are eosinophils, monocytes, lymphocytes or neutrophils, as demonstrated in Figure 2.

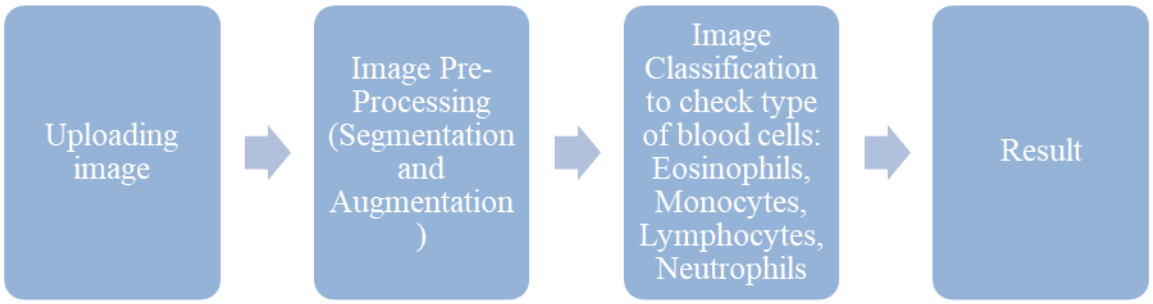


FIGURE 2 Process of classifying blood cell into 4 categories

A suitable interface for the blood donation management system shall also be provided by the application in which the user can request blood from nearby blood banks and make online payment as per the blood group of the patient. The transfusion details shall also be stored in the

system which mentions which blood group can receive the blood of which group. Real-time infection data and the number of deaths due to malaria and blood cancer shall also be visualised by the application to help prevent and diagnose malarial infection early and correctly.

The blood donation management system that provides transfusion details and allows online request of blood and shall be developed using MongoDB database, Google Maps API for location tracing, Script API for Payment interface and Firebase and Heroku for hosting the application as indicated in Figure 3.

FIGURE 3 Process of online registration for blood donation

For real-time infection and monitoring, the data from nearby clinics will be fetched using APIs and will be plotted and precautions will be recommended to the patient as demonstrated in Figure 4.

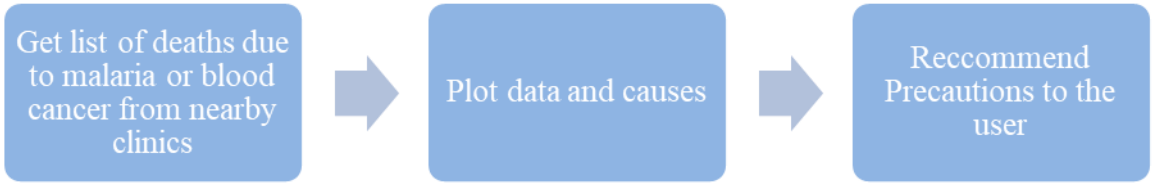


FIGURE 4 Block Diagram representing data visualization

Starting with the pathologists domain, an authorized pathologist will be able to sign up for the ML verification Service. Once the pathologist has signed up, s/he will receive his/her credentials

for the portal. After logging into his/her account the pathologist can perform a test with the microscopic image. The report generated by the ML Software can be correlated with human verification and existing technologies.

For the second domain i. e. Blood Donation Management System, the user will grant access to their current location and get the location of the nearest blood banks. The user can then register online for donating blood, following which s/he can reach the blood bank to donate blood.

For non-emergency cases of receiving blood, the user can fill details online and upload prescription, which will be vetted by the blood bank employee. Once the request is accepted, the arrangements for blood collection can be done.

Coming to the third domain, i. e. data visualisation, the user will be able to view the current trends in infectious diseases related to malaria, leukemia etc.

1.2. Need Analysis

The Conventional Method of detecting malaria involves observing the thin blood smear under microscope to check for irregularities [1]. These methods of detecting blood cancer requires CBC and peripheral blood smear along with bone marrow aspiration which make use of super-expensive equipment and there is no alternative for verification. These methods require skilled expertise and are prone to human error along with increased costs. A large number of deaths by malaria are due to late or inefficient diagnosis. The trend of deaths due to malaria can be seen in Figure 5.

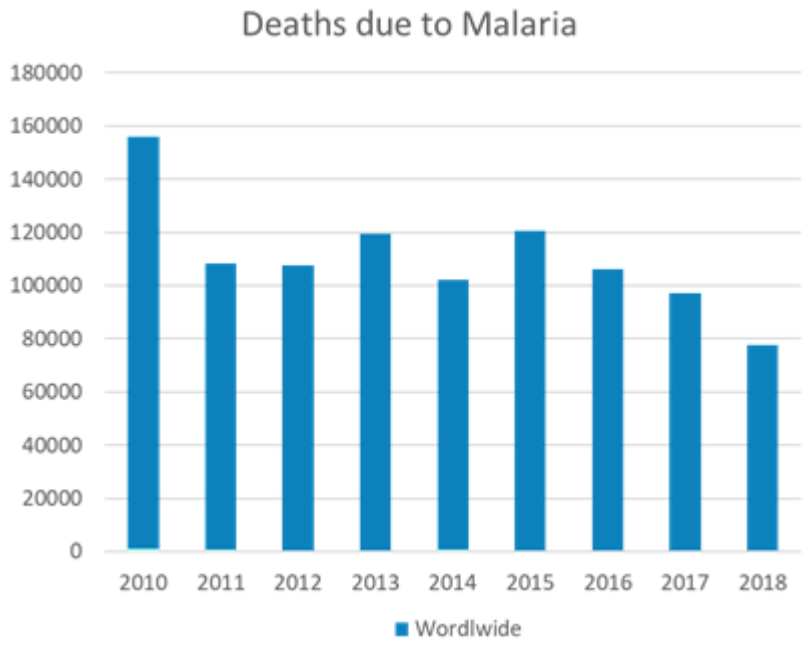


FIGURE 5 Deaths to malaria in 2010-2018

The main aim of this app is not to substitute the existing diagnosis methods but to develop a process wherein the pathologist can verify the findings with the human diagnosis to rule out any errors.

1.3. Research Gaps

A significant amount of research has already been done in detection of infectious diseases through ML models, but various research gaps seem to exist in this field. One of these include absence of a full-fledged organised system that involves detection of malaria using deep convolutional neural networks and generates report. However, detection of malaria using KNN exists but with slightly lesser recall and accuracy [2].

Another gap seems to be the absence of a combined system that can detect presence of leukemia

from microscopic images using Deep CNN with a better recall score and accuracy. The methodology may exist but presence of a full-fledged system is not yet to be seen.

In all the recent researches, detection of diseases like malaria and leukemia was performed using KNN [2] [3]. Algorithms only which had slightly lesser recall scores, where Recall is the preferred evaluation metric in algorithms that involve detection of diseases.

1.4. Problem Definition and Scope

The project “Haematology App” aims to provide a system wherein one domain includes verification of diseases through ML models by authorized pathologists who can login/register and verify tests related to malaria, leukemia or classification of blood cells.

The project also aims to develop a system where a prospective blood donor can get list of nearest blood banks and register for donating blood, and a prospective blood recipient (non-emergency cases) can raise an online request which will be both foreseen by the blood bank employee.

The project also aims to allow the user to visualize real time data regarding infectious diseases.

The scope of the project is (but not limited to) development of an integrated blood bank system for registering for blood donation, applying for receiving blood, and a full-fledged assistive technology for pathologists to detect diseases like malaria and leukemia.

1.5. Assumptions and Constraints

TABLE 1 Assumptions

S. No	Assumptions
1	It assumes that the facility of getting microscopic images of blood cells is already available with the Pathologists who would be using the software.
2	There are negligible errors due to microscope and microscopic images are accurate.
3	It assumes that the users have mobiles or desktops with GPS.
4	It assumes that the end users have access to high-speed internet.
5	It assumes that the data used for visualization is accurate.

TABLE 2 Constraints

S. No	Constraints
1	A stable internet connection is required for the web application to work efficiently.
2	The web application shall work only on microscopic images.

1.6. Standards

The training models used for image classification algorithms use a set of deep convolutional neural networks (CNN). For blood classification, custom built CNN was used that contains a sequence of 5 convolutional blocks containing combination of separable 2-dimensional CNN, while for detection of malaria, a sequence of 3 convolutional blocks containing combination of

2-D convolutions and max-pooling. For blood donation system ES6 standard was followed for back end using node.js

For documenting the software requirements specification (SRS), IEEE 830 standard was followed. IEEE 830 is a set of rules that govern the formatting of SRS.

1.7. Approved Objectives

Detection of malaria and leukemia from uploaded images and classification of blood cells.

Real-time data visualisation and geological plotting of the infected blood samples.

Development of user interface for pathology and blood bank management system

1.8. Methodology

After successfully uploading and verifying the microscopic image of the blood sample, the sample will be tested for malaria and blood cancer using an image classification algorithm and the corresponding report will be generated by the system. The user-interface (UI) for uploading the image and choosing an option for checking blood cancer or malaria and classification shall be developed using HTML/CSS/JS along with node.js and express.js and MongoDB for server-side rendering. The diseases from the blood sample shall be detected using image classification algorithms along with the OpenCV library.

The model used for detection of malaria is a deep CNN that contains a sequence of 3 convolution blocks containing combination of 2-dimensional convolutions and max-pooling. The output of final convolutional block is flattened and followed by two dense layer 6 with 2 layers containing dropout layer. The final dense layer is added with 1 unit and sigmoid activation for binary classification.

The model for classification of blood cells contains a sequence of 5 convolutional blocks containing combination of separable 2-d convolutions, batch normalisation, max-pooling and dropout layer. The output of the final convolution block is flattened and followed by three fully connected (FC) layers each with its own dropout layer. A final fully connected layer is added with 4 units and a SoftMax activation function for multiclass classification.

For pathology studies, the classification of cells into 4 categories: - eosinophils, monocytes, lymphocytes and neutrophils shall be performed using image classification algorithms.

The blood donation management system that provides transfusion details and allows online booking of blood and online payment shall be developed using MongoDB database, Google Maps API for location tracing.

For real-time infection and monitoring, the data from nearby clinics will be fetched using APIs and will be plotted.

1.9. Project Outcomes and Deliverables

Full-fledged software for pathologists that can be used as an assistive or verification technology to detect malaria & leukemia, and classification of blood cells.

Blood donation management system in which the user would be able to register for donating blood as per his/her convenience.

Another outcome includes a full-fledged software in which a user would be able to visualize data regarding malaria and blood cancer etc.

1.10.Novelty of Work

The project aims at building a full-fledged software using deep convolutional neural networks to

detect diseases from microscopic images which is still a research challenge. The CNN used in the ML models have a different architecture and focus on a better recall score, and considering it is a model that detects diseases, recall seems to be a better evaluation metric. Also, the different ML models were tested and the best one that had a better recall score and accuracy was selected. Thus, the methodology, evaluation metric, and a full-fledged blood donation system indicates the novelty of work.

2. REQUIREMENT ANALYSIS

2.1. Literature Survey

2.1.1. Theory Associated with Problem Area

As of now, there is no such device that directly detects malaria and blood cancer without human intervention. Currently, the thin blood smear is manually observed under the microscopic to check for irregularities that are prone to human error. On the other hand, blood cancer is currently diagnosed by too much or too few counts of abnormal cells, which can be observed in complete blood count. However, this method is costly as it requires high-tech machines.

A significant amount of research has been done in the detection of diseases via blood analysis using image processing techniques [1]. One of these techniques for the detection of malaria includes comparing the microscopic images with a dataset containing thousands of images corresponding to malarial infection, using minimum distance classifiers like KNN. In this, the first step includes pre-processing in which segmentation is applied to the test microscopic image and then feature extraction is applied using minimum distance classifiers like KNN.

2.1.2. Existing Systems and Solutions

Blood cancer is detected by the number of white blood cells in the segmented microscopic image. In this, the number of pixels containing the white blood cells are counted and compared with the threshold.

Other techniques include a predictive model in which instead of comparing images, the blood test parameters are used to predict the presence of a disease. Other approaches include NLP based detection of diseases based on the textual content of the clinical reports.

In most advanced usage in hospitals, many cancer cases have been discovered at an early stage based on Computer-Aided Diagnosis (CAD) systems.

In other papers, A feature selection-cum-classification scheme has been devised by combining F- statistic, statistical learning techniques i.e., bayesian learning and support vector machine (SVM) to provide the higher classification accuracy using the best set of discriminating features [4]. In this approach, the highest accuracy is provided by the bayesian network approach.

Other research includes computer-aided detection of malaria using a fast convolutional neural network architecture for the classification of cell images [5]. However, the accuracy of different models depend on different factors and no model can be abstractly called the best model. However, different models can be compared for a particular objective and the best one can be chosen among these.

The future of medical practice will be heavily cornered by mixed Augmented & Virtual reality, Artificial Intelligence and ML. It is evident from the amount of research in this field. However, different methods are used in different researches and hence their accuracy also varies. Malaria which is such a curable disease, can be fatal due to incorrect or late diagnosis. A lot of researchers have been attracted by the prospects of automating malaria and blood cancer diagnosis with its obvious advantages [6].

Not just malaria, but blood cancer though not curable, can be controlled with an early and efficient diagnosis. This can be rectified by the computer vision approaches that include different image classification based on ML algorithms like CNN, relational CNN, KNN, etc.

Despite a lot of work has already been done in this field, each with different results and different accuracies, detection of fatal diseases using ML-based image classification algorithms is going to help the pathology industry, as the manual diagnosis of blood cancer or malaria is challenged by different factors that include but not limited to lack of healthcare access or human error due

to lack of experienced personnel.

malaria being a fatal disease has caused deep research interests among scientists all over the world. Earlier, malaria was mostly diagnosed in the laboratory setting requiring a great deal of human expertise. Automatic systems relying on ML techniques were initially studied to overcome this problem [7].

Despite malaria and blood cancer can be more accurately diagnosed by robotic devices but this again leads to the source of the problem that is increased time consumption and cost in testing. Early diagnosis is required for the treatment to start early to cure malaria and control blood cancer. There have been reports of the cost of testing of malaria and blood cancer using robotic observation way too high, which is far beyond the common man's pocket.

Still, there is room for improvement for current malaria diagnostic tests including reducing cost, increasing specificity, and improving ease of use. The current gold-standard method for malaria diagnosis in the field is light microscopy of blood films. With microscopy, all parasite species can be detected. The extensive training required for a microscopist to become a proficient malaria slide reader, the high cost of training and employing, maintaining skills, and the large component of manual work involved [6], add to the disadvantages of manual observation of malaria. Not only this, a great challenge is still posed by the robotic diagnosis of malaria especially in terms of cost. However, as discussed in this approach, the accuracy of detection of blood cancer or malaria can be improved along with the faster declaration of result with ML-based image processing algorithms.

One of the types of blood cancer includes leukemia which is caused by excessive production of leukocytes in the bone marrow. Image-based detection of malignant WBCs is important for its detection [8]. A hybrid approach for efficient classification of leukemia (a type of blood cancer) has been presented in one of the papers which include the SESSA feature optimization, where

SESSA stands for Self-Swarm Algorithm, in which only the most relevant features are selected and highly correlated and noisy features are removed by this biologically inspired optimization algorithm.

Detection of diseases via blood analysis is still open to research.

2.1.3. Research Findings for Existing Literature

TABLE 3 Literature Survey

S. No.	Paper Title	Tools/ Technology	Findings	Citation
1	Detection of diseases via blood analysis using Image Processing Techniques	Count of Pixels to detect presence of Blood Cancer	Blood Cancer is detected by the number of white blood cells in the segmented microscopic image. In this, the number of pixels containing the white blood cells are counted and compared with the threshold	[1]
2	Malaria Detection Using Machine Learning With K Nearest Neighbour Algorithm	KNN	It uses force based Iterative Global Minimum Screening (IGMS), which plays out a quick screening of a thick	[2]

			smear picture to discover parasite up-and-comers.	
3	Detection of Acute Lymphocyte Leukemia using K-Nearest Neighbour Algorithm Based on Shape and Histogram Features	KNN	Automatic detection of lymphocyte leukemia through classification of lymphocyte cell images obtained from peripheral blood smear single cell by extraction of featuring cells and classifying the cells into normal and abnormal	[3]
4	Machine Learning Approach for automated screening of malaria parasites using light microscopic images	Bayesian Learning and SVM	A feature selection-cum-classification scheme that had been devised by combining statistic, statistical learning techniques to provide the higher classification accuracy using the best set of discriminating features.	[4]
5	Performance analysis	Fast CNN	A fast Convolutional	[5]

	of machine learning and deep learning architectures for malaria detection on cell images,		Neural Network (CNN) architecture for the classification of cell images was used and compared with the performance of transfer learning algorithms developed based on well-established network architectures such as AlexNet, ResNet, VGG-16 and DenseNet	
6	Image Analysis and Machine Learning for detecting Malaria	Parasite detection and cell segmentation	Different techniques were used to preprocess the images and different models like KNN, CNN were used and compared to detect Malaria	[6]
7	Deep Learning Based Automatic Malaria Parasite Detection from Blood Smear and Its Smartphone Based Application	SVM CNN KNN	A variety of techniques including knowledge distillation, data augmentation, Autoencoder, feature extraction by a CNN	[7]

			model and classified by Support Vector Machine (SVM) or K-Nearest Neighbors (KNN) are performed under three training procedures named general training, distillation training and autoencoder training to optimize and improve the model accuracy and inference performance.	
8	Efficient Classification of White Blood Cell Leukemia with Improved Swarm Optimization of Deep Features	Self-Swarm Algorithm CNN	A hybrid approach for efficient classification of Leukemia has been presented in the papers which include the SESSA feature optimization in which only the most relevant features are selected and highly correlated and noisy features are removed by biologically inspired	[8]

			optimization algorithm.	
9	Blood Diseases Detection using classical Machine Learning Algorithms	Blood Test Parameters used to predict the presence of a disease	A predictive model in which instead of comparing images, the blood test parameters are used to predict the presence of a disease	[9]
10	Four Common Types of Neural Network Layers	Neural Networks	Neural Networks consist of fully connected layer, convolutional layer, deconvolutional layer and recurrent layer.	[10]
11	Revolutionizing blood bank inventory management using the TOC thinking process: An Indian case study	Content Reality Tree Conflict Resolution Diagram	Both Current Reality Tree and Conflict Resolution Diagram were constructed to maintain the inventory of blood.	[11]
12	Blood Bank Information System Using Android Application	Android App and match making between donor and receiver	This paper featured an android application for connecting blood donors with blood receivers	[12]
13	E-Blood Bank	Searching the blood	This paper featured an	[13]

	Application for Organizing and Ordering The Blood Donation	stock using blood transfusion score	android application for organizing and ordering blood online using blood transfusion score	
14	Robust Technique for the Detection of Acute Lymphoblastic Leukemia	Image segmentation and classification	This paper demonstrates a method using morphological operations in MATLAB to segment images and compare between different classifiers to perfectly diagnose the presence of ALL in blood smear	[14]

2.1.4. Problems Identified and Proposed Solution

Most of the existing models focus only on accuracy than other evaluation metrics. Though accuracy is a good evaluation metric in case of classification, accuracy is not a sole reliable evaluation metric in case of disease prediction. If a positive case is predicted negatively, then it can be dangerous. So, ‘Recall’ and ‘Precision’ are also considered as evaluation metric along with ‘Accuracy’.

None of the existing systems feature a full-fledged application that facilitates diagnosis of malaria and blood cancer using CNN from microscopic images. Our project features a complete system which facilitates the registered pathologist to upload microscope image and get it

diagnosed using ML models that use CNN.

2.2. Software Requirement Specification

2.2.1. Introduction

Our project aims at building a web application that allows the user to upload microscopic image of blood sample to check the presence of malarial infection or blood cancer or classification of blood cells into 4 broad categories. The web application shall also provide interface for blood donation management system and transfusion details.

2.2.1.1. Purpose

- The purpose behind designing our solution are as follows: -
- The common method of detecting blood cancer requires CBC and peripheral blood smear along with bone marrow aspiration which make use of expensive equipment.
- Existing solutions require skilled expertise and are prone to human error along with increased costs.
- To provide a faster and more accurate method for confirming diagnosis.
- For general awareness a thorough study needed to be done not only in terms of statistics but also provide those statistical number to the masses.

2.2.1.2. Intended Audience and Reading Suggestions

The target groups include pathologists who have access to smart phones or computer, blood donors and prospective receivers having smart phones with fast internet and scholars who want to studies and analyse numerical and statistical data related to blood related diseases and

programmes regarding to curbing them.

2.2.1.3. **Project Scope**

- Using image classification algorithm to check whether the given sample is infected with malaria and blood cancer.
- Classification of the cells into 4 broad categories – eosinophils, lymphocytes, monocytes and neutrophils for pathology studies.
- Blood donation management system that provides transfusion details and allows online booking of blood.

2.2.2. Overall Description

2.2.2.1. **Product Perspective**

This project aims at building a web application for pathological studies and testing. The application caters to 4 different user domains – pathologists, prospective blood donors, prospective blood recipients and general users. The pathologist, shall be provided with the facility of uploading microscopic images by the application to check for malarial infection or blood cancer. The UI for uploading the image and choosing an option for checking blood cancer or malaria or classification shall be developed using HTML/CSS/JS along with node.js and express.js and MongoDB for server-side rendering. The diseases from the blood sample shall be detected using image classification algorithms along with the OpenCV library. The detailed process of automated checking for malarial/blood cancer infection is indicated in Figure 1.

If s/he wishes, the cells shall be classified into 4 broad categories: - eosinophils, monocytes, lymphocytes or neutrophils for pathological studies by the application.

A suitable interface for the blood donation management system shall also be provided by the application in which the user can request blood from nearby blood banks. The transfusion details shall also be stored in the system which mentions which blood group can receive the blood of which group. Real-time infection data of malaria and blood cancer shall be visualised by the application geographically to verify where the cases are coming from. The blood donation management system that provides transfusion details and allows online request of blood and shall be developed using MongoDB database and Google Maps API for location tracing.

For real-time infection and monitoring, the data from nearby clinics will be fetched using APIs and will be plotted demonstrated in Figure 4.

2.2.2.2. **Product Features**

- With image classification algorithms, the app will allow the user to check whether the given blood sample is infected with malaria and blood cancer.
- Categorization of blood cells into 4 broad categories i.e. eosinophils, lymphocytes monocytes, neutrophils.
- Provide the nearest location of blood banks along with online booking of blood based on the blood group of the patient.
- The app will allow the user to upload microscopic images of blood sample and provide real-time analytics in the form of graphs and geographical mapping.

2.2.3. External User Interface Requirements

2.2.3.1. **User Interfaces**

- The application shall provide the facility of login authentication and signup for

pathologists and blood bank employees.

- It shall provide facility to the pathologists for image uploading for disease processing and shall generate report in downloadable PDF's.
- For the pathologist, the application shall provide the pathologist with efficient categorization on the basis of malaria and leukemia, and blood cell type.
- The application shall provide a suitable UI for registering for blood donation or requesting for blood
- The application shall provide a suitable portal for blood bank employees to manage incoming blood requests as well as blood donor registrations.

2.2.3.2. **Hardware Interfaces**

- This application would require internet connection to let the user view website for their respective needs.
- It requires any device with any operating system that supports internet connectivity, location and browsers.

2.2.3.3. **Software Interfaces**

For Software interface we are using HTML, CSS, Bootstrap, JavaScript, Node.js and EJS.

2.2.4. Other Non-Functional Requirements

2.2.4.1. **Performance**

- It will support multiple users at the same time.

- All the daily data produced will be stored online.
- For normal conditions, the data would be processed efficiently.

2.2.4.2.**Reliability**

The product is targeted towards a wide variety of users such as laboratory assistant, blood disease patient, blood donor etc. The product must load quickly and have high accuracy for disease prediction and cell categorization. It must overcome many to one user interaction through efficient login/authentication system.

2.2.4.3.**Adaptability**

Our product can be accessed from a wide variety of devices including mobile phones and PC's. A high-speed internet is required and browsing functionality. Our website would be user friendly and shall provide a very humbling experience.

2.2.4.4.**Speed**

Our product shall provide fast response and will be up-to-time until some unpredictable error occurs.

2.2.4.5.**Scalability**

We are using two separate servers, one for disease classification another one for data analytics and blood bank management system, so that backend system won't get overloaded.

2.3. Cost Analysis

TABLE 4 Cost Analysis

Requirement	Cost ($)	Cost (in Rs)

Database (MongoDB)	0.00	0.00
Total	0.00	0.00

2.4. Risk Analysis

- Though the predictability is high, yet some false negative cases will be there too.
- The test may disrupt and pathologist may have to start over in case of internet failure.

3. METHODOLOGY ADOPTED

3.1. Investigative Techniques

In our project the haematology app, experimental investigative techniques have been used with the initial idea of contributing towards the society using our engineering skills. An experimental investigative technique involves coming up with an idea, designing the required procedure for executing the idea and then coming up with the final hypothesis for the desired project. We incorporated deep learning for judging the disease highly efficiently and using technology of google maps and web development for providing shortest path assistance blood donation procedure. The procedure designed by us included splitting the project into 3 modules-

- **The pathologist dashboard-** A platform where a pathologist not only can quickly verify and generate medical report by just inputting microscopic image of the blood cell.
- **Location coordinates-based Blood Bank-** A tool for blood bank employees as well as prospective blood donors and receivers for carrying out the whole cycle of blood donation solely based on their real time location and their basic information.
- **Data Visualization corner-** Analytics of charts & graphs.

Hypothesis

- For disease prediction we have only one input i.e. blood cell image and for this hypothesis will be whether given cell has malaria and leukemia.

- For Blood bank system, hypothesis will be location of the nearest blood bank and approval of blood package for recipient.

3.2. Evaluation Metrics and Proposed Solution

Different types of models like CNN1, CNN2, RESNET and Inception V3 were tested and the following observations were recorded. For detection of malaria, CNN1 had the best accuracy of 96% as indicated in Figure 6. Figure 7 shows the accuracy of different models for detection of blood cancer in which Inception V3 stood the best. Figure 8 shows the accuracy of different models for classification of blood cells.

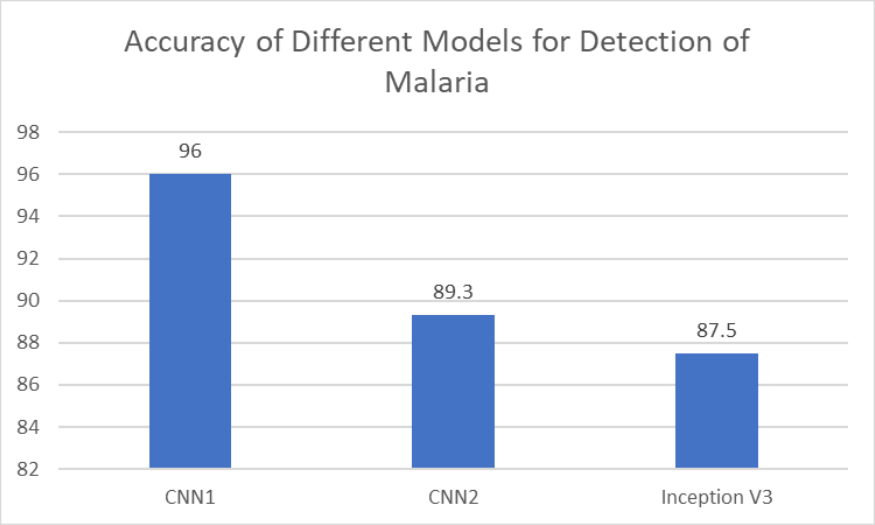


FIGURE 6 Accuracy of different models for detection of malaria

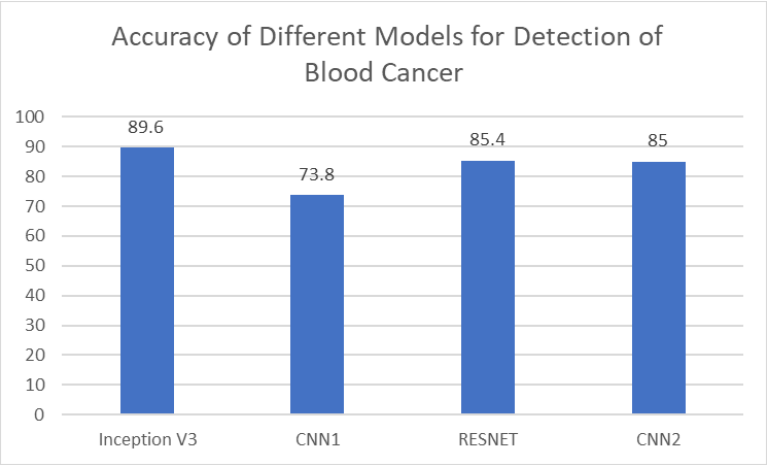


FIGURE 7 Accuracy of different models for detection of blood cancer

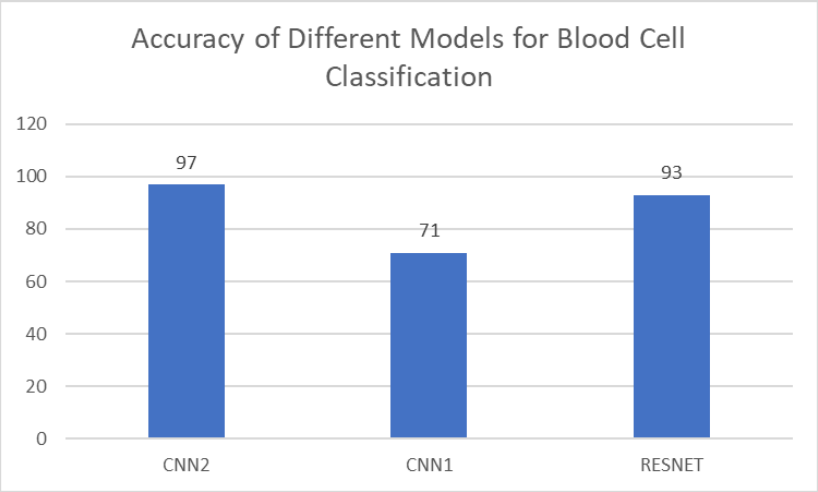


FIGURE 8 Accuracy of different models for blood cell classification

For this project, two evaluation metrics: recall and accuracy, were used to select the models. The reason for selecting recall as an evaluation metric as recall gives the ratio of how many cases have been predicted positive over total number of actual positives.

The recall must be more as false negatives must be less as false negatives are more dangerous in

disease prediction. The formula of recall is mentioned in Equation 1.

$$Recall = \frac{TP}{TP + FN} = \frac{True\ Positives}{Actual\ \ Positives} \quad (1)$$

For the ML model that predicts malaria, the evaluation metrics for the same are represented in Figure 9 and Figure 10.

	precision	recall	f1-score	support
0	0.93	0.95	0.94	2755
1	0.95	0.93	0.94	2755
accuracy			0.94	5510
macro avg	0.94	0.94	0.94	5510
weighted avg	0.94	0.94	0.94	5510

FIGURE 9 Evaluation Metrics for malaria classifying ML model

Recall for positive prediction: 0.93 - about 93 percent of actual positives were predicted positive which can be said to be a fair model.

Recall for Negative Prediction: 0.95 - about 95 percent of actual negatives were predicted negative which can be said to be a fair model.

The model may be slightly fairly good for substituting prediction for positives but for most of the cases, it is better to be used for verification. It can be used to detect the cases where human error has diagnosed positive but actually it is negative.

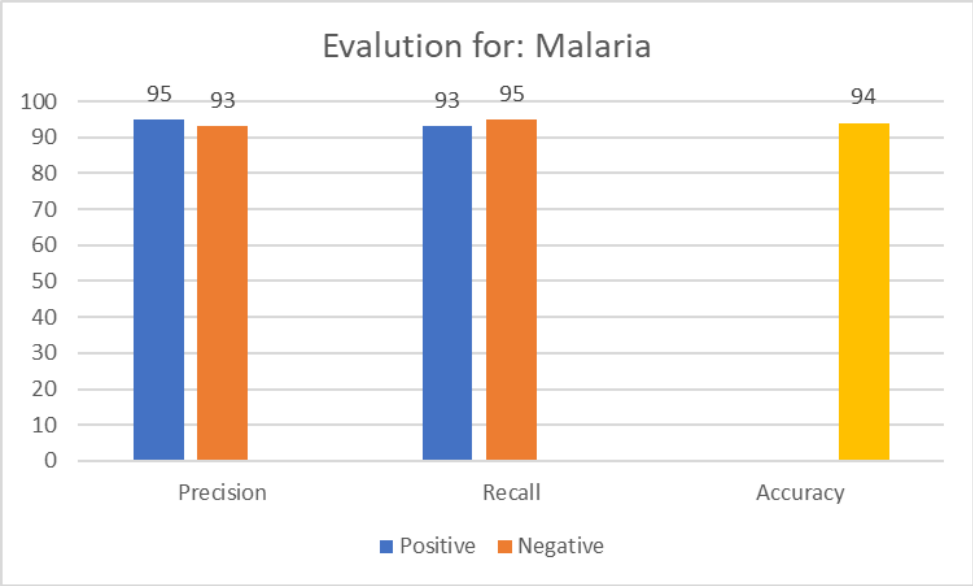


FIGURE 10 Evaluation Metrics for malaria

For the evaluation model that classifies blood cells, accuracy seems to be a better evaluation metric as it focusses on correct classification and since it is not prediction of disease, accuracy can be a better evaluation metric. The formula for precision is mentioned in Equation 2.

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} = \frac{True\ Positives + True\ Negatives}{All\ Positives + All\ Negatives} \quad (2)$$

The evaluation metrics for blood cell classification are represented in Figure 11 and Figure 12 . Accuracy has been considered as an evaluation metric here as it is concerned with classification only and in this case, for incorrect classification, it is not that dangerous as negative prediction of a positive sample while predicting diseases.

	precision	recall	f1-score	support
EOSINOPHIL (Class 0)	0.97	0.94	0.95	324
LYMPHOCYTE (Class 1)	1.00	1.00	1.00	276
MONOCYTE (Class 2)	0.99	0.99	0.99	290
NEUTROPHIL (Class 3)	0.95	0.96	0.95	325
accuracy			0.97	1215
macro avg	0.97	0.97	0.97	1215
weighted avg	0.97	0.97	0.97	1215

FIGURE 11 Evaluation Metric for Blood Cell Classification

The recall for each of these can be seen to be more than 0.95: This means for each cell type, about 95% cell have been correctly detected out of actual correct cell type.

The overall accuracy of the model is 97% which is fairly good.

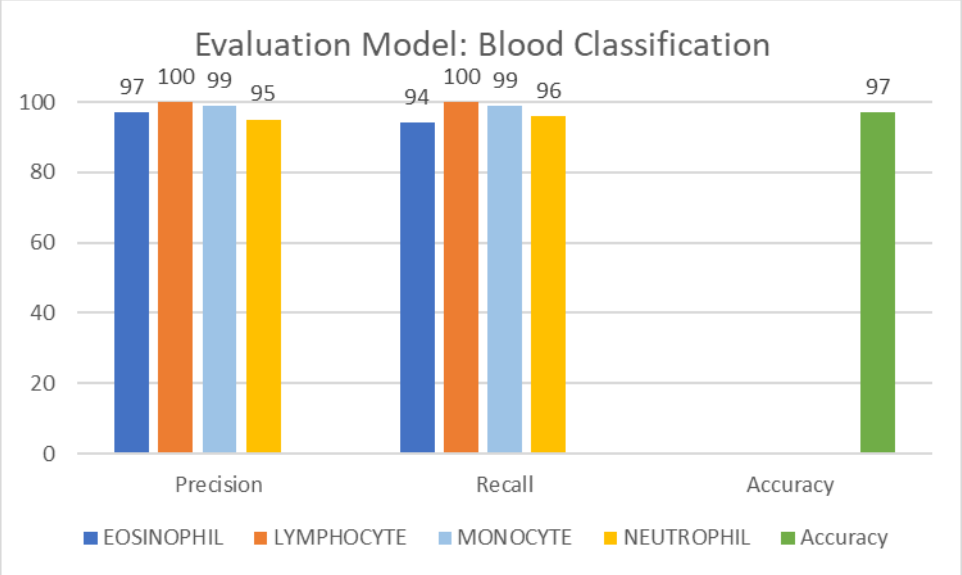


FIGURE 12 Evaluation Metric for Blood Cell Classification.

The project will be further explored with more ML models with a different architecture and the one with a better recall score will be selected for disease detection and accuracy for blood cell classification.

3.3. Work Breakdown Structure

The WBS is a deliverable-oriented breakdown of a project into smaller components as depicted in Figure 14. The WBS is commonly used to develop the project schedule and required deliverables. We have used WBS tree structure view to illustrate the work packages and gantt chart to illustrate project schedule.

Stage	Sno.	Task	01 April 2021	15 April 2021	29 April 2021	13 May 2021	27 May 2021
1	1	HTML,CSS,JS					
	2	ReactJS					
	3	ML					
	4	NodeJS					
	5	MongoDB					
	6	Postgre SQL					
2	7	Pre-Processing Model 1					
	8	Website Home Page Design					
	9	Documentation					
3	10	Design & Implementation ML Model 1					
	11	UI Layout & Designing					
	12	Front-End Making					
			10 June 2021- 9 July 2021	10 July 2021	24 July 2021	07 August 2021	21 August 2021
4	13	Training & Testing ML Model-1					
	14	Front-End Implementation & Testing					
	15	Tuning ML Model-1	EXAM				
			BREAK				
5	16	Back-End Environment Setting & Route Testing					
	17	Pre-Processing Model 2					
			04 September 2021	18 September 2021	02 October 2021	16 October 2021	30 October 2021
6	18	Back-End Development & DB Making					
	19	Design & Implementation ML Model 2					
7	20	Scaling & Optimising Back-End & Front-End					
	21	Training ,Testing & Tuning ML Model-2					
	22	Integrating ML Model-1 & Model-2					
			30 October 2021	13 November 2021	27 November 2021	11 December 2021	25 December 2021
8	23	Integration & Testing Final Project					
	24	Documentation & Web Hosting					

FIGURE 13 Gantt Chart for Tentative Schedule

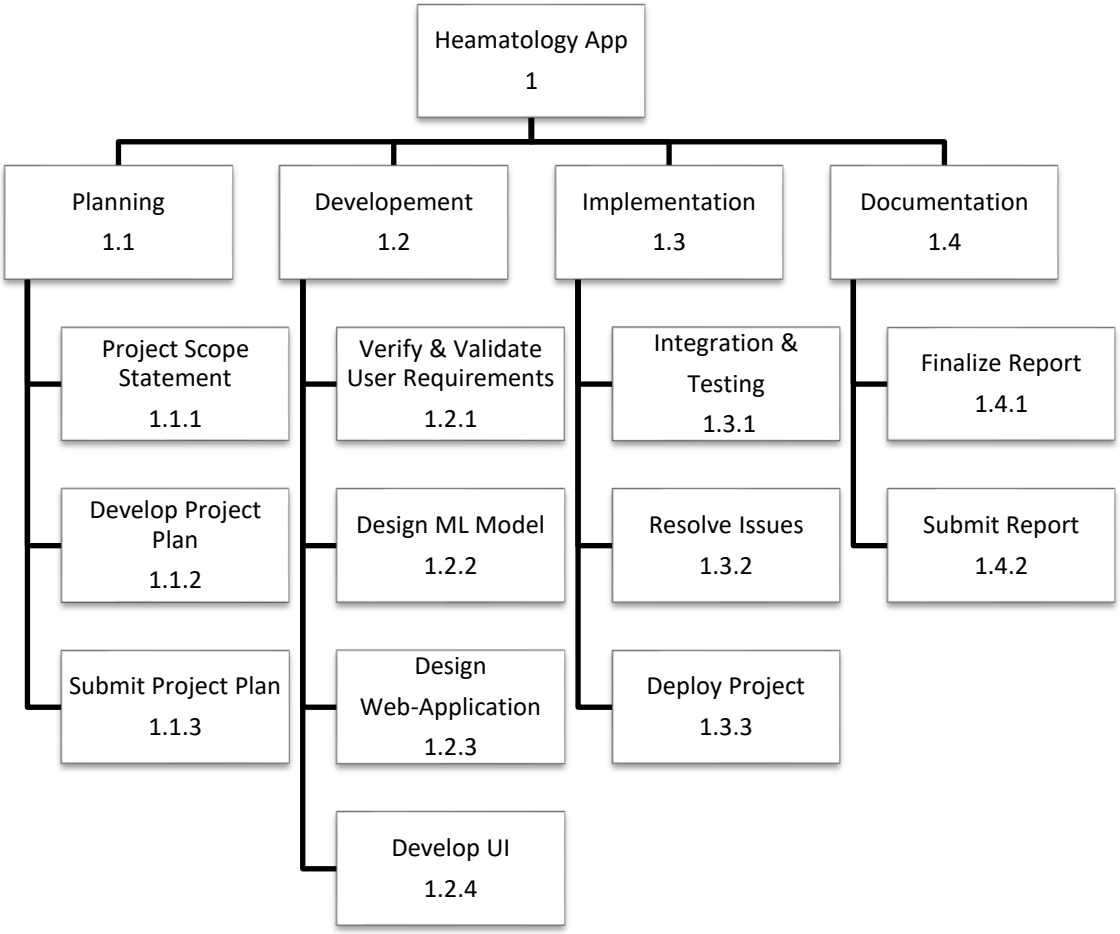


FIGURE 14 Work Breakdown Structure

Modules

- **Planning: -** During this phase, we decide the extent of scope of the project and devise a timeline to be followed for development of the project.

- **Development: -** During this phase, we perform requirement gathering and requirement

analysis for the project and implement various ML models and develop user interface.

- **Design ML model: -** In this phase we develop and implement various models to detect malaria and leukemia and perform blood cell classification.

- **Design web-application: -** During this phase we develop the web-application to be used for pathology and blood bank management system.

- **Implementation: -** In this phase, we implement the system and run various tests to detect and resolve any issues that arise before deploying the overall system.

3.4. Tools and Technology

The model used for detection of malaria is a deep CNN that contains a sequence of 3 convolution blocks containing combination of 2-dimensional convolutions and max-pooling. The output of final convolutional block is flattened and followed by two dense layer-6 with 2 layers containing dropout layer. The final dense layer is added with 1 unit and sigmoid activation for binary classification.

The model for classification of blood cells contains a sequence of five convolutional blocks containing combination of separable 2D convolutions, batch normalisation, max-pooling and dropout layer. The output of the final convolution block is flattened and followed by three fully connected (FC) layers each with its own dropout layer. A final fully connected layer is added with 4 units and a SoftMax activation function for multiclass classification.

Proposed Work

The proposed framework is based on CNN architecture. CNN, ResNet is explained and compared for classification of blood cell images. Features are extracted from the convolutional layer and pooling layer. The extorted features are fed into a fully connected layer for a classification.

3.4.1. Convolutional Neural Networks

CNN contains convolutional layer, activation function, pooling layer, flattening, and fully connected layer. Convolutional and pooling layers are used for learning the features. Flattening and a fully connected layer are used for classification.

The proposed work consists of 2 CNN models. First, the model contains 3 conv blocks containing a combination of conv2D and max-pooling. The output of the final block is flattened and followed by 2 dense layers with 2 layers containing the dropout layer. The final dense layer is added with 1 unit and sigmoid activation function for binary classification. Second, the model contains a seq of 5 conv blocks containing a combination of separable conv2D, batch normalization, max pooling and dropout layer. The output of the final block is flattened and followed by 3 fully connected layers each with its dropout. The final dense layer is added with 4 units and a softmax activation function for classification

3.4.1.1. Convolutional Layer

The convolutional layer consists of an input image and filter. The input image is convolving by filter with padding,and number of the filter. The filter is also called as spatial extent. The spatial extent may be 3*3 or 5*5 or 7*7. The WBCs input image contain size w1 * h1 * c and filter contain size f1 * f2 * c. The output is w2 * h2. The output images are also called feature maps. The w2 and h2 are defined using Equation (3).

$$w2 = (w1 - f + 2p) / s + 1 \; h2 = (h1 - f + 2p) / s + 1 \quad (3)$$

Where w1 and h1 represent input width and height , f1 and f2 represent filter width and height, w2 and h2 represent output width and height, f represent filter size, s represent stride. p represent padding.

3.4.1.2. Separable Convolutional Layer

This layer performs convolution in two dimensions with a factorization of the convolution kernel

into two smaller kernels.

3.4.1.3. **Padding**

The input image is convolving by filter. Corner pixel of input image will get cover one time. Corner pixel information is loss. Padding is introduced to overcome this problem. Padding is classified into same padding and valid padding. Zeros are added around the input image in same padding. Corner pixel gets cover more than once in input image. Input and output image has the same dimension in same padding. Zeros are not added around the input image in valid padding. Input and output image has the different dimension in valid padding.

3.4.1.4. **Activation Function**

The input image is convolving by filter. Corner pixel of input image will get cover one time. Corner pixel information is loss. Padding is introduced to overcome this problem. Padding is classified into same padding and valid padding. Zeros are added around the input image in same padding. Corner pixel gets cover more than once in input image. Input and output image has the same dimension in same padding. Zeros are not added around the input image in valid padding. Input and output image has the different dimension in valid padding.

$$f(x) = x \text{ if } x > 0 \quad (2)$$
$$0 \text{ otherwise} \qquad (4)$$

The equation (4) of the ReLU activation function removes negative values. ReLU changes the negative value by zero to produce the featured image. The gradient is always high (equal to 1) if the neuron activates. The softmax function, or normalized exponential function,[2]:198 is a generalization of the logistic function to multiple dimensions. It is used in multinomial logistic regression and is often used as the last activation function of a neural network to normalize the output of a network to a probability distribution over predicted output classes.

3.4.1.5.**Pooling Layer**

Pooling Layer: The result of the convolutional layer's output is redundant because of much information. Convolutional layers will produce similar values for neighbouring pixels in outputs. Convolutional layer output is passed as input to the pooling layer. The pooling layer reduces the size of the input. The pooling layer is done by an operation like max, average, and sum. Max Pooling gives the maximum pixel value from the portion of the image covered by the filter. Average Pooling gives the average of all the pixel values from the portion of the image covered by the filter. Sum Pooling gives the sum of all the pixel values from the portion of the image covered by the filter. The proposed works is done with max pooling. The pooling layer is also performed with padding and stride.

3.4.1.6.**Flattening**

Flattening exists between the convolutional layer and the fully connected layer. Flattening converts a two-dimensional matrix of pooling layer output to the vector. The vector can be given to the fully connected neural network.

3.4.1.7.**Fully Connected Layer**

The Fully Connected Layer (F.C.L) uses the activation function (SoftMax or sigmoid) in the output layer. In a fully connected layer, every neuron in the previous layer is connected to every neuron in the next layer [10]. F.C.L is used to classify image input into different categories based on training data. A fully integrated layer is used to predict classes.

3.4.2. RESNET 50

ResNet50 has two basic blocks, namely Conv Block and Identity Block. The input and output dimensions of Conv Block are different, so they cannot be connected in series. Its function is to change the dimension of the network; Identity Block input dimensions and output The

dimensions are the same and can be connected in series to deepen the network.

3.4.3. Node.js and EJS

For the blood bank domain, node.js and EJS would be used to develop and integrated backend system.

3.4.4. Google Maps API

For blood donor, the location of the donor would be accessed using google maps API.

3.5. Workflow

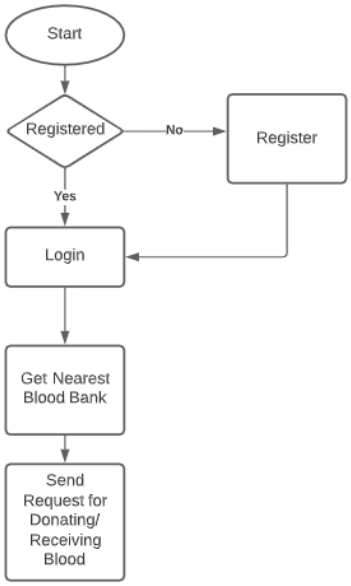


FIGURE 15 Workflow for Blood Bank Portal

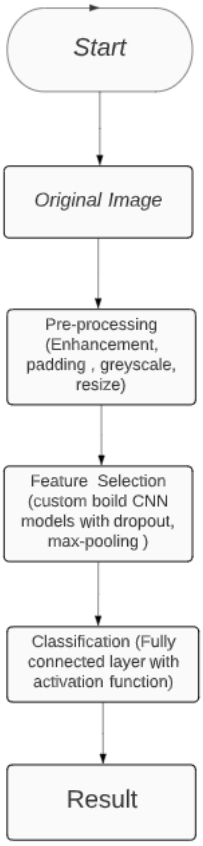


FIGURE 16 Workflow for Pathology Portal

4. DESIGN SPECIFICATIONS

4.1. System Architecture

A system architecture is the conceptual model that defines the structure, behaviour, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviours of the system. A system architecture consists of system components and the sub-systems developed, that function together to implement the overall system.

We have made use of component diagrams (Figure 17 to Figure 19) to depict various components that are used to run the project. Our project consists of three components:

- **Pathology: -** Test sample is given to the pathologist who in turn tests the sample and gives report. It consists of a database which contains details about the pathologists employed for testing and a database which has details of the blood sample to be tested. In addition to this, it also includes ML server which runs various ML models on the test samples and produces the final result.

- **Blood Bank: -** Donors who wish to donate their blood can do so and patients can submit request for the required blood. It consists of a database which stores the details of all the employees and managers working at the blood bank. In addition to this, it has a separate database which stores the details of the donors and recipients. The blood bank server manages the user-interface and all other operations of the blood bank.

- **Data Visualisation: -** It is used to provide real-time data to the customer using data analytics and visualization

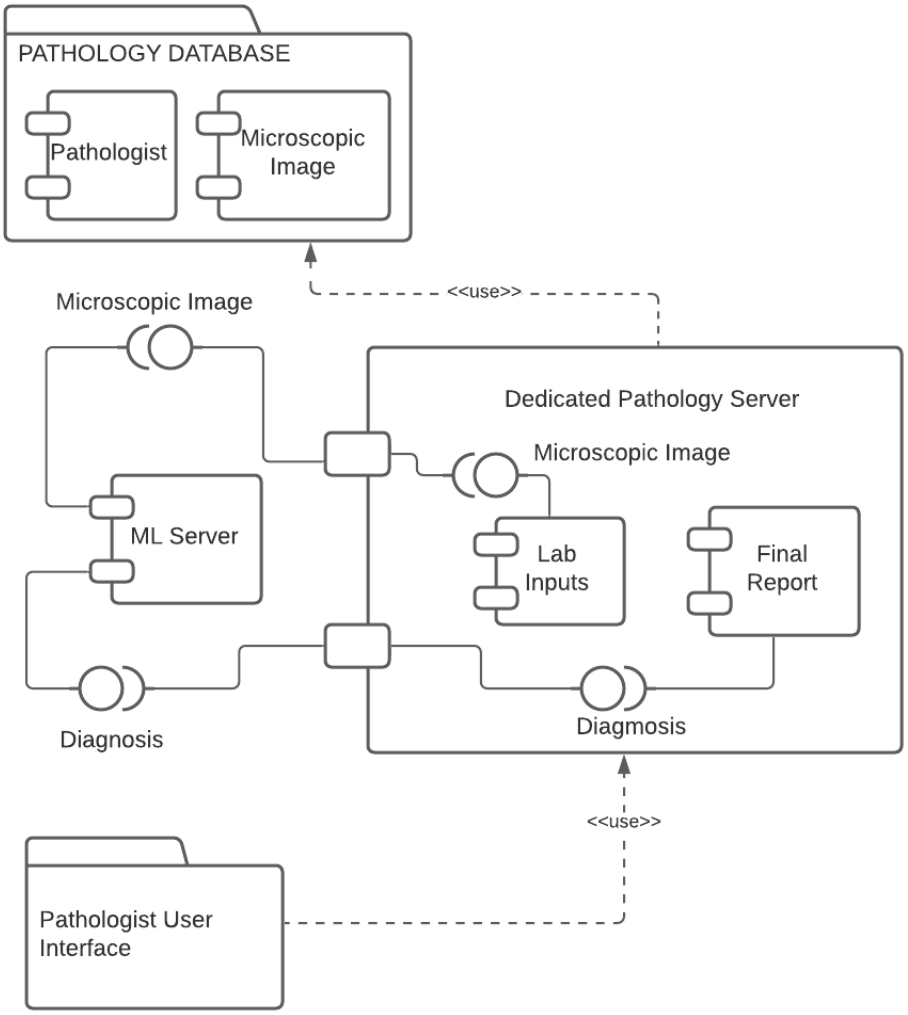


FIGURE 17 Component Diagram for Pathology Domain

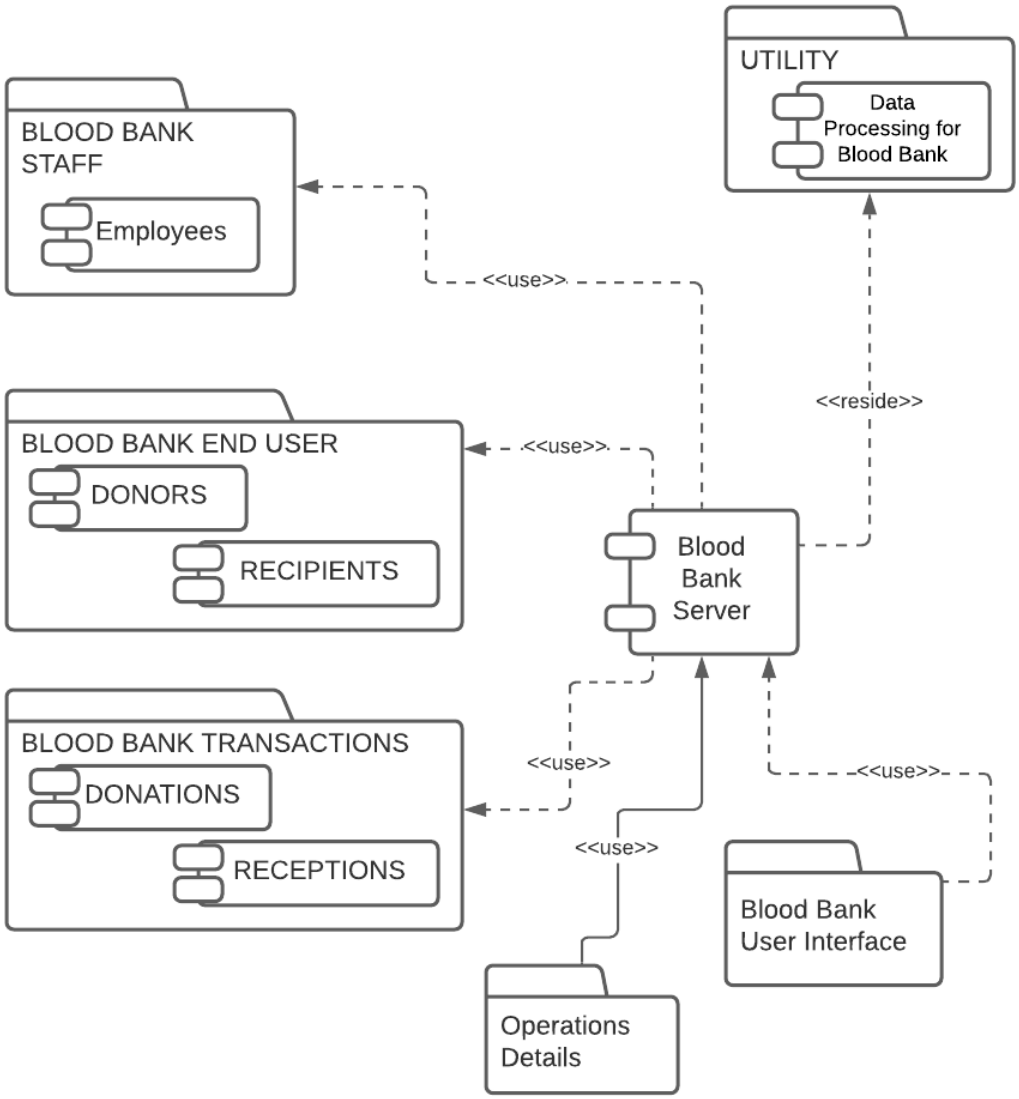


FIGURE 18 Component Diagram for Blood Bank Domain

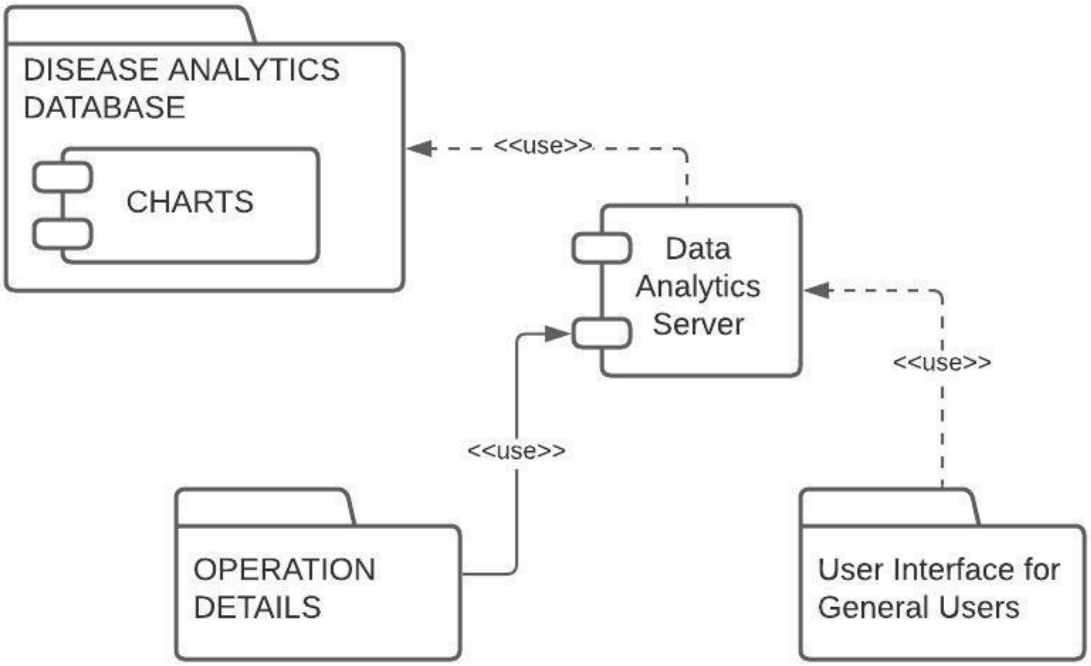


FIGURE 19 Component Diagram for Data Visualization

4.2. Design Level Diagrams

4.2.1. Activity Diagrams

In Figure 20, the activity diagram for the Pathology domain is shown. If the pathologist is not yet registered, then s/he can register at the portal with the lab registration code, which will be verified later by the verification team. If the pathologist is registered and enters the correct login credentials, then only will the pathologist be able to continue. After successfully logging into the portal, the pathologist will be able to perform the tests by uploading microscopic image of the sample.

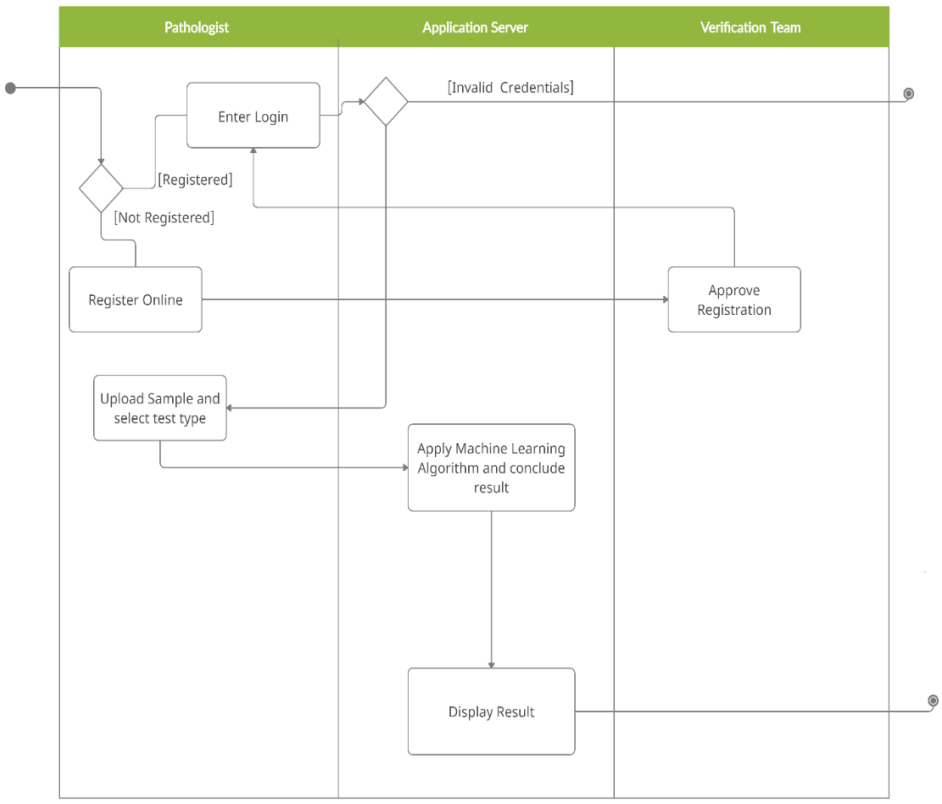


FIGURE 20 Activity Diagram for Pathologist

For the Blood bank domain, the activity diagrams for blood donation and blood reception are Figure 22 and Figure 21. For the blood donation, the user will be prompted to give location access. Once location access is granted, the user will be able to view the list of nearest blood banks. The user cannot view the list of nearest blood banks unless and until location access is granted. After getting the list of nearest blood banks, the user will be asked where s/he would be willing to donate blood and fill details. The blood bank employee will then go through the details of the prospective donor and check for fitness through parameters entered online and physically. If the user is deemed fit for blood donation, then the employee will take blood and update the said quantity on the portal. If the prospective donor is not fit for blood donation, then the blood will not be taken.

For the blood reception, the user will be able to send a request online by uploading necessary documents. This request will be scrutinised by the blood bank employee, and if the request is authentic, then only further actions will be performed. If the request is inauthentic, then request will be declined. If the request is authentic, then the request will be approved subject to availability of blood. If blood is not available, them the blood bank employee will put up a notice asking for blood as indicated in Figure 21.

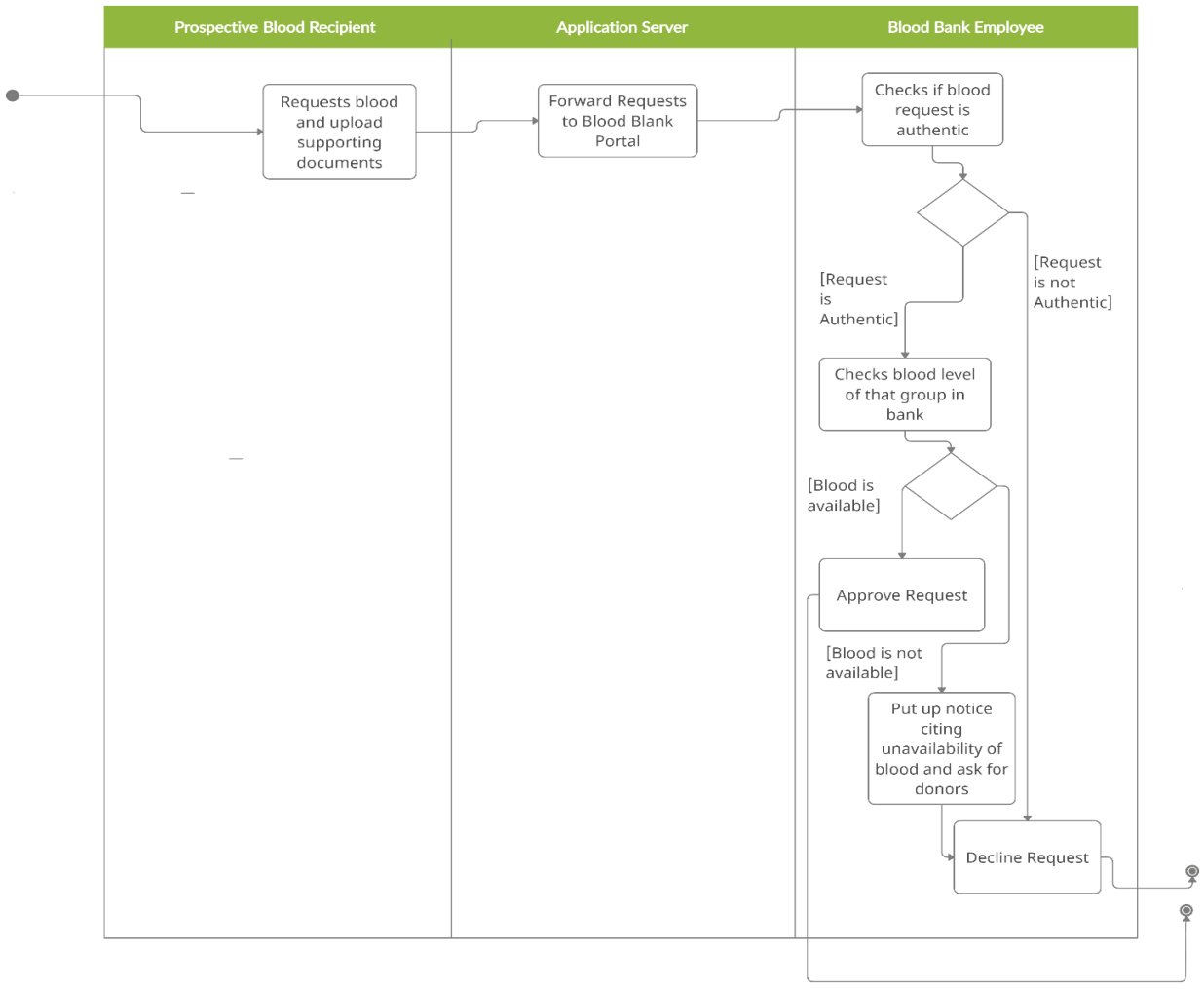


FIGURE 21 Activity Diagram for Blood Recipient

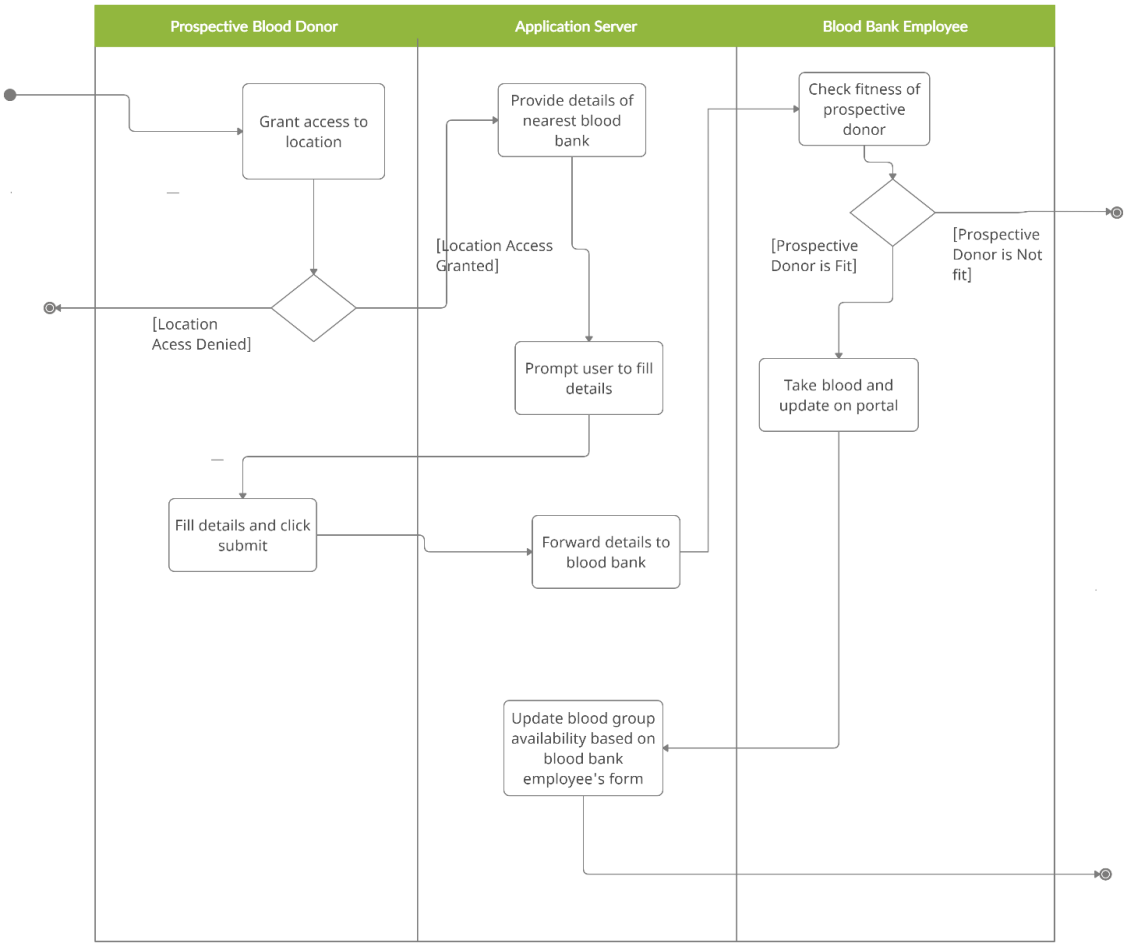


FIGURE 22 Activity Diagram for Blood Donation

In case of data visualization, the user will be able to view real time data corresponding to malaria and leukemia without any significant action required from the user's side as indicated in Figure 23.

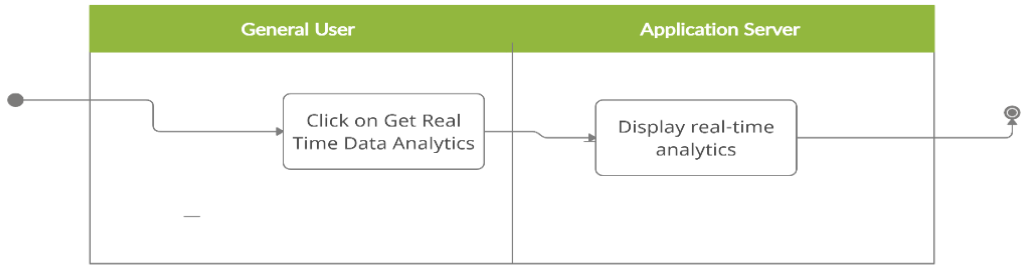


FIGURE 23 Activity Diagram for Data Visualization

4.2.2. Sequence Diagram

The sequence diagrams are represented by Figure 24, Figure 25, Figure 26 and Figure 27. There are different diagrams for the three different domains.

In Figure 24, the sequence diagram for the pathology domain is shown. If the pathologist is not yet registered, then s/he can register at the portal with the lab registration code, which will be verified later by the verification team. If the pathologist is registered and enters the correct login credentials, then only will the pathologist be able to continue. After successfully logging into the portal, the pathologist will be able to perform the tests by uploading microscopic image of the sample.

For the blood bank domain, the sequence diagrams for blood donation and blood reception are Figure 26, Figure 22 and Figure 25. For the blood donation, the user will be prompted to give location access. Once location access is granted, the user will be able to view the list of nearest blood banks. The user cannot view the list of nearest blood banks unless and until location access is granted. After getting the list of nearest blood banks, the user will be asked where s/he would be willing to donate blood and fill details. The blood bank employee will then go through the details of the prospective donor and check for fitness through parameters entered online and physically. If the user is deemed fit for blood donation, then the employee will take blood and

update the said quantity on the portal. If the prospective donor is not fit for blood donation, then the blood will not be taken.

For the blood reception, the user will be able to send a request online by uploading necessary documents. This request will be scrutinised by the blood bank employee, and if the request is authentic, then only further actions will be performed. If the request is inauthentic, then request will be declined. If the request is authentic, then the request will be approved subject to availability of blood. If blood is not available, them the blood bank employee will put up a notice asking for blood as indicated in Figure 26.

In case of data visualization, the user will be able to view real time data corresponding to malaria and leukemia without any significant action required from the user's side as indicated in Figure 27.

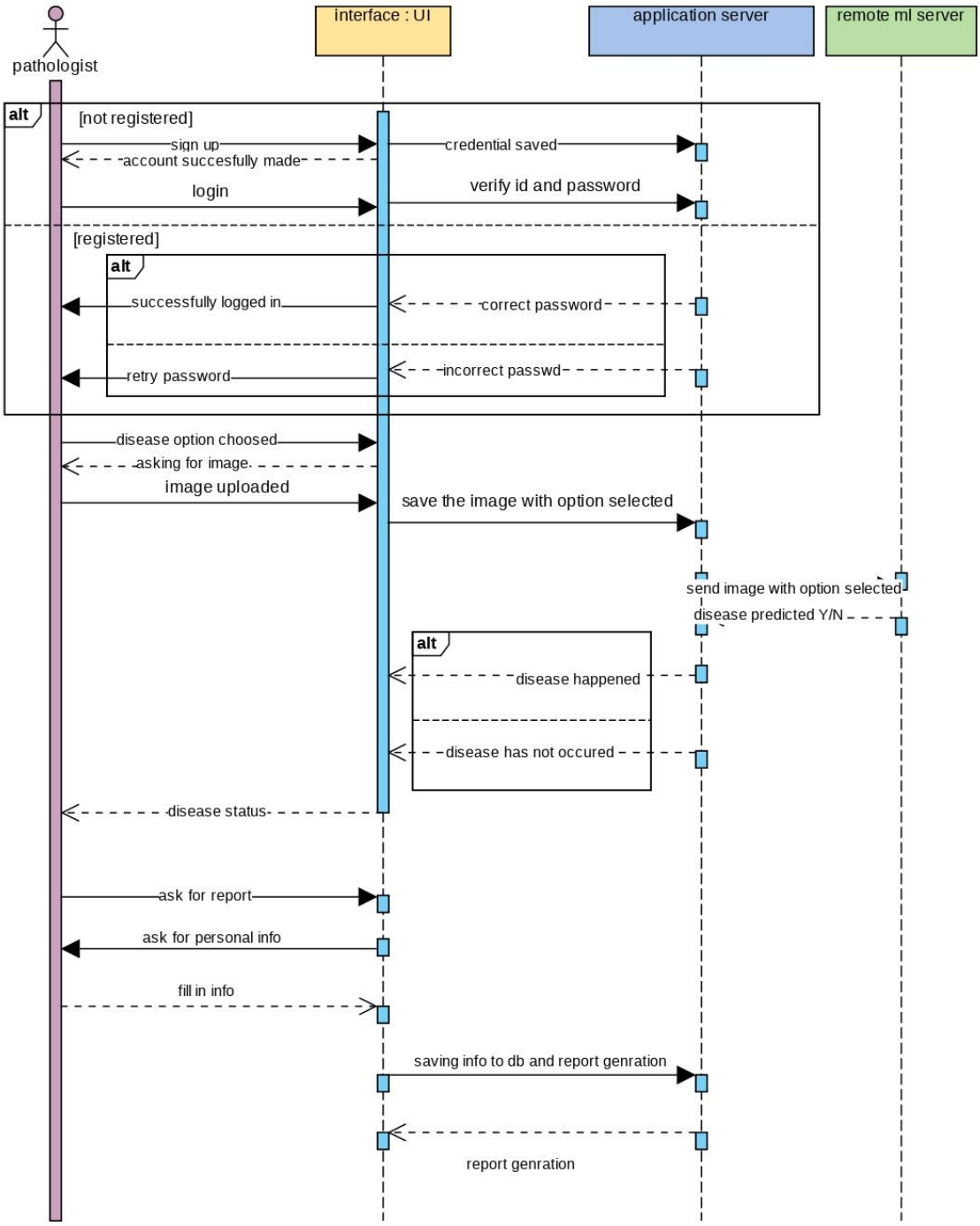

pathologist
interface : UI
application server
remote ml server
alt
[not registered]
sign up
account succesfully made
credential saved
login
verify id and password
[registered]
alt
successfully logged in
correct password
retry password
incorrect passwd
disease option choosed
asking for image.
image uploaded
save the image with option selected
send image with option selected
disease predicted Y/N
alt
disease happened
disease has not occured
disease status
ask for report
ask for personal info
fill in info
saving info to db and report genration
report genration

FIGURE 24 Sequence Diagram for Pathologist

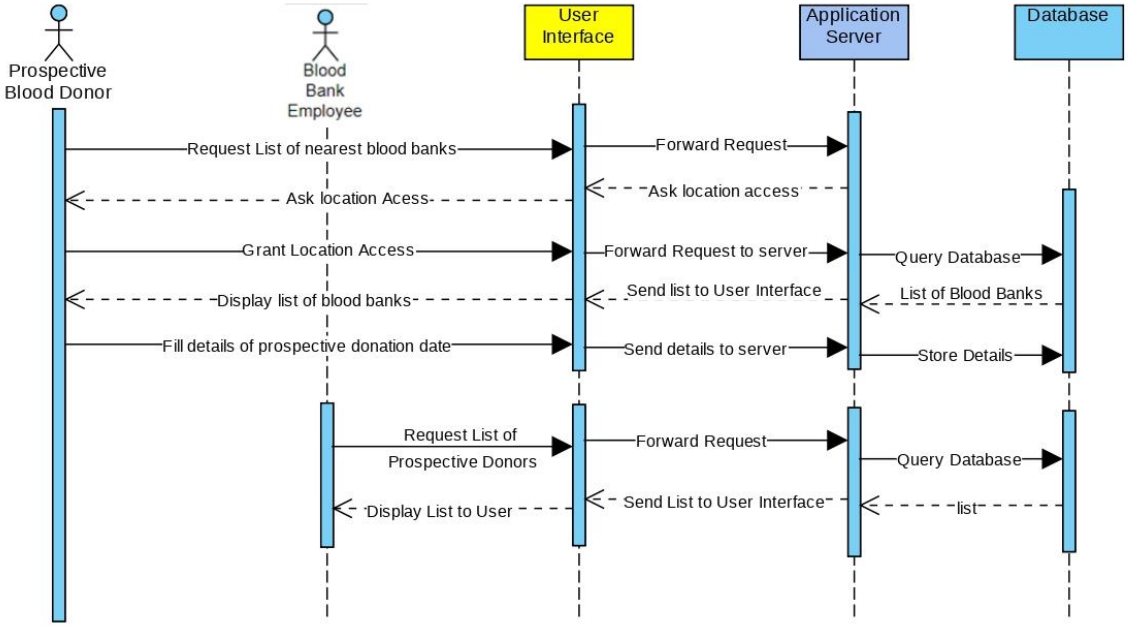


FIGURE 25 Sequence Diagram for Prospective Blood Donation

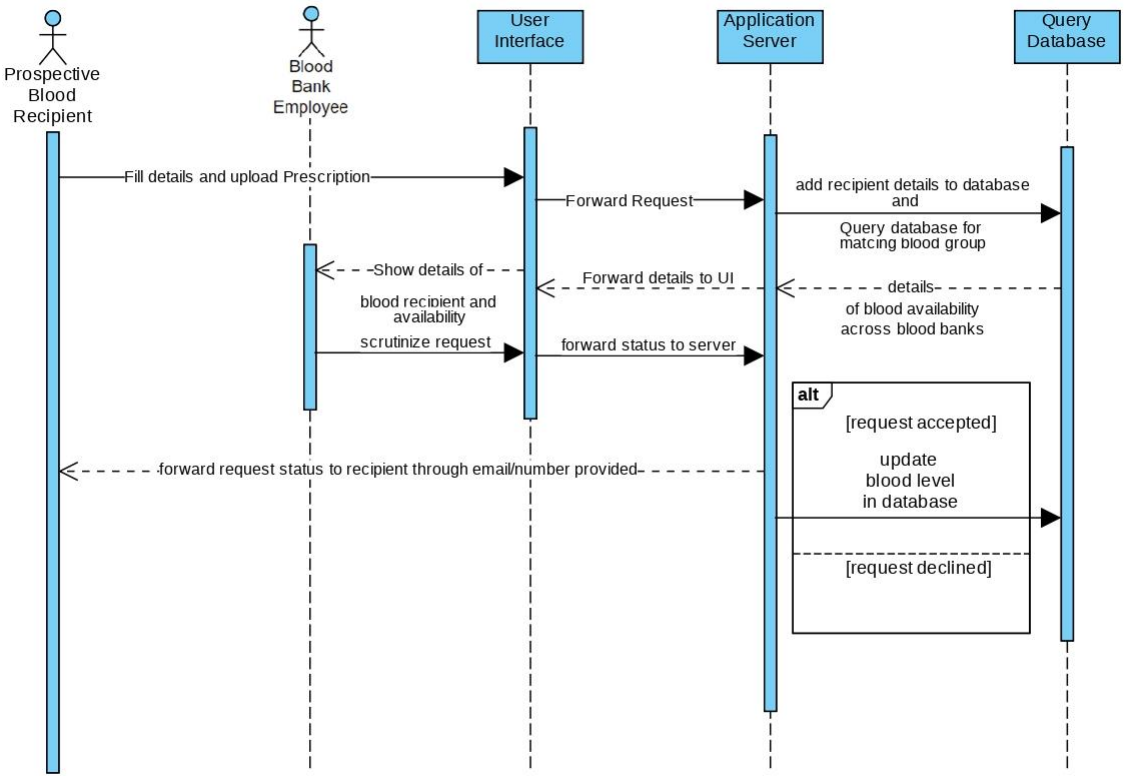


FIGURE 26 Sequence Diagram for Blood Reception

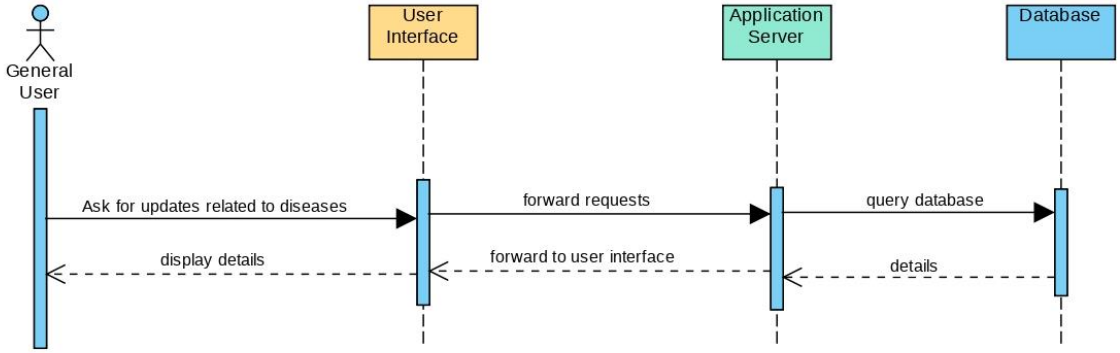


FIGURE 27 Sequence Diagram for Data Visualization

4.2.3. State Chart Diagrams

The state chart diagrams for the project are represented in Figure 28, Figure 29, Figure 30, Figure 31, and Figure 32.

For data visualisation, the user will just need to open the web app and can see real-time data without login/signup as indicated in Figure 28.

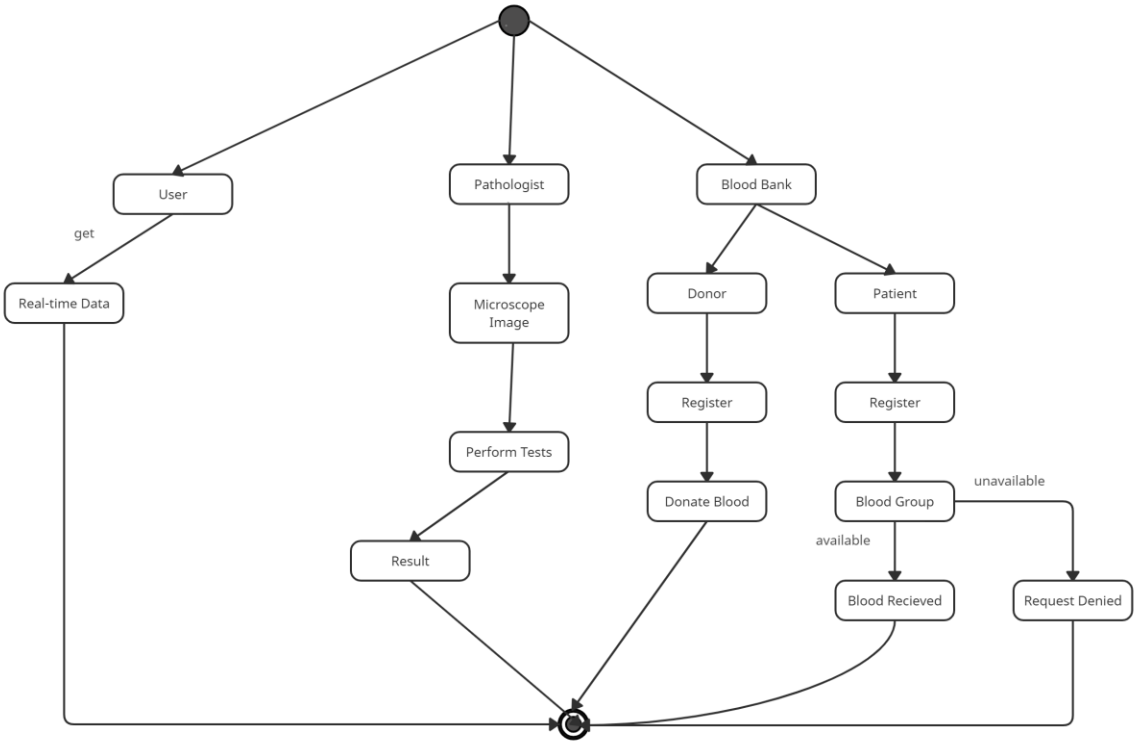


FIGURE 28 State Chart Diagram for Overall Project

For the pathology domain, the pathologist, after successful login, would be able to upload image and get it diagnosed by ML models and generate report. The system would take the uploaded microscopic image and diagnose it for presence of leukemic or malarial infection as per the request of the pathologist as indicated in Figure 29.

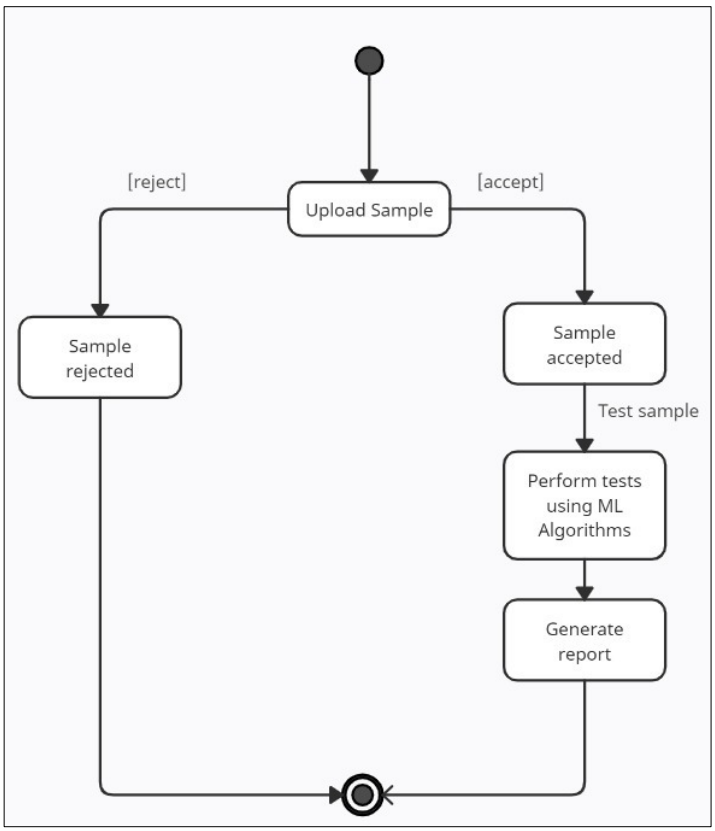


FIGURE 29 State Chart Diagram for Pathologist

As indicated in Figure 30 and Figure 31, for the blood bank domain, the project focusses on providing a system where the user can register for donating bloods online or can request blood online by uploading supporting documents.

For blood donation registration, the system will receive an application from the prospective blood donor. If the application is accepted, the blood bank employee would check the fitness of the prospective blood donor. If the person is fit for donating blood, the blood will be collected and blood levels would be updated in the database.

For receiving blood, the system will receive an application for blood request along with

prescription and clinic blood demand slip. The blood bank will scrutinise the request. If the documents are rejected, then blood request is also rejected. If documents are accepted, the request is approved.

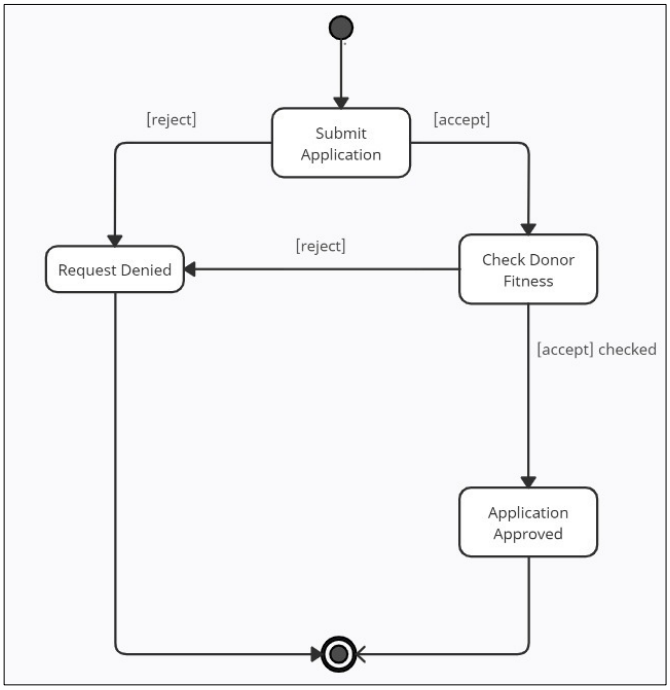


FIGURE 30 State Chart Diagram for Blood Donation

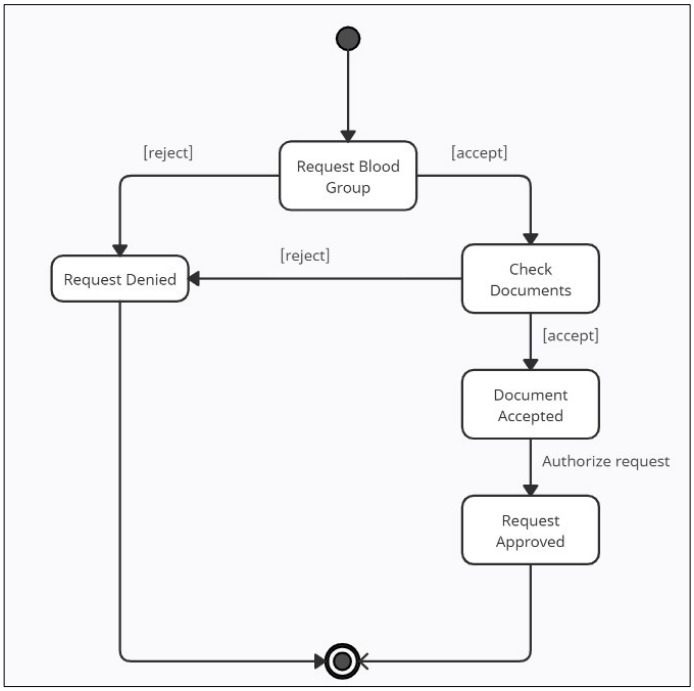


FIGURE 31 State Chart Diagram for Blood Request

For real-time data, if the server accepts the user request for real-time data, the real-time data corresponding to infectious diseases is shown to the user,

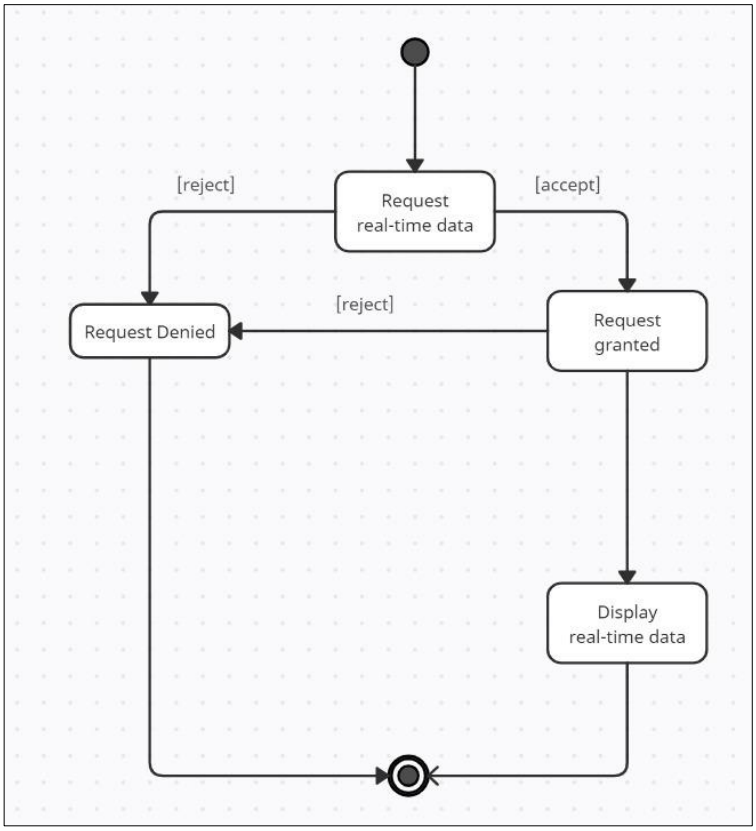


FIGURE 32 State Chart Diagram for Data Visualization

4.2.4. Class Diagram

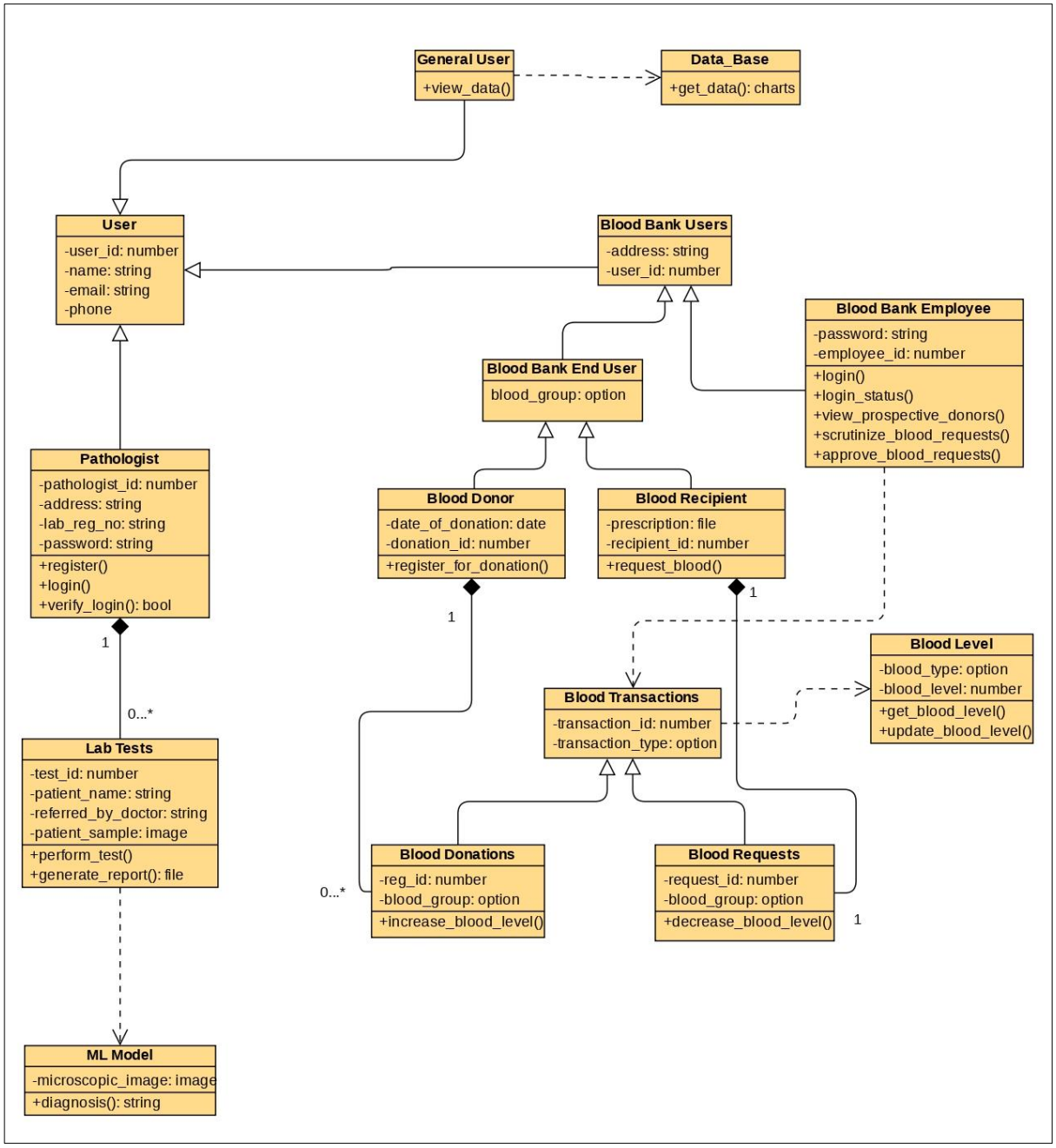


FIGURE 33 Class Diagram

In Figure 33, The class diagram has 5 main classes i.e. pathologist, user, blood donor, blood recipient and blood bank employee. Each classes have unique functions like the pathologists can register and login whereas blood bank employee can view the blood donors and recipients and approve or deny requests. Other classes include blood level, ML model, blood level, blood requests, blood donations and lab tests.

4.2.5. ER Diagrams

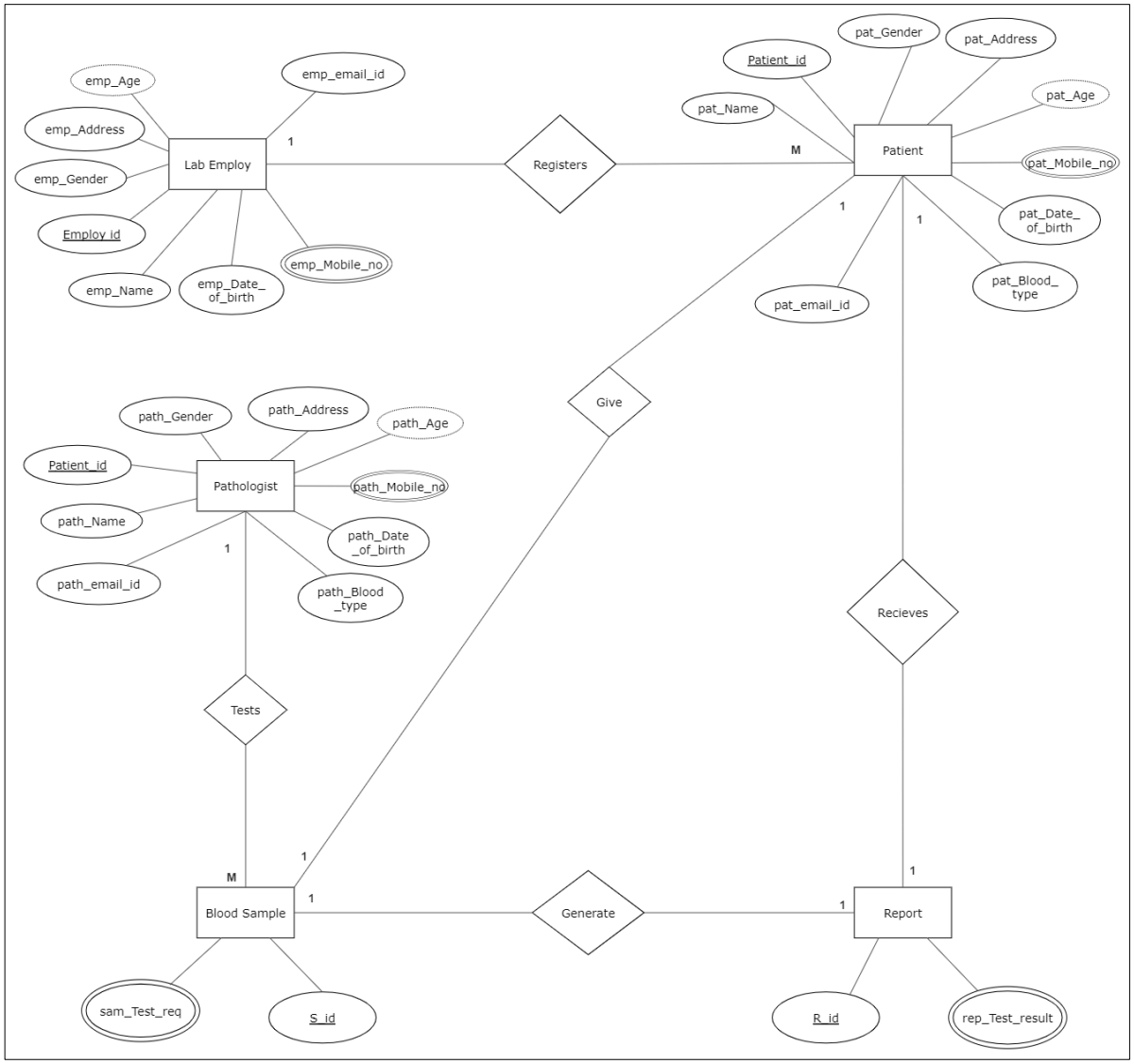


FIGURE 34 ER Diagram 1

In Figure 34, pathologist logins to access the disease prediction system. He then inputs the patient data and uploads microscopic image for testing. The disease prediction system generates the report to be viewed by the pathologist.

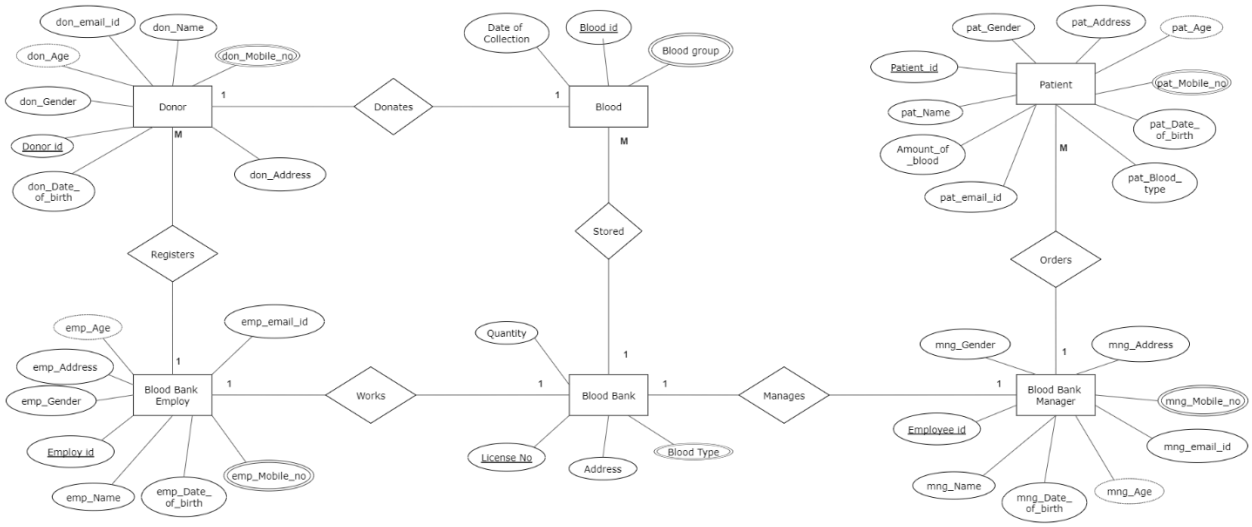


FIGURE 35 ER Diagram 2

In Figure 35, blood bank employee manages the blood bank portal. Blood bank employee logins and manages all incoming requests. The blood donor gets the details of nearest blood banks and registers for blood donation. Blood bank employee acknowledges the request, checks donor details and accepts or denies the request. The blood recipient generates a request for the blood type required and uploads the prescription and other supporting documents. The blood bank employee verifies the documents and then accepts or denies the request.

4.2.6. Data Flow Diagrams

4.2.6.1. Data Flow Diagrams for Pathologist Domain

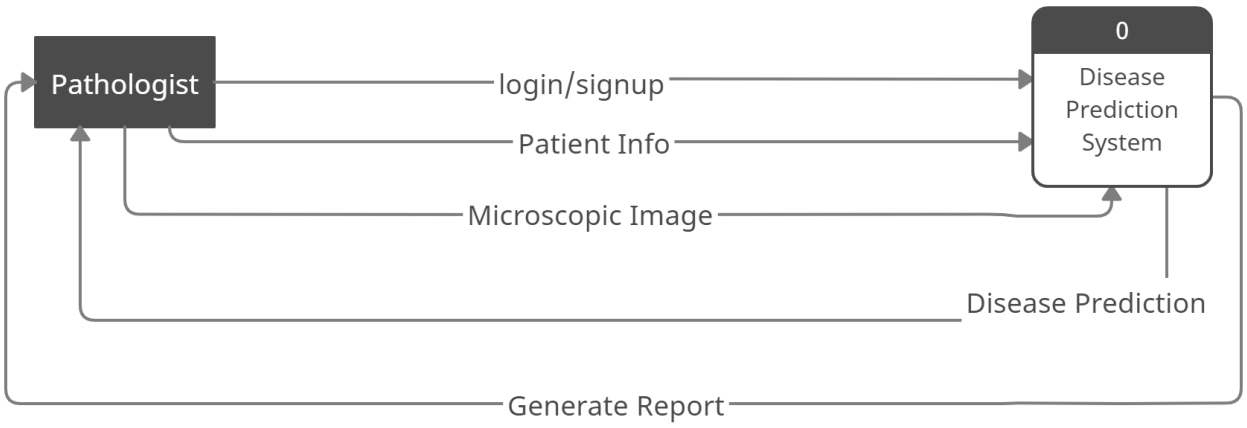


FIGURE 36 Context Level Diagram (DFD Level 0) for Pathologist Domain

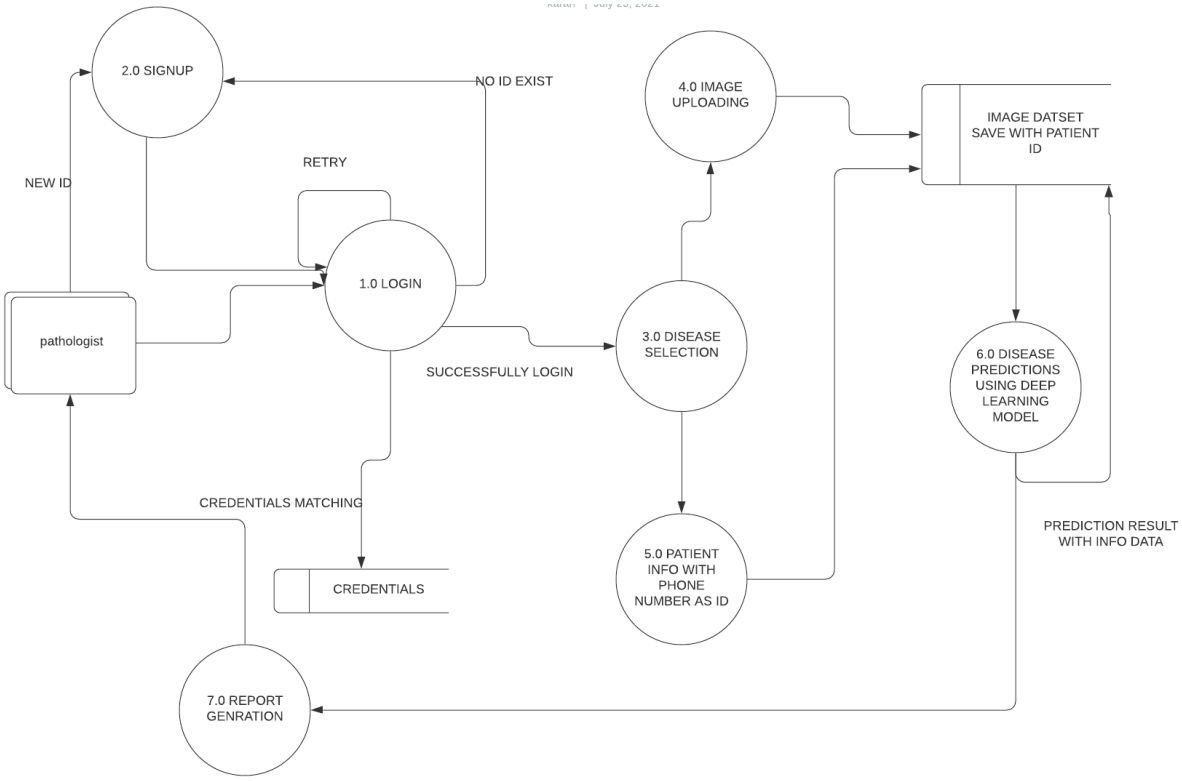


FIGURE 37 DFD Level1 for Pathology Domain

In Figure 36, pathologist logins to access the disease prediction system. He then inputs the patient data and uploads microscopic image for testing. The disease prediction system generates the report to be viewed by the pathologist.

In Figure 37, pathologist registers on the portal if logging in for the first time. After successful login, the pathologist select the disease(s) for which the test must be done (either leukemia or malaria or both).A microscopic image of the blood sample is uploaded and the deep learning model which predicts whether the sample is infected or not. A report is generated to be reviewed by pathologist.

4.2.6.2.**Data Flow Diagrams for Blood Bank Domain**

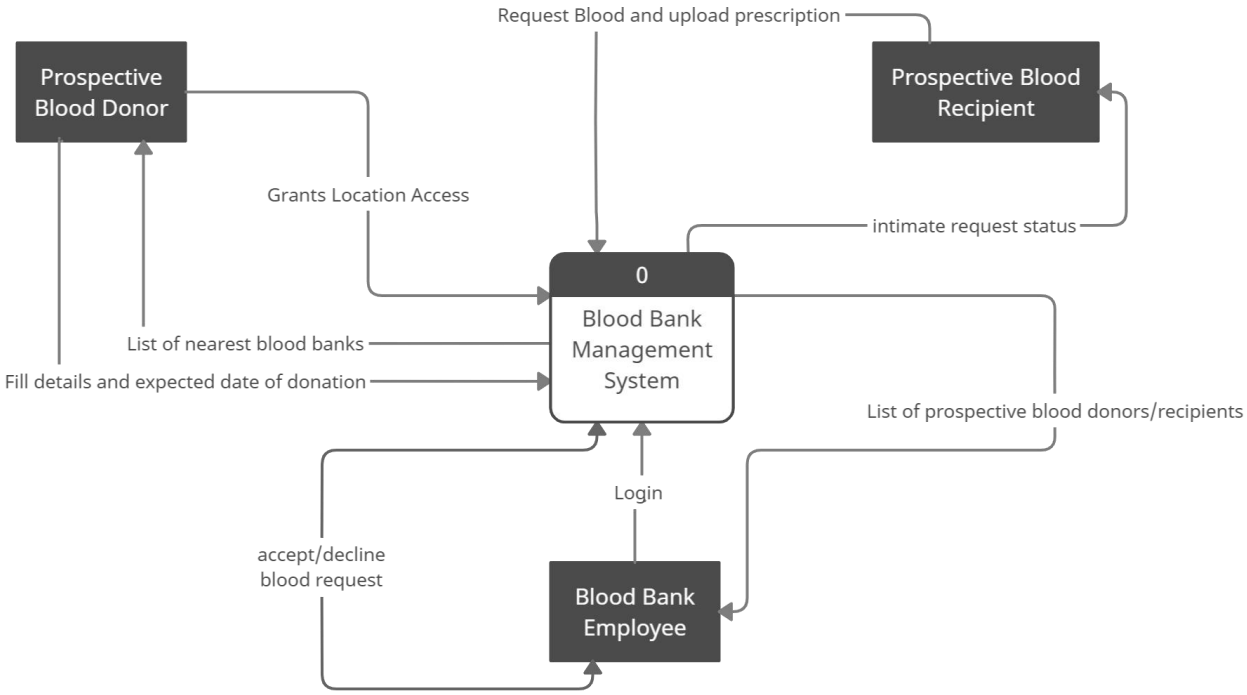


FIGURE 38 Context Level Diagram (DFD Level 0) for Blood Bank Domain

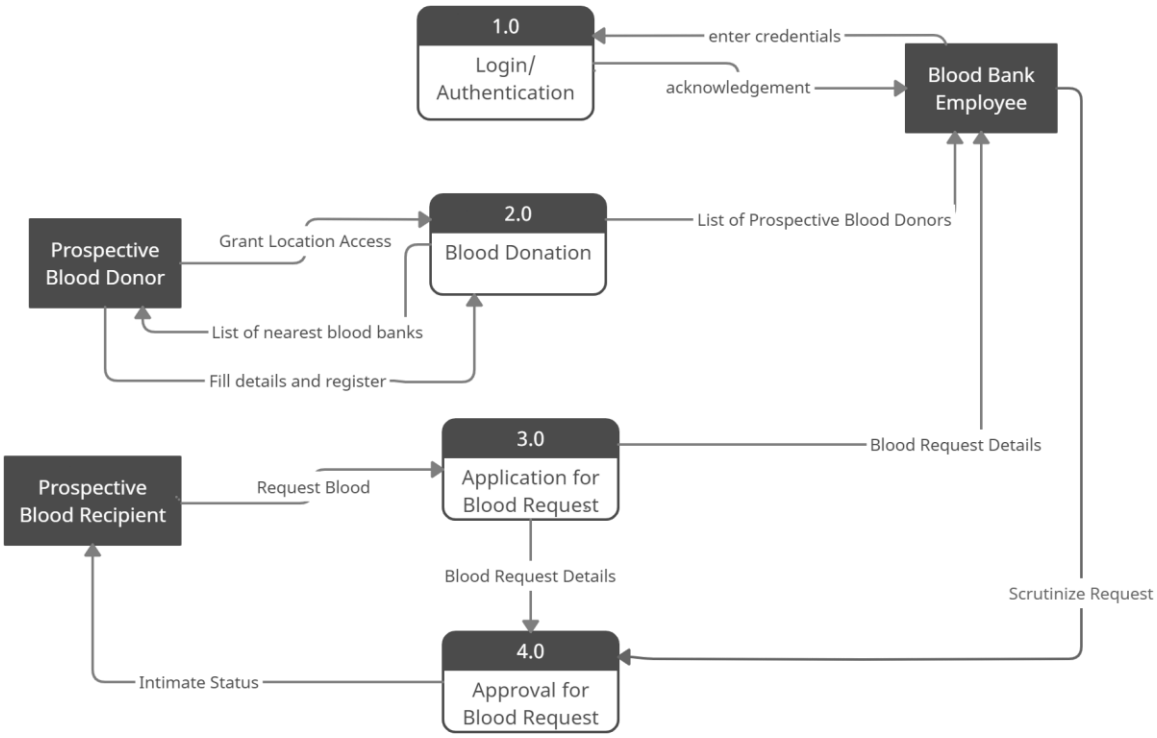


FIGURE 39 DFD Level 1 for Blood Bank Domain

In Figure 38, The blood donor fills the details and expected date of donation. The blood recipient uploads required documents and type of blood required. Blood bank manger logs in the blood bank portal and manages the requests.

In Figure 39, Blood bank employee manages the blood bank portal. Blood bank employee logins and manages all incoming requests. The blood donor gets the details of nearest blood banks and registers for blood donation. Blood bank employee acknowledges the request, checks donor details and accepts or denies the request. The blood recipient generates a request for the blood type required and uploads the prescription and other supporting documents. The blood bank employee verifies the documents and then accepts or denies the request.

4.2.6.3. **Data Flow Diagram for Data Visualization**

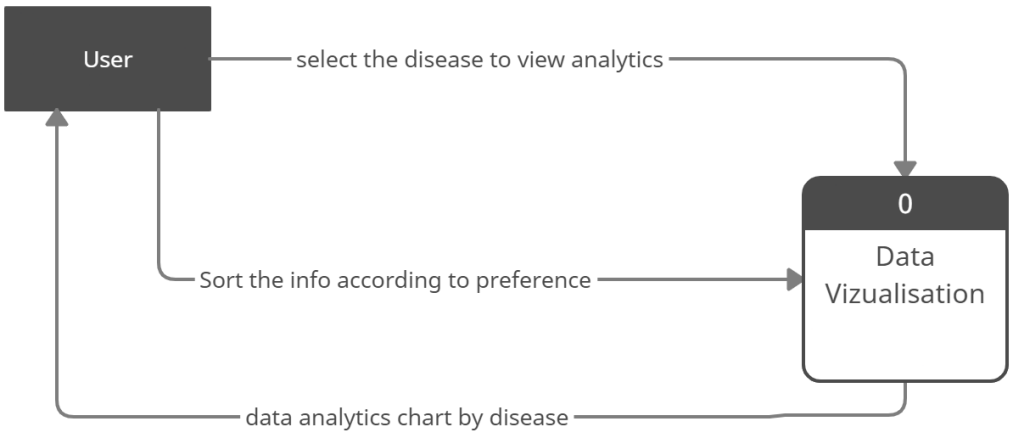


FIGURE 40 Context Level Diagram (DFD Level 0) for Data Visualization

Figure 40, user selects the disease and is then able to view bar or line charts corresponding to that disease.

4.3. User Interface Diagrams

4.3.1. Use Case

4.3.1.1. **Use Case Diagram for Overall Project**

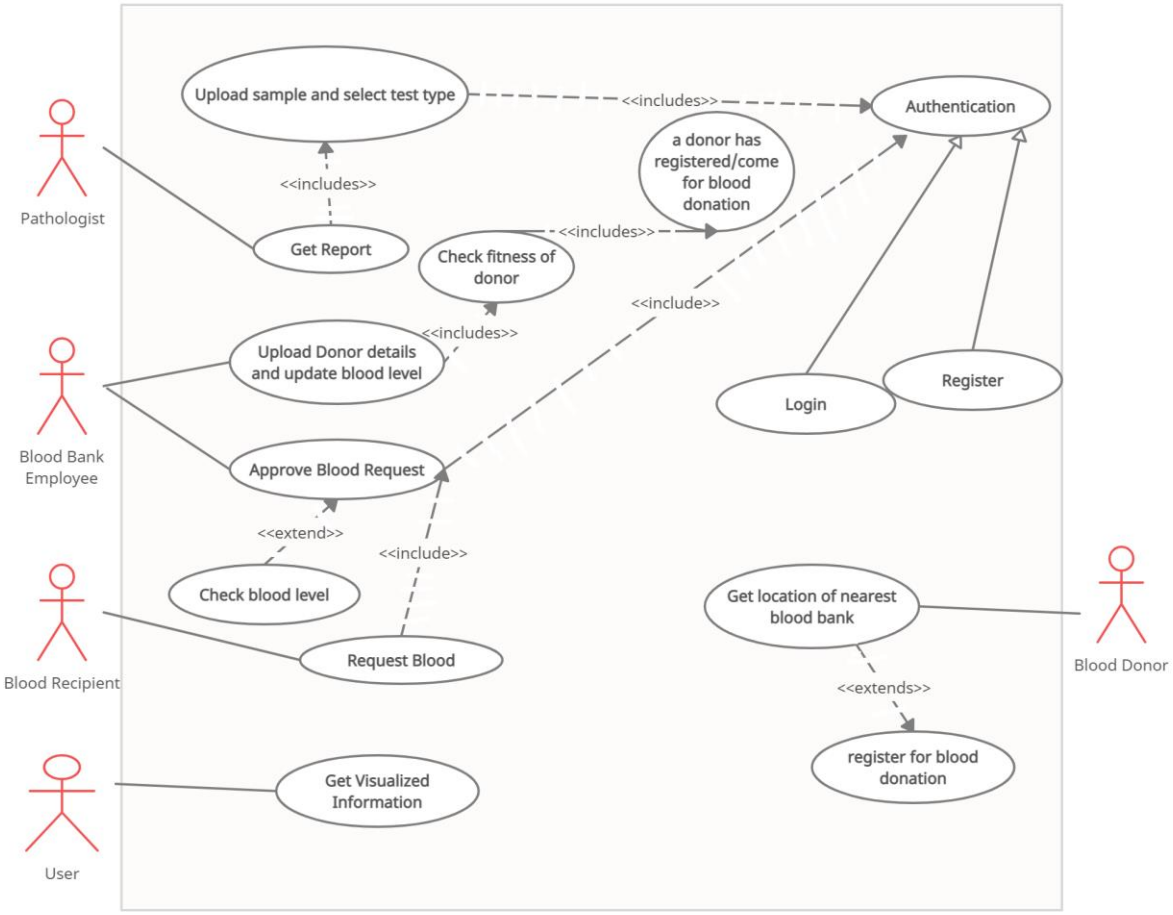


FIGURE 41 Overall Use Case Diagram

4.3.1.2.**Use Case for Pathologist**

4.3.1.2.1. Use Case Diagram

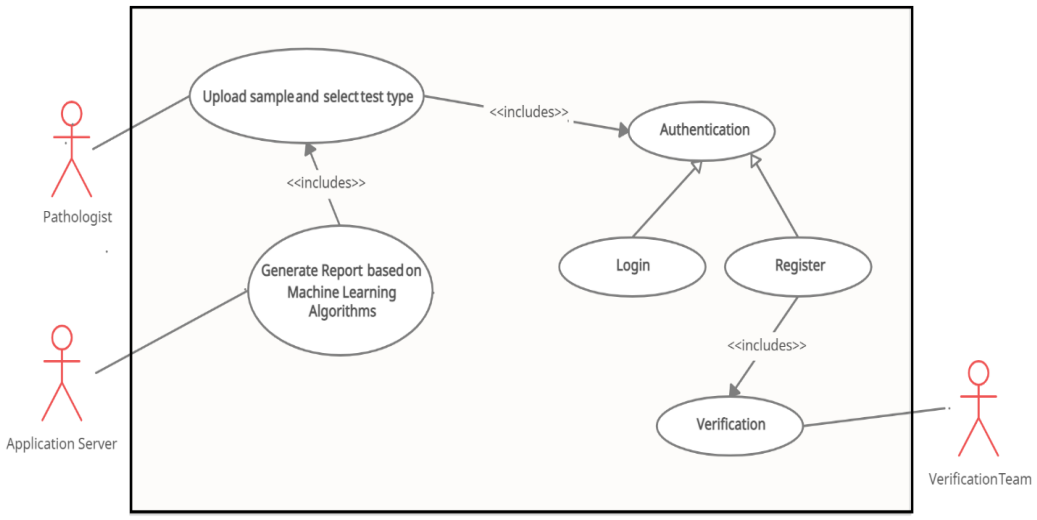


FIGURE 42 Use Case Diagram for Pathologist

4.3.1.2.2. Use Case Template

TABLE 5 Use Case Template for Pathologist

1.	Use Case Title	Upload Sample and Select Test Type
2.	Abbreviated Title	Test
3.	Use Case ID	1
4.	Primary Actors	Pathologist
4.1	Secondary Actors	Verification Team Application Server
5.	Description	The pathologist logs into his/her portal and selects appropriate test among malaria and blood cancer and uploads the microscopic image. The application server thus generates a result based on ML classification algorithms.
5.1	Pre-Conditions	Pathologist must have registered and logged into the portal with

		correct credentials
5.2	Task Sequence	i. Log into the portal with correct credentials ii. Fill patient details, select test type and upload microscopic image iii. On clicking Submit, System generates the result after applying ML Algorithms on the image.
5.3	Post Conditions	Pathologist can choose to print or mail reports.
6	Alternate Flow	While filling details, he may choose to press cancel after change of mind
7.	Exceptional Flow	Pathologist is not logged in or not yet registered.
8.	Last Modified	May 22, 2021

4.3.1.3.**Use Case for Blood Bank Domain**

4.3.1.3.1. Use Case Diagram for Receiving Blood and Approval

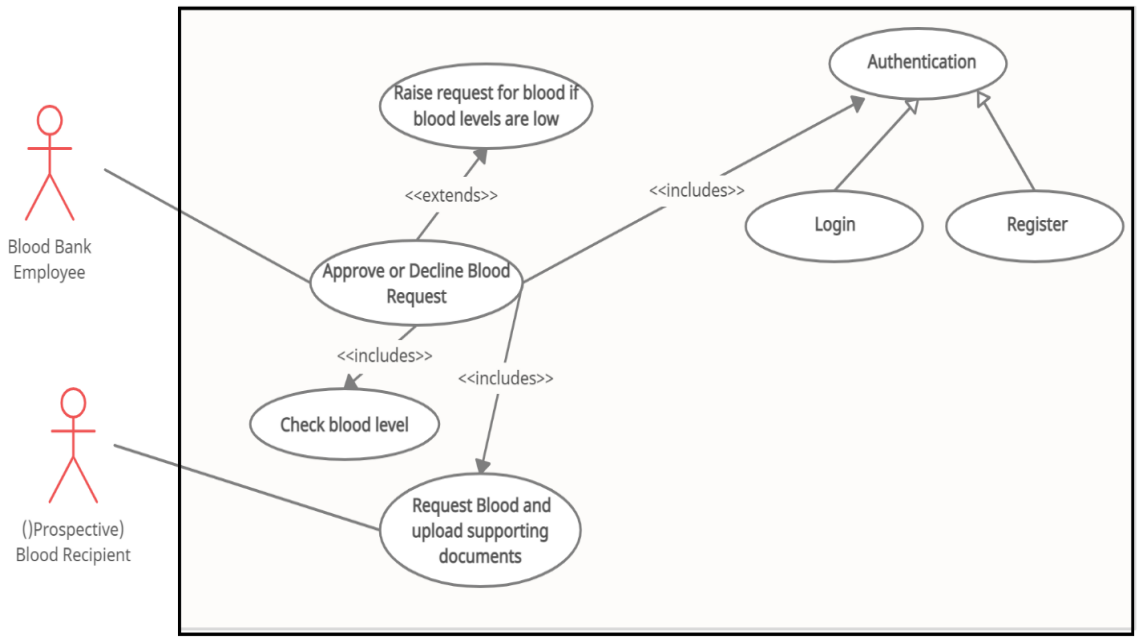


FIGURE 43 Use Case Diagram for Blood Reception

4.3.1.3.2. Use Case Templates for Receiving Blood and Approval

TABLE 6 Use Case Template for blood request

1.	Use Case Title	Request Blood and upload Supporting Documents
2.	Abbreviated Title	Blood Request
3.	Use Case ID	1
4.	Primary Actors	(Prospective) Blood recipient, blood bank employee
5.	Description	The person (or his/her kin) who is in need for blood can register with supporting documents and treating doctor's note
5.1	Pre-Conditions	Must have valid medical documents in soft copy
5.2	Task Sequence	i. (Prospective) Blood Recipient or his/her kin Clicks on link

		for blood reception section ii. Fill details and upload supporting medical documents that state requirement of blood iii. Request is sent to blood bank
5.3	Post Conditions	The blood bank employee approves/declines the blood request
6	Alternate Flow	The requester may not have complete medical documents and hence can't proceed online.
7.	Exceptional Flow	Request is not genuine
8.	Last Modified	May 22, 2021

TABLE 7 Use Case Template for Blood Approval

1.	Use Case Title	Request Blood and upload Supporting Documents
2.	Abbreviated Title	Blood Approval
3.	Use Case ID	2
4.	Primary Actors	Blood Bank Employee
5.	Description	The blood bank employee logins to his/her portal and checks the genuinity of the blood request
5.1	Pre-Conditions	There must be existing blood requests Blood bank employee must be logged into their portal
5.2	Task Sequence	i. The blood bank employee is shown the blood requests. ii. The employee checks the genuinity of requests by scrutinizing the documents. iii. For genuine requests and if blood is available, the employee approves the request and calls the person to collect blood or facilitates delivery.

5.3	Post Conditions	System updates the Blood level in the blood bank
6	Alternate Flow	Non - Genuine requests are declined
7.	Exceptional Flow	Sufficient blood is not available in blood bank
8.	Last Modified	May 22, 2021

4.3.1.3.3. Use Case Diagram for Receiving Blood

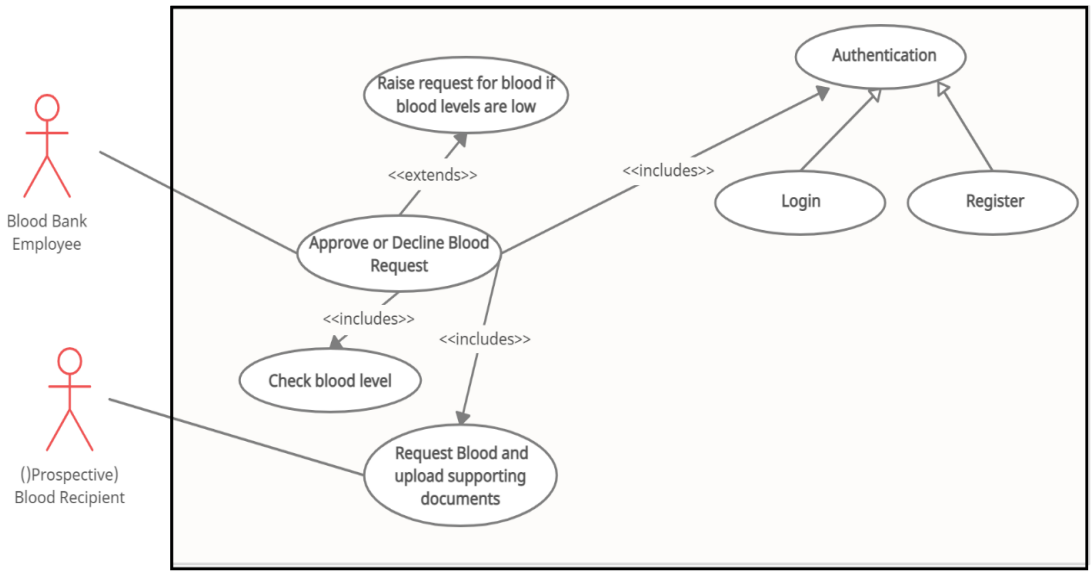


FIGURE 44 Use Case Diagram for Blood Donation

4.3.1.3.4. Use Case Template for Blood Donation

TABLE 8 Use Case Template for Blood Donation

1.	Use Case Title	Upload donor details and update blood level
2.	Abbreviated Title	Blood Donation

3.	Use Case ID	2
4.	Primary Actors	Blood Bank Employee, (Prospective) Blood Donor
5.	Description	The blood bank employee checks the fitness of the prospective blood donor. If the person is fit, then the employee takes the blood and updates in the portal.
5.1	Pre-Conditions	A registered or unregistered (prospective) blood donor has come for blood donation The (prospective) blood donor is fit for blood donation
5.2	Task Sequence	i. A registered or unregistered (prospective) blood donor has come for blood donation ii. The blood bank employee checks the fitness of that person., iii. If the person is fit, then blood is taken. iv. Details are uploaded and updated in the portal
5.3	Post Conditions	The blood bank employee generates a certificate for the blood donor
6.	Exceptional Flow	(Prospective) Blood Donor is not fit for blood donation.
7.	Last Modified	May 22, 2021

4.3.1.4.**Use Case for Data Visualization**

4.3.1.4.1. Use Case Diagram

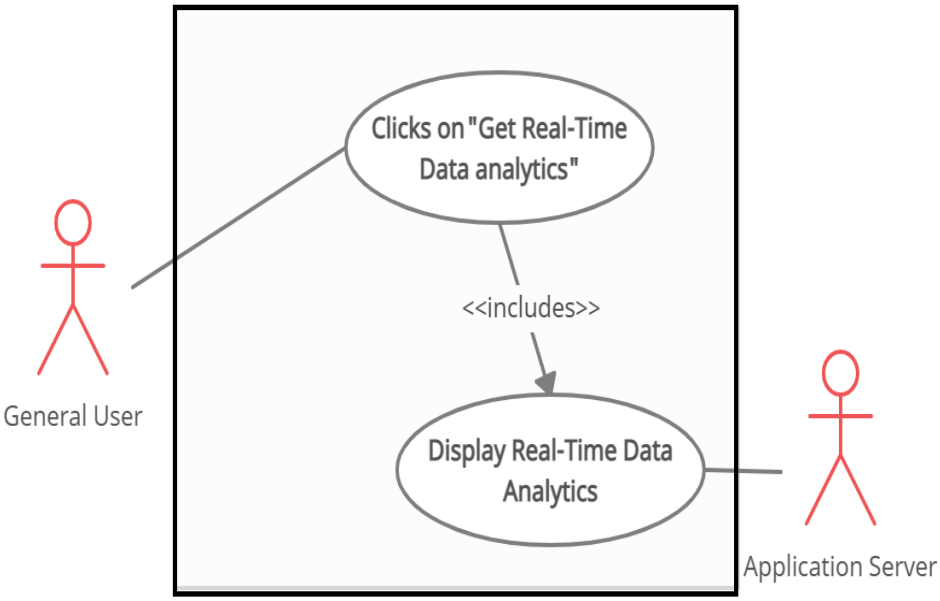


FIGURE 45 Use Case Diagrams for Data Visualization

4.3.1.4.2. Use Case Template

TABLE 9 Use Case Template for Real Time Data Analytics

1.	Use Case Title	Real-Time Analytics
2.	Abbreviated Title	Real-Time Analytics
3.	Use Case ID	1
4.	Primary Actors	General User
4.1	Secondary Actors	Application Server
5.	Description	The user requests for real-time analytics corresponding to various diseases which are provided by the system
5.1	Pre-Conditions	User must have internet access

5.2	Task Sequence	i. User clicks on “Get Real-Time Data Analytics” ii. System Application Server displays real-time data corresponding to various diseases
5.3	Post Conditions	User may exit the application.
8.	Last Modified	May 22, 2021

4.4. Graphic User Interface Design

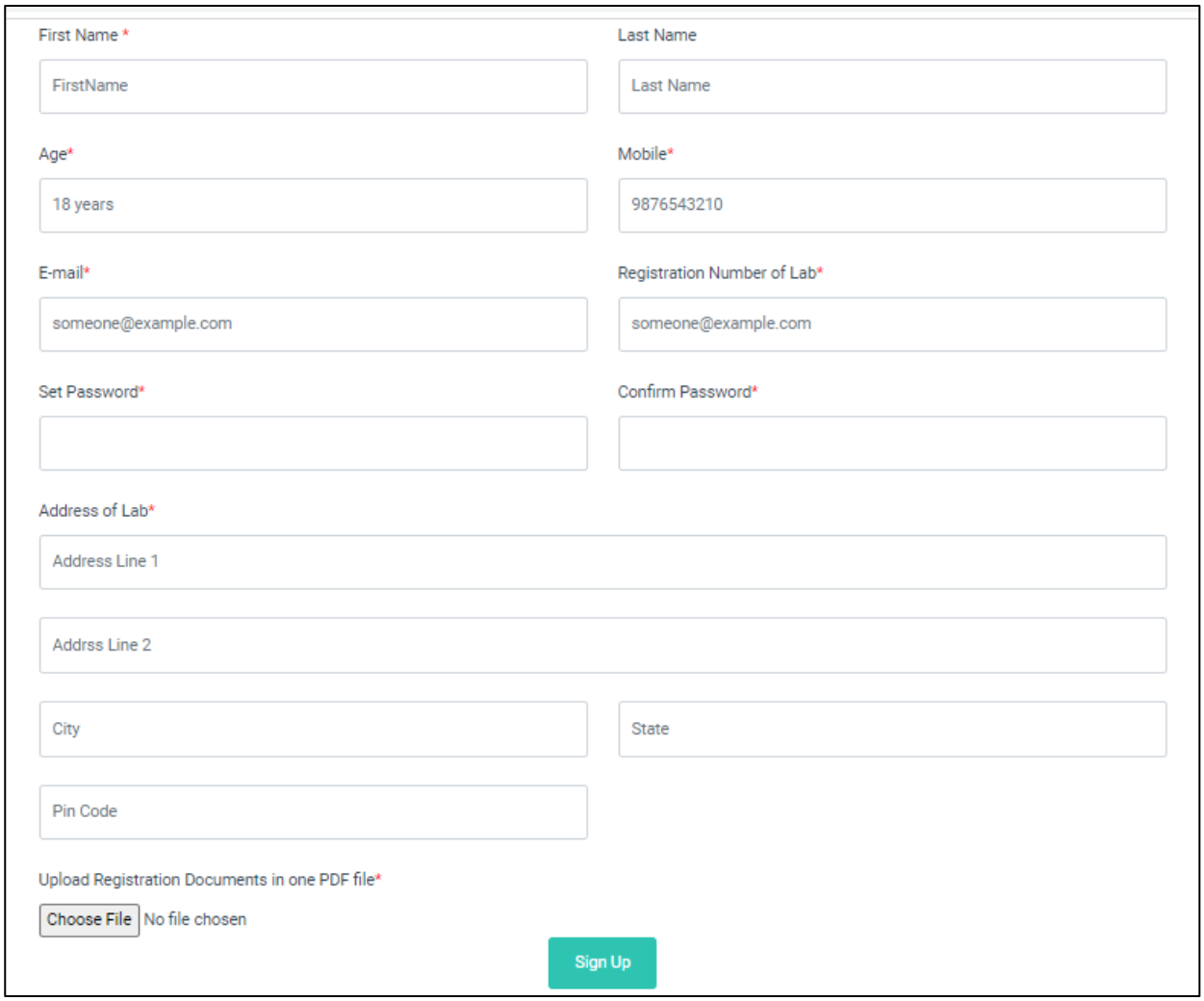


FIGURE 46 Registration for Pathologist

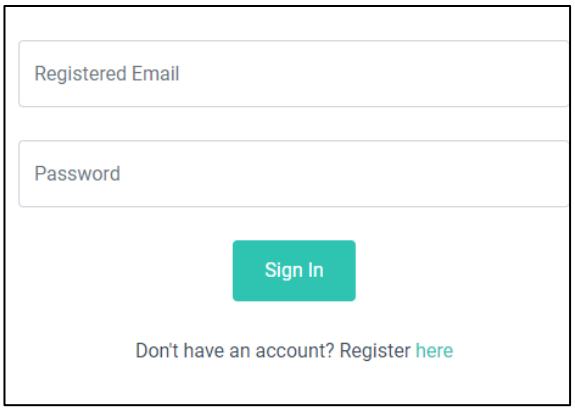


FIGURE 47 Login for Pathologist

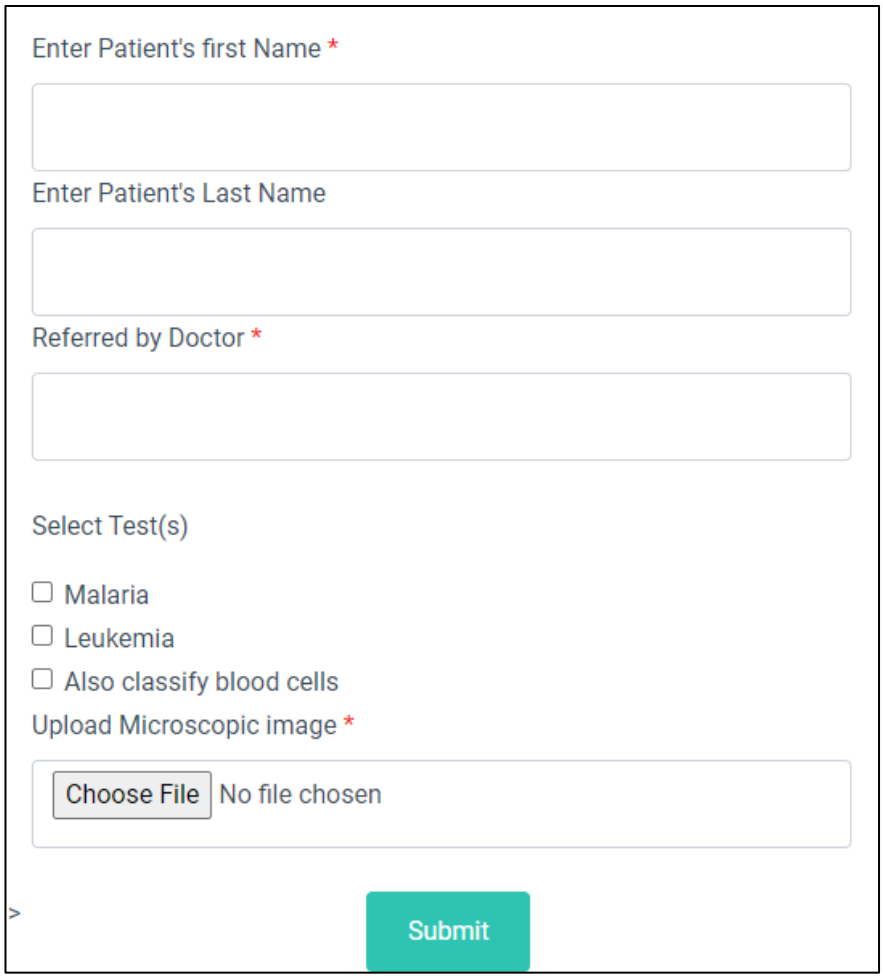


FIGURE 48 ML Based Diagnosis

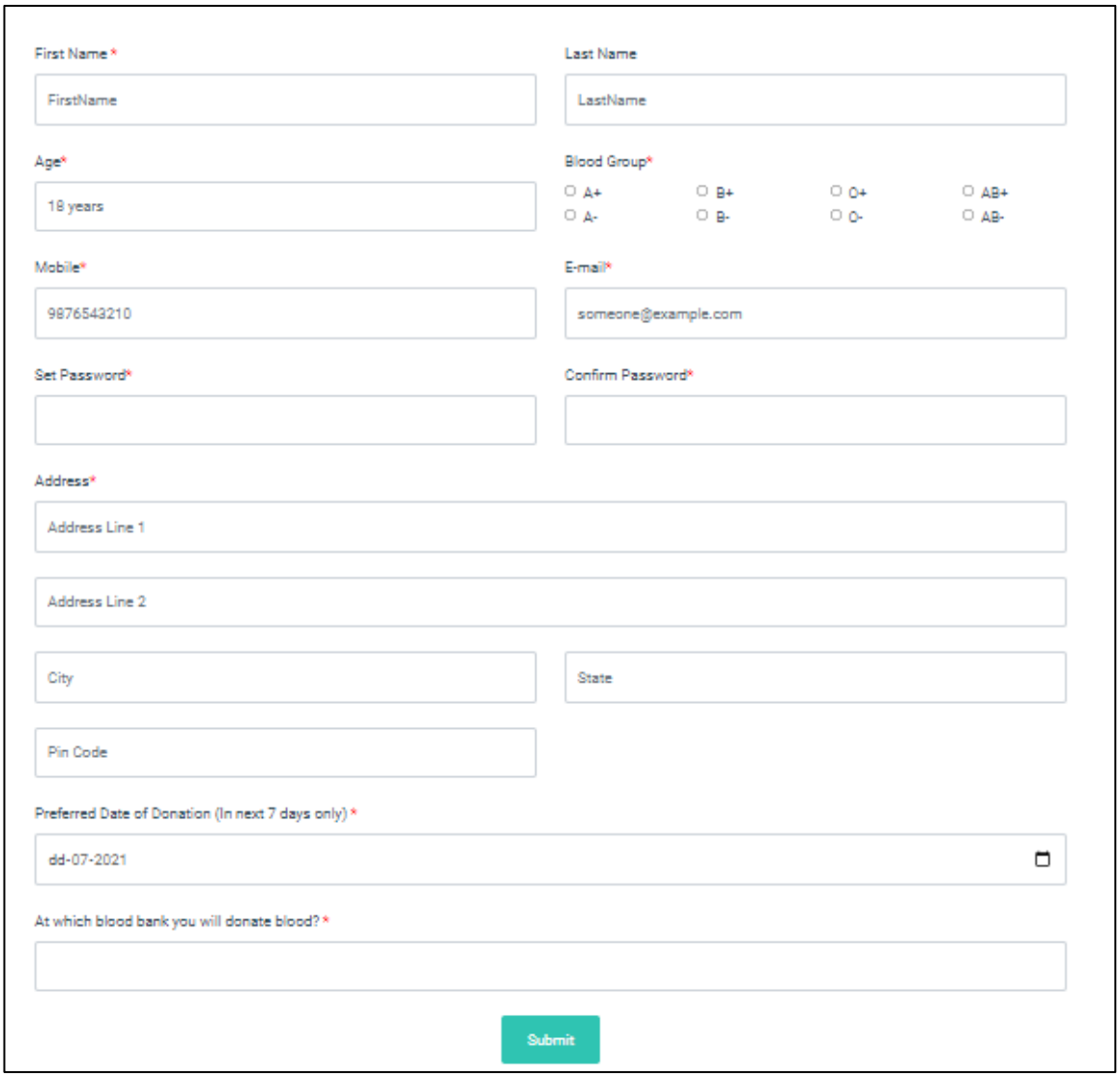


FIGURE 49 Blood Donation Registration

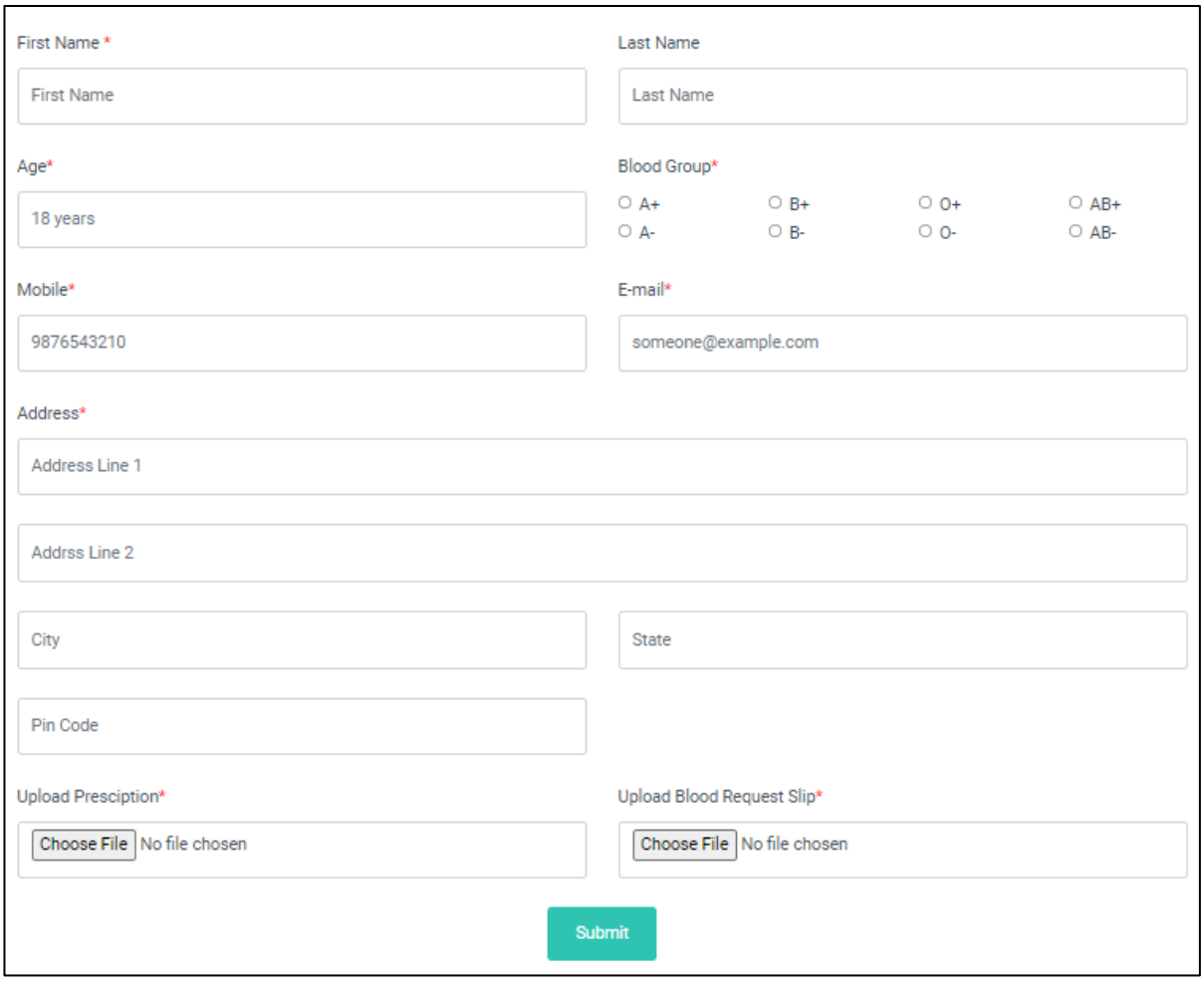


FIGURE 50 Blood Request Form

5. IMPLEMENTATION AND EXPERIMENTAL RESULTS

5.1. Experimental Setup

Our website interface was designed after researching and studying the layouts of professional blogs and websites. The design, through multiple iterations of experiment and modification was created in such a way so as to give users easy access to all the features, while being aesthetically pleasing and efficient. Our web app is divided into three parts: blood bank portal, pathology portal and data visualisation portal. The blood bank portal is used to handle the blood donation and blood receiving requests. Pathology portal contains the framework to deal with detection of diseases (malaria and leukemia) from blood cell images. Data Visualisation visualise the data based on malaria and leukemia.

5.2. Experimental Analysis

5.2.1. Data

5.2.1.1. For Blood Bank Portal

Storage Design

The proposed system has a fully dynamic and functional database. The database service used was MongoDB. The database stores the blood levels, login information of blood donors, blood donation requests, blood receiving requests and login information of blood bank employees. For Blood Donors, following data will be collected:

- First Name
- Last Name

- Age
- Blood Group
- Mobile
- Email
- Password
- Address
- City
- State
- Pin Code

The following data will be collected for placing Blood Reception Requests

- Location of User
- First Name
- Last Name
- Age
- Blood Group
- Mobile
- Correspondence Email

- Blood Request Slip
- Nearest Blood Bank (Detected Automatically)

The following data about blood bank employees is stored in the database:

- Email Address
- Password
- Name

The total units of blood of each blood group are stored in a “bloodlevels” collection.

5.2.1.2.For Data Visualisation Portal

The user data will not be collected for data visualisation portal. A user can open the website and see the data corresponding to HIV, TB, malaria and leukemia.

5.2.1.3.For Pathology Portal

The following data was collected for pathology portal.

For Register/Login of Pathologist

- Pathologist’s Name
- Email Address
- Phone Number
- Registration Number of Lab

- Address of Lab
- Documents related to registration of lab

For Testing of Microscopic Blood Cell Images using ML Model

- Microscopic image of blood cell
- Patient name
- Tests to be performed

5.2.2. Workflow

5.2.2.1. Blood Bank Portal

Placing Blood Donation Requests

1. User enters his/her details and gets registered for the blood donor's portal.
2. Validation checks are performed
3. Details are submitted if they are okay.
4. User logs into the blood donor's portal.
5. User is able to view his/her profile and is able to place blood requests at the blood bank in the city the person chose while registering.
6. User is able to view the status of existing blood donation requests made by the user.

Placing Blood Receiving Requests

1. User enters details and uploads blood request slip.
2. Validation checks are performed
3. Request is submitted if all details are okay.

Blood Bank Employee Portal

1. Blood bank employee logs into the portal.
2. Employee is able to see blood donation and receiver requests and approve/deny them.
3. Corresponding blood levels are adjusted based on input.

5.2.2.2. For Data Visualisation

1. User opens the website
2. User can see line or bar charts on data related to malaria, HIV, Tuberculosis.

5.2.2.3. For Pathology Portal

1. Pathologist registers himself/herself on the portal if not registered.
2. If the pathologist is registered, then he/she logs into the portal.
3. The pathologist then gets access to the test site.
4. The pathologist enters the patient details.
5. The pathologist uploads the microscopic image and select the tests to be performed.
6. The pathologist then gets the report.

5.2.3. Performance Parameters

- Accuracy: - It is most common performance metric for ml models. It may be defined as the number of correct diseases predicted relative to total samples
- Precision: - It is the number of correct predictions made by our model
- Recall: - It is the total amount of positive predictions given by our ml model
- Latency: - Latency is the amount of time taken by the website in between the user actions
- Throughput: - It is the number of requests being made to the website per second. It tells us how much pressure the website is able to tolerate

5.3. Working of the Project

5.3.1. Algorithmic Approaches Used

For ML Model

Detection of malaria: The model used for detection of malaria is a **Deep CNN** that contains a sequence of 3 convolution blocks containing combination of 2-dimensional convolutions and max-pooling. The output of final convolutional block is flattened and followed by two dense layer-6 with 2 layers containing dropout layer. The final dense layer is added with 1 unit and sigmoid activation for binary classification

Blood cells classification: The model for classification of blood cells contains a sequence of five convolutional blocks containing combination of separable 2D convolutions, batch normalization, max-pooling and dropout layer. The output of the final convolution block is flattened and followed by three fully connected (FC) layers each with its own dropout layer. A final fully connected layer is added with 4 units and a Soft-max activation function for multiclass

classification

For Blood Bank Portal

Detection of Nearest Blood Banks: Google Places API was used to detect the nearest blood bank. The latitude and longitude of the user were detected with the permission of the user and passed to the back-end's app.post() method. The latitudes and longitudes were then passed to the google places API and list of nearest blood banks was retrieved. The results are biased on the user's IP by default.

For Saving the Registration Information: The personal details were collected using forms and passed to back-end's post method which were then stored in the database. The passwords were encrypted using bcrypt library.

For Login: The login information collected from the users was compared with the details present in the database. If the credentials match, then the users were allowed to access their dashboard.

For Data Visualisation:

The data is fetched from external sources using APIs. The data is then passed to chart.js library which creates the chart for that data.

5.3.2. Project Deployment

Figure 51, Figure 52, and Figure 53 correspond to the deployment diagrams for pathology portal, data visualisation portal and blood bank portal respectively. The pathology portal consists of three components within web server node, the components are authentication (login/register), detection of diseases (malaria/leukemia) and viewing test history. The database corresponding authentication is the database that stores login information of pathologists and the database corresponding to tests and history is the database that stores the test information with results.

This database is also used for map visualisation in data visualisation portal.

The blood bank portal consists of three components which are blood donation portal, blood receiver portal and blood bank employee portal. The databases corresponding to the blood donation portal are the appointment details and authentication information of donors. The blood receiver portal corresponds to patient details database and the blood bank employee portal corresponds to authentication of blood bank employees, blood requests and blood levels.

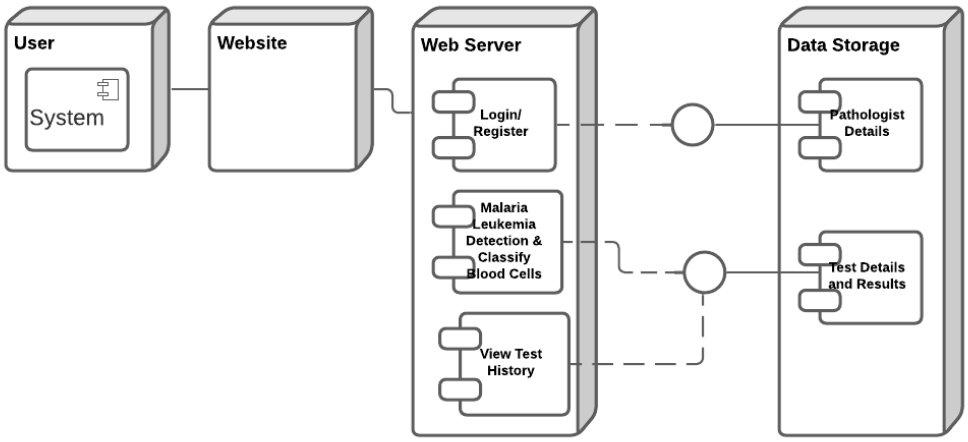


FIGURE 51 Deployment Diagram for Pathology Portal

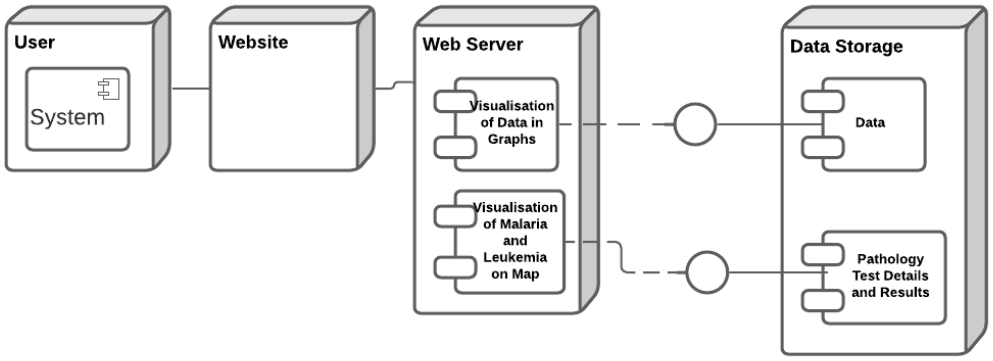


FIGURE 52 Deployment Diagram for Data Visualisation Portal

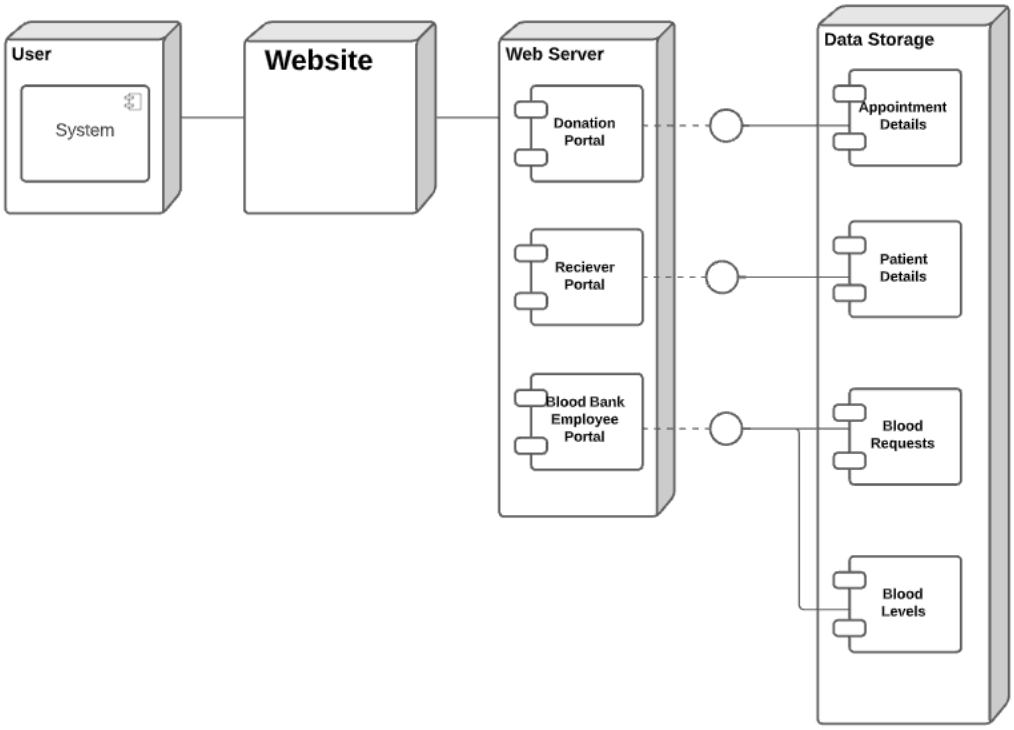


FIGURE 53 Deployment diagram for blood bank portal

5.3.3. System Screenshots

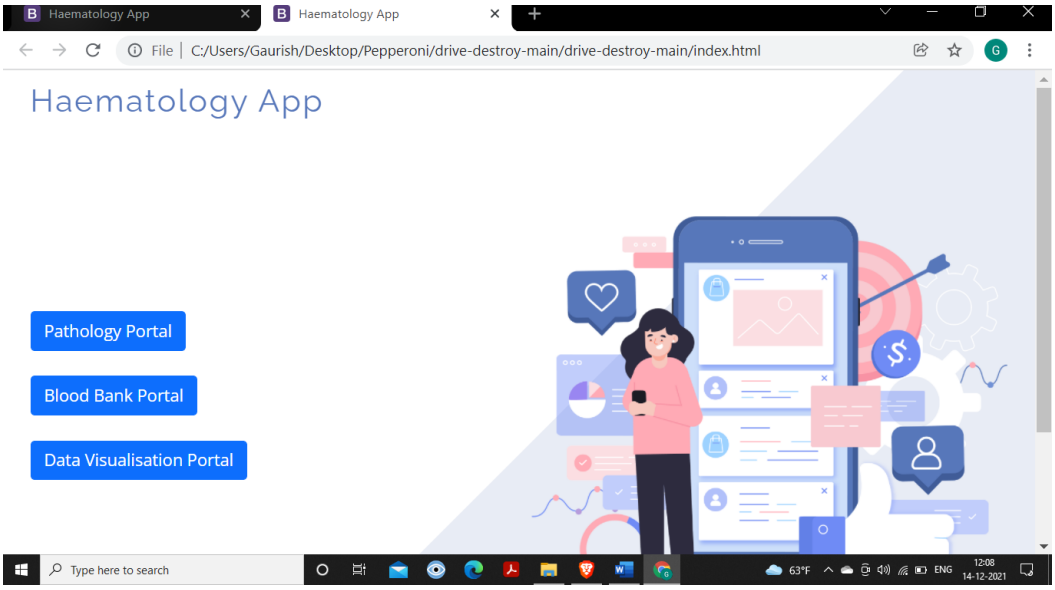
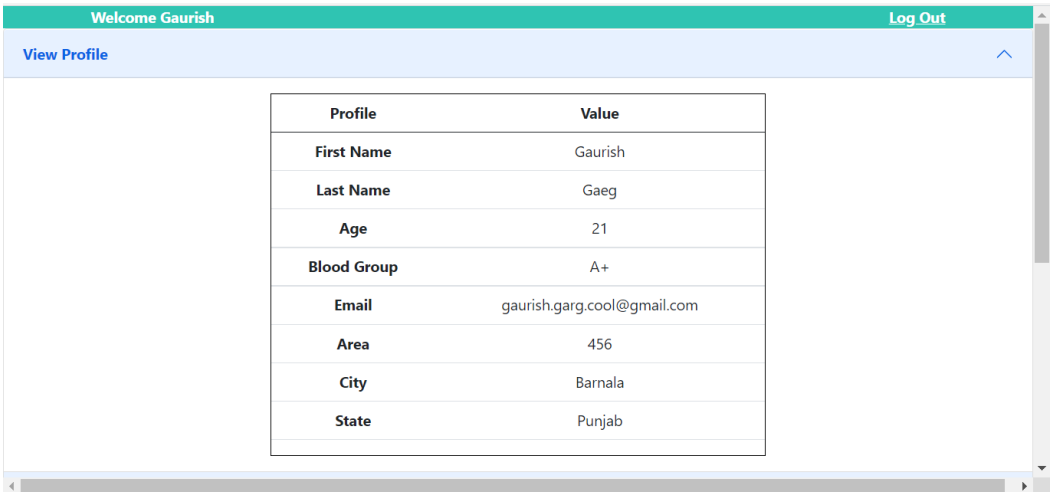


FIGURE 54 Homepage



Profile	Value
First Name	Gaurish
Last Name	Gaeg
Age	21
Blood Group	A+
Email	gaurish.garg.cool@gmail.com
Area	456
City	Barnala
State	Punjab

FIGURE 55 Blood Donor Dashboard

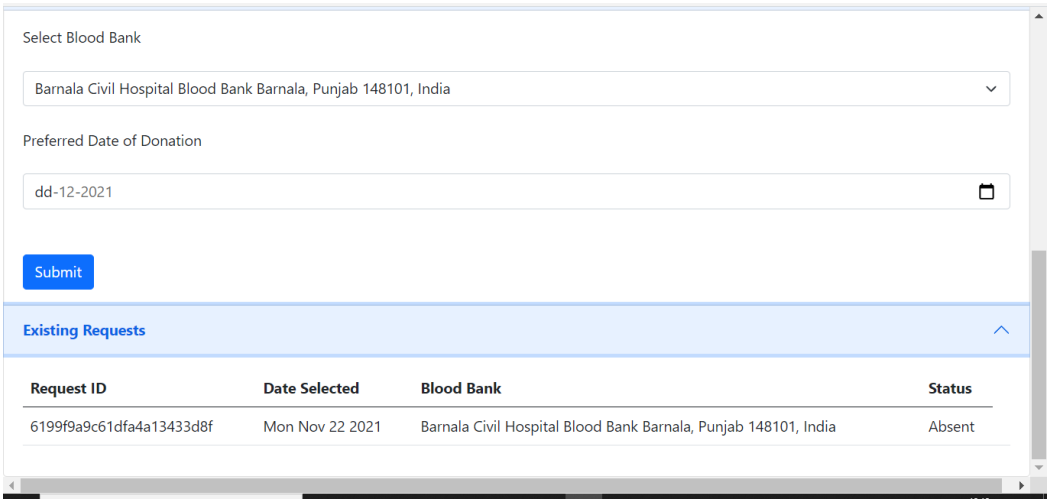


FIGURE 56 Blood Donor Dashboard

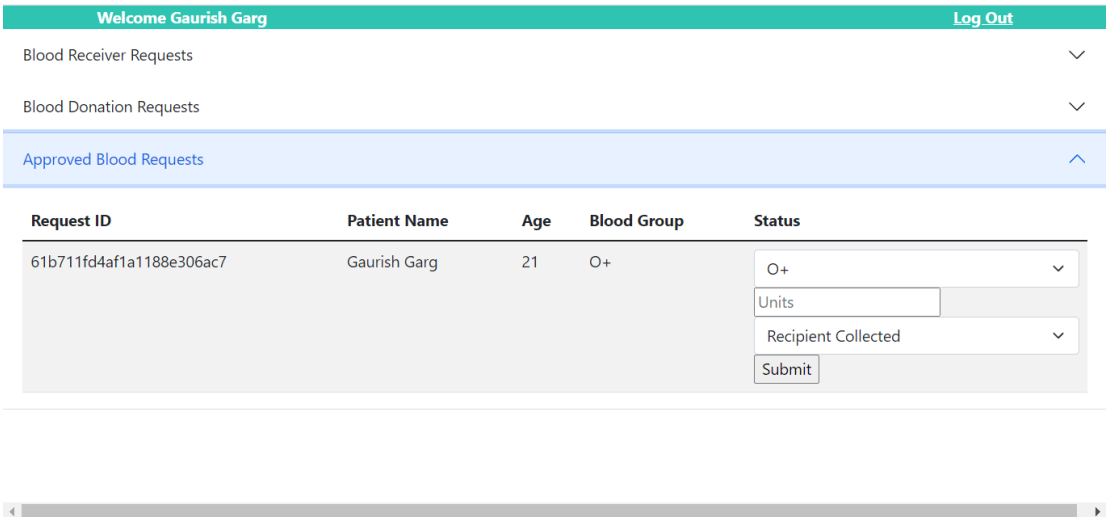


FIGURE 57 Blood Bank Employee dashboard

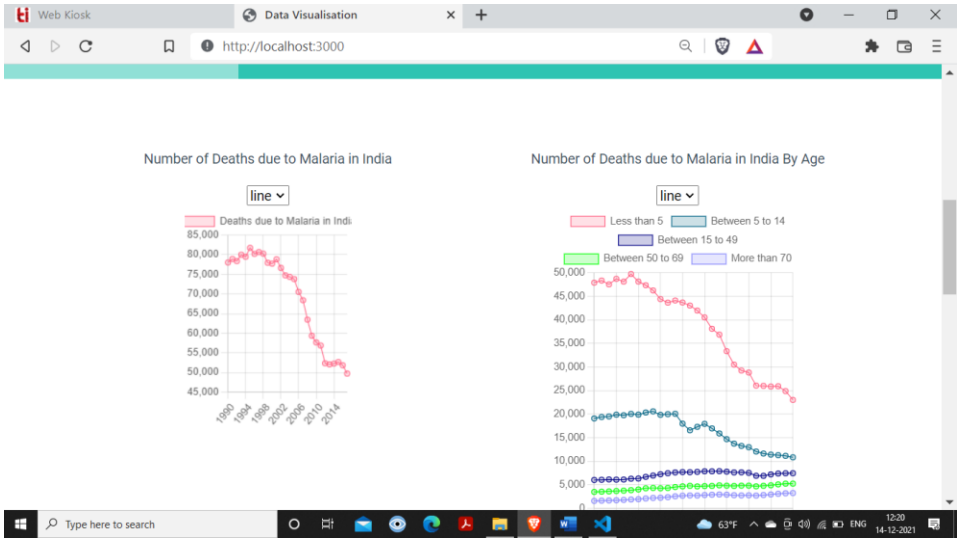


FIGURE 58 Data Visualisation Portal

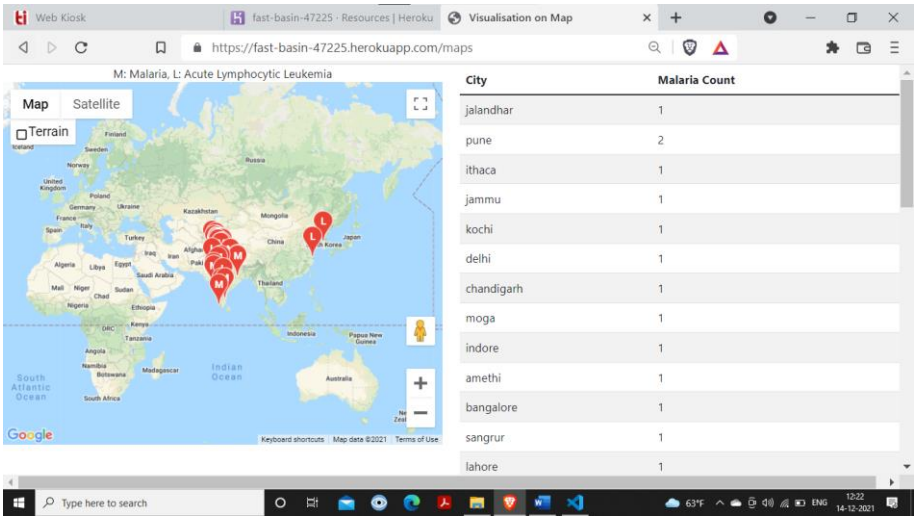


FIGURE 59 Data Visualisation Portal

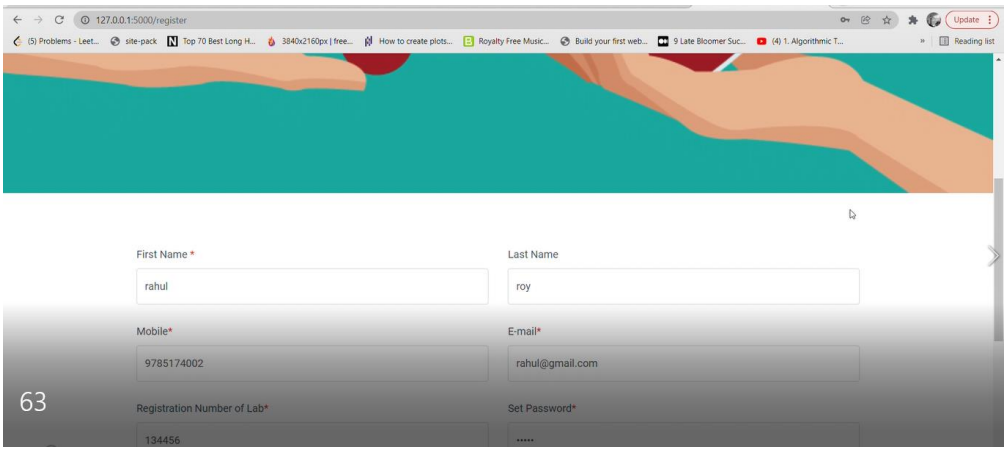


FIGURE 60 Registration Page for Pathology Portal

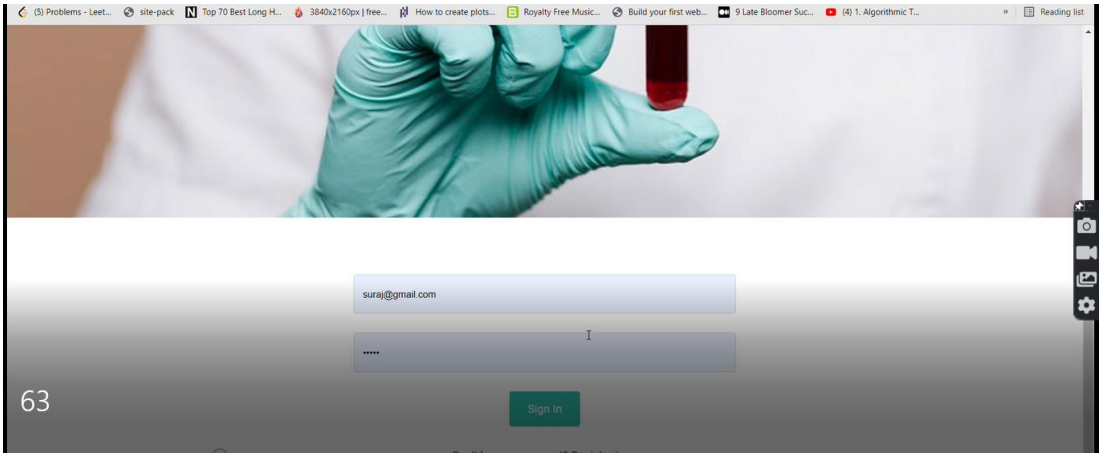


FIGURE 61 Login Page for Pathology Portal

FIGURE 62 Test Result in Pathology Portal

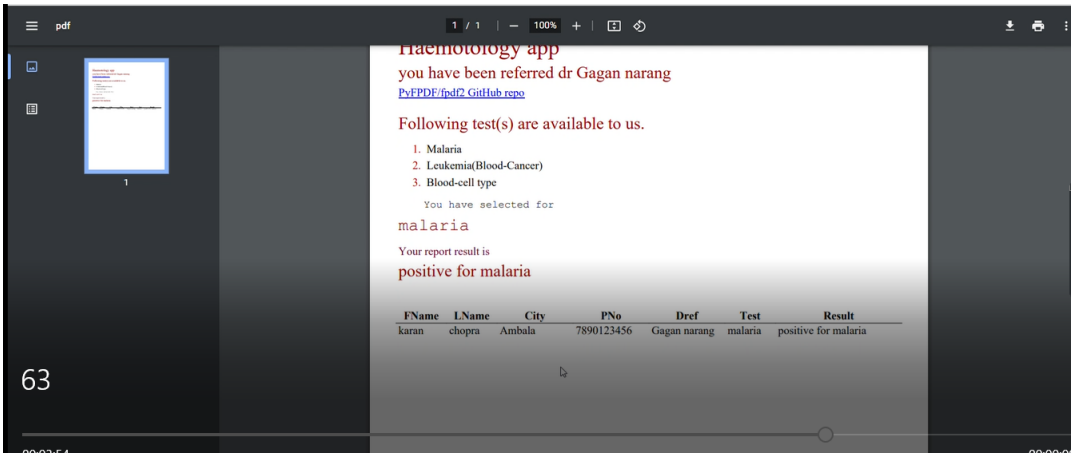


FIGURE 63 PDF Generation in Pathology Portal

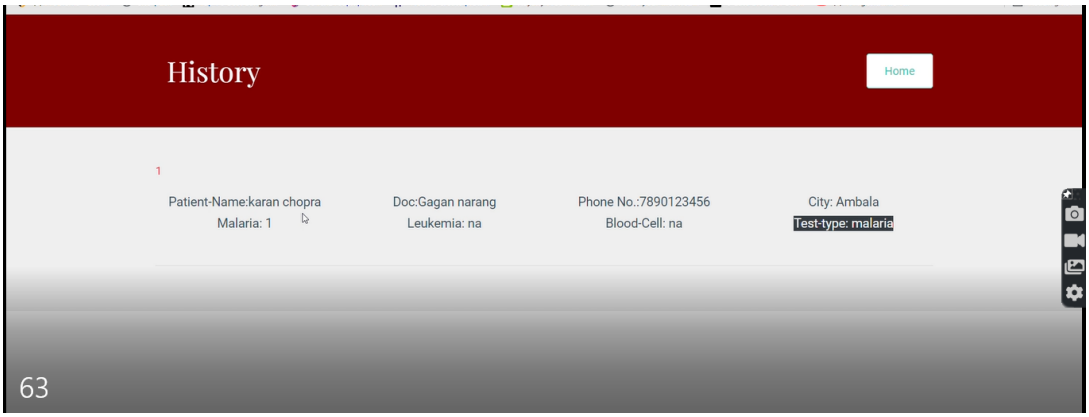


FIGURE 64 Test History in Pathology Portal

5.4. Testing Process

5.4.1. Test Plan

Since our website was built keeping in mind the usability and usefulness, the test plan is to check the ease of access to different features provided and ensure everything works seamlessly.

5.4.2. Features to be Tested

Register/Login

Data validation

Detection of malaria and leukemia

Visualisation of data related to blood diseases graphically

Detection of nearest blood banks

5.4.3. Test Strategy

- Define testing goals
- Plan the test approach
- Plan the individual tests
- Predict the expected results
- Select testing tools
- Test case design
- Test case execution
- Collection of results
- Analysis of Results

5.4.4. Test Techniques

Black Box Testing: Black box testing checks for the functionality of a software or an application without knowing the design, internal components, or structure of an application to be tested.

We performed black box testing by asking our parents and siblings who have no knowledge of our project development process to test the website.

Unit Testing: In unit testing, each component or individual unit of the software shall be tested. The aim of the unit testing is to check internal data structures, logic, boundary conditions for input and output data as per the design.

Integration Testing: In integration testing, individual units are integrated and tested to understand if the integrated components work efficiently. We performed integration testing by

integrating each component one at a time and performing tests.

System Testing: The purpose of system testing is to verify that all the system elements are tested and its overall function and performance comply with the specific requirements. In this approach, the system's hardware and software components are integrated and tested as a whole. We performed system testing by testing the entire system when completed.

Usability testing: The usability testing checks for usability and user-friendliness of the software. This test is performed to determine if the software is seamless to use by any user. We performed usability testing by testing the system using various skilled and unskilled personnel.

5.4.5. Test Cases and Results

For Blood Bank Portal

TABLE 10 Test Case 1

Test Case #	1	**Test Case Name:**	Validation of Password
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Validation of Password and Confirm Password Matching		

Pre-Conditions:
User has a valid email
The user has a stable internet connection
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User enters different passwords in Password and Confirm Password Fields	Display an Error Message that "Passwords Don't Match"	Pass
2	User enters same passwords in Password and Confirm Password Field	Allow Registration if other validation checks are complete	Pass
3	**Check post condition 1**		

Post Conditions:
1. User registered successfully if other validation checks are complete.

TABLE 11 Test Case 2

Test Case #	2	**Test Case Name:**	Validation of Phone number
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021

Short Description	Validation of 10-digit mobile number		

Pre-Conditions: User has a valid Mobile number of 10-digit. The user has a stable internet connection The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User enters moblie number of less than 10 digit	Display an Error Message that "Invalid phone number"	Pass
2	User enters moblie number of more than 10 digit	Display an Error Message that "Invalid phone number"	Pass
3	User enters valid mobile number of 10-digit	Allow Registration if other validation checks are complete	Pass
4	**Check post condition 1**		

Post Conditions: 1. User registered successfully if other validation checks are complete.

TABLE 12 Test Case 3

Test Case #	3	**Test Case Name:**	Validation of email
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal

Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Validation of user email		

Pre-Conditions:
User has a valid email-id.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User enters email of the form :"abc"	Display an Error Message that "Invalid email-format"	Pass
2	User enters email of the form : "abc@def"	Display an Error Message that "Invalid email-format"	Pass
3	User enters email of the form : "abc.def"	Display an Error Message that "Invalid email-format"	Pass
4	User enters valid email address of form: "abc@def.ghi"	Allow Registration if other validation checks are complete	Pass
5	**Check post condition 1**		

Post Conditions:
1. User registered successfully if other validation checks are complete.

TABLE 13 Test Case 4

Test Case #	4	**Test Case Name:**	Validation of pre-registered user
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	User has registered before on the portal		

Pre-Conditions:
User has a valid email-id.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	Email-id or phone of user matches email-id or phone in database already registered	Display an Error Message that "Email or mobile already exists"	Pass

2	Email-id or phone of user does not match email-id or phone in database already registered	Allow Registration if other validation checks are complete	Pass
3	**Check post condition 1**		

Post Conditions:
1. User registered successfully if other validation checks are complete.

TABLE 14 Test Case 5

Test Case #	5	**Test Case Name:**	Authentication of login
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Login authentication of user		

Pre-Conditions:
User has already registered.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**

1	Login-id and password do not match	Display an Error Message that “Invalid email or password”	Pass
2	Login-id and password match	Allow Authentication	Pass
3	Login-id is not present in registered database	Display an Error Message that “Invalid email or password”	Pass
4	**Check post condition 1**		

Post Conditions:
1. User logs in successfully if other validation checks are complete.

TABLE 15 Test Case 6

Test Case #	6	**Test Case Name:**	Detection of nearest blood bank
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Detection of blood bank based on area and city		

Pre-Conditions:

User has already registered. User has logged into portal. The user has a stable internet connection. The software can run on the user's browser

Step	Action	Expected System Response	Pass/fail
1	Nearest blood bank based on user's area and city is displayed	Nearest blood bank is selected	Pass
2	**Check post condition 1**		

Post Conditions:
1. Blood bank nearest the user is selected

TABLE 16 Test Case 7

Test Case #	7	**Test Case Name:**	Submition of donation request
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Donation cannot be made more than once in 84 days		

Pre-Conditions:
User has already logged in. The user has a stable internet connection. The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User is donating for the first time	Request submitted successfully	Pass
2	User is donating before 84 days from last donation	Request denied	Pass
3	User is donating after 84 days from last donation	Request submitted successfully	Pass
4	**Check post condition 1**		

Post Conditions:
1. Request submitted successfully if all conditions are satisfied. 2. Request unsuccessfull if conditions are not satisfied.

TABLE 17 Test Case 8

Test Case #	8	**Test Case Name:**	Submition of donation request within 7 days
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021

Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Donation Request cannot be made twice within 7 days of booking		

Pre-Conditions:
User has already logged in.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User request for the first time	Request submitted successfully	Pass
2	User request within 7 days from booking	Request denied	Pass
3	User request after 7 days from booking	Request submitted successfully	Pass
4	**Check post condition 1**		

Post Conditions:
1. Request submitted successfully if all conditions are satisfied.
2. Request unsuccessfull if conditions are not satisfied.

TABLE 18 Test Case 9

Test Case #	9	**Test Case Name:**	Status of existing request

System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	See existing requests and their status		

Pre-Conditions:
User has already logged in.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User sees existing requests	Status viewed successfully	Pass
2	**Check post condition 1**		

Post Conditions:
1. Status of existing request is seen.

TABLE 19 Test Case 10

Test Case #	10	**Test Case Name:**	Validation of Phone number
System:	Blood Bank System	**Subsystem:**	Blood Reciever Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021

Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Validation of 10-digit mobile number		

Pre-Conditions: User has a valid Mobile number of 10-digit. The user has a stable internet connection The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User enters moblie number of less than 10 digit	Display an Error Message that "Invalid phone number"	Pass
2	User enters moblie number of more than 10 digit	Display an Error Message that "Invalid phone number"	Pass
3	User enters valid mobile number of 10-digit	Allow Registration if other validation checks are complete	Pass
4	**Check post condition 1**		

Post Conditions: 1. User registered successfully if other validation checks are complete.

TABLE 20 Test Case 11

Test Case #	11	**Test Case Name:**	Validation of email

System:	Blood Bank System	**Subsystem:**	Blood Reciever Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Validation of user email		

Pre-Conditions:
User has a valid email-id.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User enters email of the form :"abc"	Display an Error Message that "Invalid email-format"	Pass
2	User enters email of the form : "abc@def"	Display an Error Message that "Invalid email-format"	Pass
3	User enters email of the form : "abc.def"	Display an Error Message that "Invalid email-format"	Pass
4	User enters valid email address of form: "abc@def.ghi"	Allow Registration if other validation checks are complete	Pass
5	**Check post condition 1**		

Post Conditions:

1. User registered successfully if other validation checks are complete.

TABLE 21 Test Case 12

Test Case #	12	**Test Case Name:**	Detection of nearest blood bank
System:	Blood Bank System	**Subsystem:**	Blood Reciever Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Detection of blood bank based on user location		

Pre-Conditions:
User has given location access.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	Nearest blood bank based on user's area and city is displayed	Nearest blood bank is selected	Pass
2	**Check post condition 1**		

Post Conditions:
1. Blood bank nearest to the user is selected.

TABLE 22 Test Case 13

Test Case #	13	**Test Case Name:**	Validation of upload file
System:	Blood Bank System	**Subsystem:**	Blood Reciever Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Validation of upload file: File size must be less than 2 MB.		

Pre-Conditions:
User has the file on the system.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	File size > 2MB	Displays error: "File size must be less than 2MB"	Pass
2	File size < 2MB	File upload successful	Pass
3	**Check post condition 1**		

Post Conditions:
1. File is uploaded successfully given the required conditions are met.

TABLE 23 Test Case 14

Test Case #	14	**Test Case Name:**	See blood donations and requests
System:	Blood Bank System	**Subsystem:**	Blood Bank Employee Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	See existing blood donations and receiving requests		

Pre-Conditions:
User is a registered blood bank employee.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	See all present day blood donations.	Display present day donations	Pass
2	See all blood receive requests	Display blood receive requests	Pass

3	**Check post condition 1**		

Post Conditions:
1. Blood bank employee is able to view all blood donations and requests

TABLE 24 Test Case 15

Test Case #	15	**Test Case Name:**	Respond to blood requests
System:	Blood Bank System	**Subsystem:**	Blood Bank Employee Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Update status as success or failure of request.		

Pre-Conditions:
User is a registered blood bank employee.
The user has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	Accept the blood request	Display the request as accepted	Pass

2	Deny the blood request	Display the request as rejected	Pass
3	No action taken	Display the request as pending	Pass
4	**Check post condition 1**		

Post Conditions:
1. Blood bank employee is able to view the updated status of all requests

TABLE 25 Test Case 16

Test Case #	16	**Test Case Name:**	Update blood donor status
System:	Blood Bank System	**Subsystem:**	System
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Updates the status of blood donations		

Pre-Conditions:
User has booked an appointment for blood donation.
The system has a stable internet connection.

Step	**Action**	**Expected System Response**	**Pass/fail**

1	Donor does not come for blood donation	Display the status as absent	Pass
2	Donor comes and does blood donation	Display the status as donated	Pass
3	Appointment date is yet to come	Display the status as pending	Pass
4	**Check post condition 1**		

Post Conditions:

1. Blood bank employee is able to view the updated status of all donors

TABLE 26 Test Case 17

Test Case #	17	**Test Case Name:**	Blood reviever request status
System:	Blood Bank System	**Subsystem:**	System
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Mails the status of request to the user as accepted or rejected		

Pre-Conditions:

User has submitted a blood recieive request.

The system has a stable internet connection.

Step	Action	Expected System Response	Pass/fail
1	Request is accepted	Mail the status to user as accepted	Pass
2	Request is denied	Mail the status to user as rejected	Pass
3	Request is pending	No mail to the user	Pass
4	**Check post condition 1**		

Post Conditions:
1. User gets the status of blood request in the mail.

TABLE 27 Test Case 18

Test Case #	18	**Test Case Name:**	Validation of pinode
System:	Blood Bank System	**Subsystem:**	Blood Donor Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Validation of 6-digit pincode		

Pre-Conditions:
User has entered a valid pincode of 6-digit.

The user has a stable internet connection The software can run on the user's browser

Step	Action	Expected System Response	Pass/fail
1	User enters pincode of less than 6 digit	Display an Error Message that "Invalid pincode"	Pass
2	User enters pincode of more than 6 digit	Display an Error Message that "Invalid pincode"	Pass
3	User enters valid pincode of 6-digit	Allow Registration if other validation checks are complete	Pass
4	**Check post condition 1**		

Post Conditions: 1. User registered successfully if other validation checks are complete.

TABLE 28 Test Case 19

Test Case #	19	**Test Case Name:**	Authentication of login
System:	Blood Bank System	**Subsystem:**	Blood Bank Employee Portal
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021

Short Description	Login authentication of user		

Pre-Conditions: User has already registered. The user has a stable internet connection. The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	Login-id and password do not match	Display an Error Message that "Invalid email or password"	Pass
2	Login-id and password match	Allow Authentication	Pass
3	Login-id is not present in registered database	Display an Error Message that "Invalid email or password"	Pass
4	**Check post condition 1**		

Post Conditions: 1. User logs in successfully if other validation checks are complete.

Data Visualisation Portal

TABLE 29 Test Case 20

Test Case #	20	**Test Case Name:**	Data visualization of disease

System:	Data Visualisation Portal	**Subsystem:**	Data visualization
Designed by:	Gaurish	**Design Date:**	November 3, 2021
Executed by:	Mihir	**Execution Date:**	November 22, 2021
Short Description	Select the disease to view data as line or bar charts		

Pre-Conditions:
User has selected the disease to view data.
The system has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User wants to view data in line charts	Display data in line chart	Pass
2	User wants to view data in bar charts	Display data in bar chart	Pass
3	**Check post condition 1**		

Post Conditions:
1. User views the data in desired format

TABLE 30 Test Case 21

Test Case #	21	**Test Case Name:**	Data visualization of disease

System:	Data Visualisation Portal	**Subsystem:**	Data visualization
Designed by:	Gaurish	**Design Date:**	December 10, 2021
Executed by:	Gaurish	**Execution Date:**	December 10, 2021
Short Description	View data corresponding to luekemia and malaria on map chart		

Pre-Conditions:
The system has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	User wants to view data on map charts	Display data on map chart	Pass
2	**Check post condition 1**		

Post Conditions:
1. User views the data in desired format

Pathology Portal

TABLE 31 Test Case 22

Test Case #	22	**Test Case Name:**	Pathologist Authentication

System:	Pathology Portal	**Subsystem:**	Pathologist Authentication
Designed by:	Karanbir	**Design Date:**	December 10, 2021
Executed by:	Gaurish	**Execution Date:**	December 10, 2021
Short Description	Pathologist enters credentials to login		

Pre-Conditions:
The system has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	Pathologist enters invalid credentials	Display Error Message	Pass
2	Pathologist enters valid credentials	Give pathologist access to test site	Pass
3	**Check post condition 1**		
4	Pathologist is not registered on the portal but tries to login	Display Error Message	Pass
5	Pathologist is already registered but tries to register again	Display Error Message	
6	**Check post condition 2**		

Post Conditions:

1. Pathologist logs in successfully with valid credentials
2. Pathologist is registered successfully if all checks are complete

TABLE 32 Test Case 23

Test Case #	23	**Test Case Name:**	Perform Test
System:	Pathology Portal	**Subsystem:**	Perform Test
Designed by:	Karanbir	**Design Date:**	December 10, 2021
Executed by:	Gaurish	**Execution Date:**	December 10, 2021
Short Description	Pathologist performs test from microscopic images		

Pre-Conditions:
The Pathologist must be logged in
The system has a stable internet connection.
The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	Pathologist selects tests to perform and uploads microscopic image	Display Result	Pass
2	**Check post condition 1**		

Post Conditions:
1. Pathologist gets result on performing tests

TABLE 33 Test Case 24

Test Case #	24	**Test Case Name:**	View History
System:	Pathology Portal	**Subsystem:**	View History
Designed by:	Karanbir	**Design Date:**	December 10, 2021
Executed by:	Gaurish	**Execution Date:**	December 10, 2021

Short Description	Pathologist views test history		

Pre-Conditions: The Pathologist must be logged in The system has a stable internet connection. The software can run on the user's browser

Step	**Action**	**Expected System Response**	**Pass/fail**
1	Pathologist clicks on view history	Display the tests performed by the pathologist	Pass
3	**Check post condition 1**		

Post Conditions: 1. Pathologist gets to view the history of tests performed by him/her.

5.5. Result and Discussion

For pathology portal. Following observations were recorded:-

The ML model has an overall accuracy of 94%. It is able to detect positive cases with a precision of 95% and has a recall of 93% for positive cases. For negative cases, the ML model gives a recall of 95% and a precision of 93%.

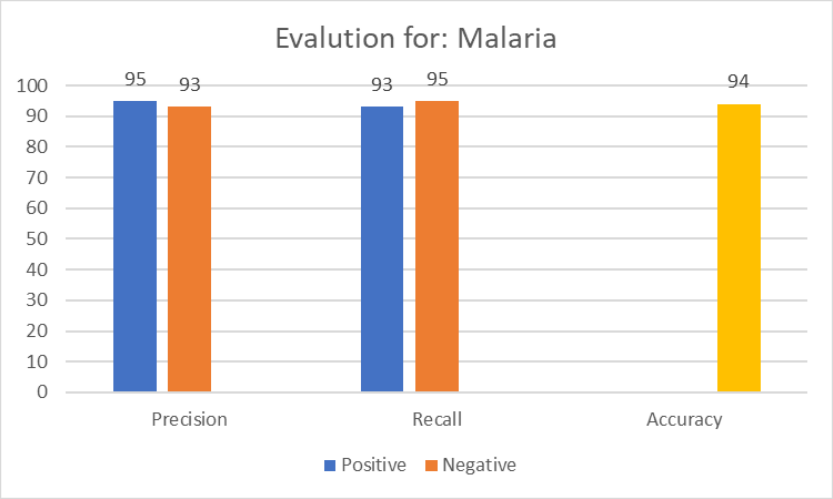


FIGURE 65 Evaluation Metric for malaria

The blood classification model has an overall accuracy of 97% with precision of each blood type is greater than 95% and goes up to 100% in case of lymphocyte. In case of recall, eosinophil has a recall of 94% whereas lymphocyte has a recall of 100% followed by monocyte and neutrophil with recall of 99% and 96%, respectively.

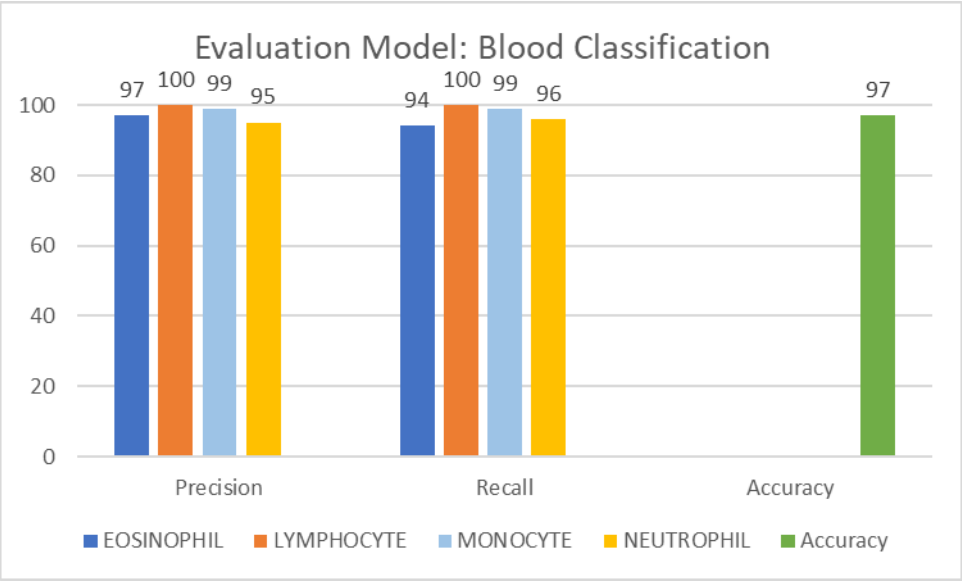


FIGURE 66 Evaluation Metric for Blood Classification

For the blood bank and data visualisation portal, following observations were recorded

1. Accepts password if both password are matching.
2. Accepts phone number if number of digits is 10.
3. Accepts email if the email is of form “abc@def.ghi”.
4. Allows registration only if email is not already in database.
5. Allows login if valid email and password is used.
6. Nearest blood bank is located to the user.
7. User is able to successfully submit donation request if request is made after 84 days of donation.
8. Donation request cannot be made within 7 days of first request.
9. Status of existing request can be seen.
10. Accepts phone number if number of digits is 10.
11. Accepts email if the email is of form “abc@def.ghi”.
12. Nearest blood bank is located to the user.
13. All files less than 2 Mb can be uploaded.
14. Blood bank employee can view existing requests of donors and receivers.
15. Blood bank employee is able to respond to blood requests.

16. Status of blood donor is updated on the system.

17. Status of blood receiver request is updated and shown on the system.

18. Pin code of length 6-digit is accepted.

19. Allows login if valid email and password is used.

20. Disease for data visualization is selected by the user.

21. Data visualisation of disease is shown to the user.

5.6. Inferences Drawn

- Website needs to be upgraded to a more expensive platform once the user base increases.
- Design of website is user friendly.
- Back-end connection with database can be improved in terms of speed.
- ML models can be trained with more data to improve efficiency.
- Payment portal could be included to make online payments of appointments.

5.7. Validation of Objectives

TABLE 34 Validation of Objectives

Objective	Status
Detection of diseases like malaria and leukemia from microscopic image of	The system is successfully able to detect malaria and leukemia from the uploaded

blood cell and categorization of blood cell.	microscopic images. Categorization of blood cell into its respective type is also successfully taking place.
Real-time data visualization and geological plotting of the infected blood samples.	The system is able to visualize data based on data from APIs and database of pathology portal onto graphs and maps
Development of user interface for pathology and blood bank management system	The UI consists of interface for three portals namely pathology portal, blood bank portal and data visualization portal. Users are successfully able to login and place blood donation requests and blood receiving requests. Detection of nearest blood bank is also working appropriately

6. CONCLUSION AND FUTURE SCOPE

6.1. Work Accomplished

As of 15 December, the work accomplished is that Ml models are trained and ready for deployment and integrated with back end. The user interfaces for all the domains are ready.

TABLE 35 Current Status of Work

Approved Objectives/Status	User Interface	Mathematical Model	Back End	Deployment
WEB APPLICATION USER INTERFACE	Completed	NA	NA	NA
DETECTION OF DISEASES FROM UPLOADED IMAGES	Completed	Completed	Completed	Completed
AUTOMATED CLASSIFICATION OF BLOOD CELLS FOR PATHOLOGY STUDIES	Completed	Completed	Completed	Completed
BLOOD DONATION MANAGEMENT SYSTEM	Completed	Completed	Completed	Completed
REAL-TIME INFECTION DATA	Completed	Completed	Completed	Completed

6.2. Conclusions

- The ML models need to be compared with more models and focus on a better recall score and accuracy.

- For detection of malaria and leukemia, recall is a better evaluation metric
- For classification of blood bells, accuracy is a better evaluation metric
- The back-end will be done using node.js and EJS for blood bank domain and data visualization while the back end for ML models will be integrated using flask.
- To avoid server overloading, two different servers will be used for pathology domain and blood bank domain.

6.3. Socio-Economic Benefits

Usage of the ML models for disease prediction seems as an assistive technology that would help in accurate disease prediction and avoid late/incorrect diagnosis, which would have been costlier in that case.

7. PROJECT METRICS

7.1. Challenges Faced

We faced several challenges during the project. We found it difficult to integrate ML models with the user interface. We also found it difficult to generate reports in PDF file. We also found it difficult to manage images of blood request slip and display it in blood bank employee's portal. It was also difficult to integrate the front end with the back end when dealing with files.

It was difficult for us to manage the project on time due to unavailability of resources at initial stages and also training of ML models took longer than usual.

7.2. Relevant Subjects

TABLE 36 Relevant Subjects

Subject Code	Subject	Description
UCS503	Software Engineering	Software Requirement Specification UML Diagrams Planning
UML501	Machine Learning	Development and training of ML models
UCS310	Dara Base Management Systems	Storing and Retrieving Data from

		Database
-	UI/UX Design	Development of Web Interface
-	Introduction to Python	Used as a language for running ML models
-	Full Stack Development with Flask	Used to Integrate front end with back end for pathology portal
-	Full Stack Development with Node	Used for integrating front end with back end for blood bank portal

7.3. Interdisciplinary Knowledge Sharing

- Link between DBMS, python and web development
- Use of data to provide real time analytics
- Use of neural networks to make ml models
- Use of MongoDB and NodeJs to create and update database

7.4. Peer Assessment Matrix

TABLE 37 Peer Assessment Matrix

Evaluation out of 5 1 – Lowest 5 - Highest		Evaluation Of			
		Karanbir Singh	Gaurish Garg	Purushartha Tyagi	Mihir Kumar
Evaluation By	Karanbir Singh	-	4	4	4
	Gaurish Garg	4	-	4	4
	Purushartha Tyagi	4	4	-	4
	Mihir Kumar	4	4	4	-

7.5. Role Playing and Work Schedule

7.5.1. Work Distribution

TABLE 38 Role Playing

Candidate	Role Played
Karanbir Singh	Integration of ML Models with User Interface Documentation Poster

Gaurish Garg	Front End Development Back End Development for Blood Bank Portal Development of Data Visualization Portal Documentation
Purushartha Tyagi	ML Models Documentation Video Editing
Mihir Kumar	Front End (HTML Forms) Documentation Video Editing

7.5.2. Member Specific Gantt Charts

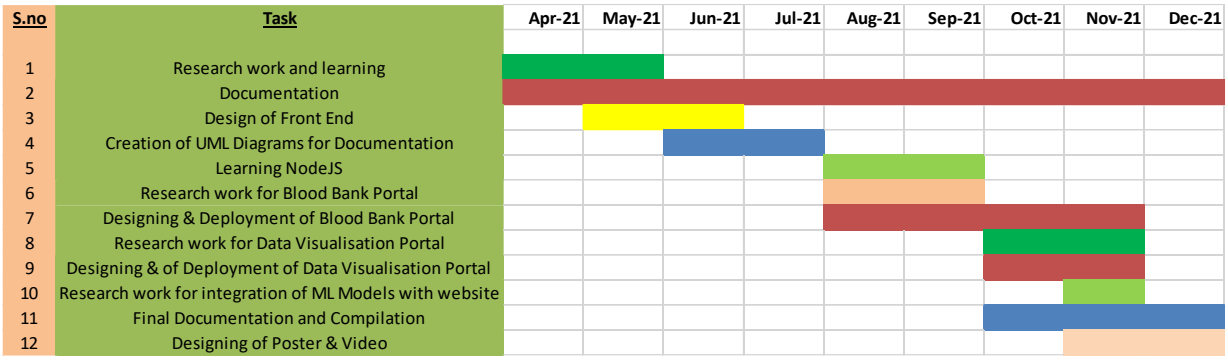


FIGURE 67 Gantt Chart of Gaurish Garg

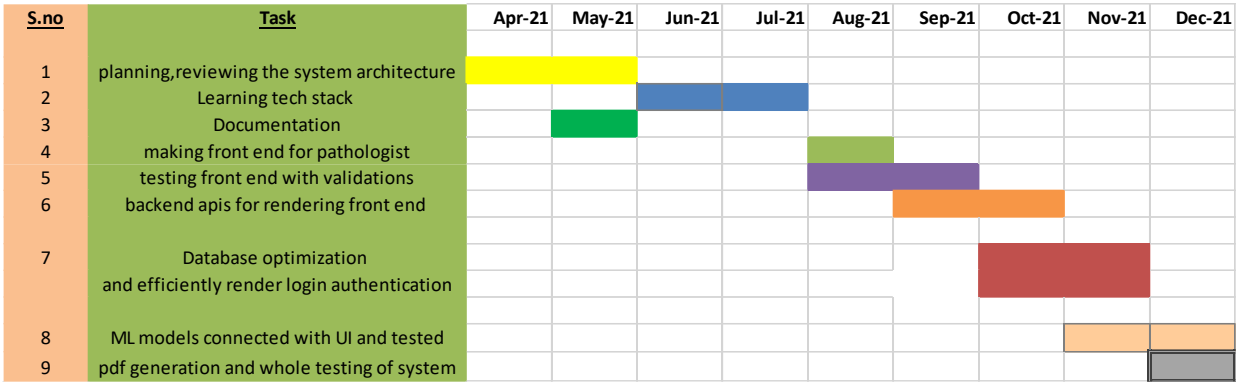


FIGURE 68 Gantt Chart of Karanbir Singh

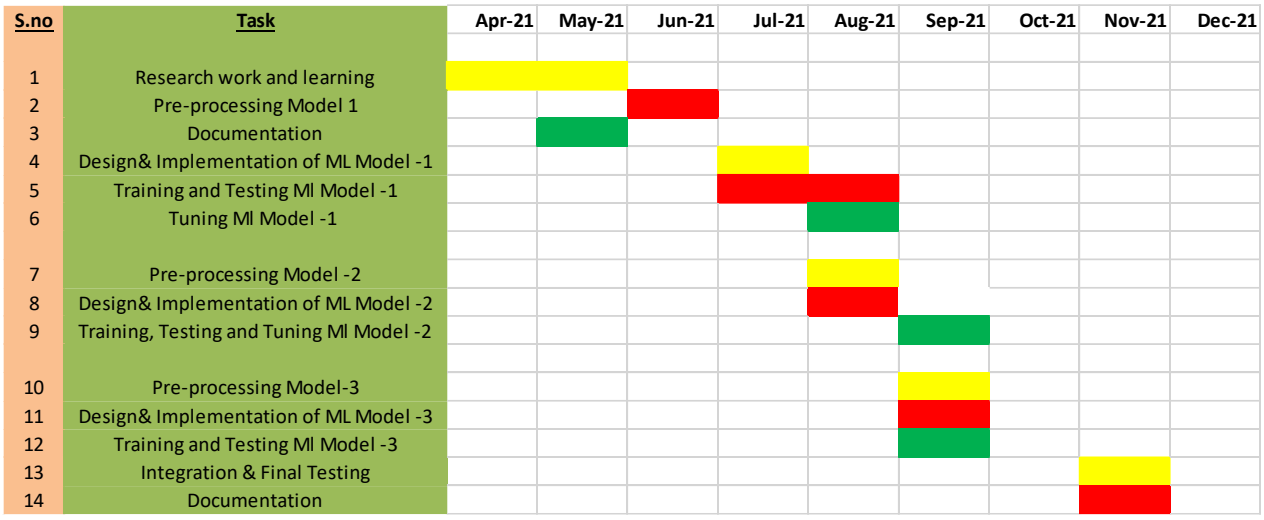


FIGURE 69 Gantt Chart of Purushartha Tyagi

FIGURE 70 Gantt Chart of Mihir Kumar

7.6. Student Outcomes Description and Performance Indicators

TABLE 39 SO Mapping

SO	SO Description	Outcome
1.1	Ability to identify and formulate problems related to computational domain	Identified problem of degraded and poor-quality images. & Adjusted the size of the image according to the ml model trained and the 'test' chosen..
1.2	Apply engineering, science, and mathematics body of knowledge to obtain analytical, numerical, and statistical solutions to solve engineering problems.	Acknowledged the requirement of nearest possible blood bank, we implemented the shortest distance capacity of google maps for it.
2.1	Design computing system(s) to address needs in different problem domains and build prototypes, simulations, proof of concepts, wherever necessary, that meet design and implementation specifications.	The team managed to build a project in which the users from almost each domain can participate and get assistance from our project by participating in blood donation.

2.2	Ability to analyse the economic trade-offs in computing systems.	Yes, we acknowledged that sometimes system may be overloaded because of heavy traffic and inappropriate image input and thus tried to implement the system using entirely different server for that purpose.
3.1	Prepare and present variety of documents such as project or laboratory reports according to computing standards and protocols.	Yes, the inbuilt pdf generator is provided for producing the final report. Also, the pathologist has to submit the registration document for verification.
3.2	Able to communicate effectively with peers in well organized and logical manner using adequate technical knowledge to solve computational domain problems and issues.	Indeed, we discussed the compatibility of ML with Flask as the backend in order to render the whole system smoothly, yet operating the bank management system in Node js.
4.1	Aware of ethical and professional responsibilities while designing and implementing computing solutions and innovations.	Blood sampling is not a trivial matter. Our team understood that we are not at all experts in this field. Thus, our systems were developed keeping in mind the studies, tests and papers that have been devised by haematologists and experts. This way we ensured that we are ethically correct and can provide a platform for our users to get correct outcome.
	Evaluate computational engineering solutions considering environmental,	Our team was very clearly aware of the impact the project would have on the environment as it

4.3	societal, and economic contexts.	removes the requirement of chemicals involved in testing and generating result paperless.
5.1	Participate in the development and selection of ideas to meet established objective and goals.	A large portion of the knowledge required and utilized by our team throughout the project was self-studied & thus each member contributed their ideas with proper evidences and reasons to implement them.
5.2	Able to plan, share and execute task responsibilities to function effectively by creating collaborative and inclusive environment in a team.	Each member was easily able to switch from one responsibility to another responsibility to the need. Documentation and development responsibilities were shared among all the members.
6.1	Ability to perform experimentations and further analyse the obtained results.	Various models have been applied and verified by comparing the results and trade-off between time and cost they took, and thus final models were selected.
6.2	Ability to analyse and interpret data, make necessary judgement(s) and draw conclusion(s).	Each Test takes different kind of image input ,thus models have been implemented accordingly.
7.1	Able to explore and utilize resources to enhance self-learning.	A large portion of the knowledge required and utilized by our team throughout the project was self-studied through research from books and the internet. We scoured forums whenever we were

		stuck on certain problems

7.7. Brief Analytical Assessment

Sources of Information

The team started reading a number of research papers and blogs to explore the current problems which could be turned into the Capstone project. We looked at various problem statements from hackathon websites and popular tech magazines. Some of the ideas were discarded when their actual implementations were beyond our expertise or when they didn't fulfil the requirements of the capstone project. After many deliberations, malaria and Lymphoma Detection and Blood Bank Management System was chosen as a capstone.

Analytical Computation and Experimental Methods

Proper working of our project and correct result generation was validates using more than one algorithm and continuous refining of our project was done. Knowledge of engineering principles: The successful completion of the project required basic knowledge of Web Development concepts, Natural Language processing, Artificial General Intelligence, DBMS.

Sharing of Responsibilities

To coordinate design and manufacturing dependencies, we divided the responsibilities among us and used to update each other about the progress. We shared the responsibilities and everyone did his or her share of work quite dedicatedly and consistently. The documentation was shared among all the members for consistency.

Appreciation for Problem Solving

Working on the capstone project gave us a simulation of the actual problem-solving practices. We came to learn about the importance of proper documentation and requirement analysis. We also came to understand the importance of dividing up the task into different independent modules and linking them together at the end. This project also gave us deep insight of our subjects.

APPENDIX A: References

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APPENDIX B: Plagiarism Report