IOT DEVICE TO DETECT ANEMIA: A CASE STUDY

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Declaration

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to Sri Lanka Institute of Information Technology the non-exclusive right to reproduce and distribute my dissertation in whole or part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as article or books).

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Signature of the Supervisor: Date:

Acknowledgement

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Finally, I would like to thank all the team members of the project for their contribution and effort towards achieving the project goals and objectives.

Abstract

In our day to day live, the diseases are increasing simultaneously and there are solutions for some disease and not for others. This project is based on Health and Informatics. Our title is "IOT Device to Detect Anemia using IOT". Anemia is the disease which caused by lack of Fe3+ in the human body. It is specially affected to ladies and children. To detect the Anemia disease, found a device to collect the tactics to find the disease with the specific device, that is called as "Doc-Detector". The main part of the project is Mobile Application with IOT. The mobile application is used to find the disease level with their symptoms via questionnaire and it has shown the actual results of the human body's disease level with the connection of the device. The mobile application is only used by Doctors who consulting the Anemia disease patient. The mobile application is easier to the doctors to handle the results with their hands. The project covers the development of the Doc-Detector application as well as the data server connection between the mobile application to facilitate data exchange between the mobile application and the server.

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List of Abbreviations

Abbreviation	Description
GUI	Graphical User Interface
OS	Operating System
UI	User Interface

1. Introduction

1.1 Background Literature

According to the World health organization (WHO) report, anemia is defined as a condition in which the number of red blood cells or their oxygen carrying capacity is insufficient to meet physiological, needs. Anemia affects about two billion people such as 30% of the population. It mostly detects in Africa and South-East Asia countries. Anemia is the disease which caused by lack of Fe3+ (iron) level in the human body. It doesn't have enough healthy red blood cells or hemoglobin to carry adequate oxygen level to the body's tissues. It is specially detecting for ladies and young children and people with chronic diseases are at increased risk of anemia. Important factors to remember are:

- Certain forms of anemia are hereditary and infants may be affected from time of birth.
- Women are mostly blood loss from during their pregnancy level and loss lots of blood.
- Adults have the risk of the Anemia by poor diet and other medical conditions.

The Anemia is the lifelong disease and able to decrease the level but unable to cure the disease for affected person. There are some symptoms to detect the Anemia whether person affected or not.

- Fatigue
- Weakness
- Pale or yellowish skin
- Irregular heartbeats
- Shortness of breath
- Dizziness or light headedness
- Chest pain
- Col hands and feet
- Headache

In order to the disease, need to find the level of the disease with the help of application to detect the person who affected by Anemia or not. The mobile application helps to

find the level of Anemia affected to the person. Earlier, in order to find the disease, they are using blood samples and crops red blood cells to detect anemia and it shows with the certain device or lab report. Our team designs the uniqueness to detect the disease by non-invasive method. It has no blood cells to check with the machine. It contains with the device that gets image processing and detects the anemia by mobile application.

There is a portable device to detect the hemoglobin level of the human body with the blood cell. It is the first generation of Portable POC hemoglobin device with the single use.

Figure 1.1.1: The first generation Portable POC

After some years, they find the non-invasive method to detect anemia. This method has become commercially available using near infrared spectroscopy to identify the special pattern of Hemoglobin in an underlying blood vessel and derive a measurement of Hemoglobin concentration.

Other non-invasive method device use white light and capture the reflected transmission data in order to measure Hemoglobin levels in tissue or send the multiple wavelength light and observe the Hemoglobin concentration. A finger clip is used to the device to apply the sensor to detect the disease.

Our team gives the unique product to detect anemia/ hemoglobin level of the human body with the image processing and mobile application with IOT method to show the results via mobile phone. It is much easier to get the results.

1.2 Research Gap

The main and unique part of the project is detecting the disease in the finger tips with the image processing level. There isn't a mobile application with the connection of created device our product. Earlier devices, it directly shows the results included the blood to the device. Next generation, the non-invasive method is directly sends wave to the finger and gives the results in the mobile application and only focus with single symptom level. These level product or device are showed the accuracy between 60% - 70% rate.

The main gap of the research is detecting the anemia by image processing level and calculates the disease with the machine learning process. Then it gives the results calculation with the questionnaire part. This is the unique in the device and specially in the mobile application it shows the combination result of questionnaire and device results. This product gives best accuracy than the earlier products. Therefore, the product is increased their accuracy level in the product.

Features / Products	Anemia detection Device by Jaime Punter(2015)	Anemia detection device by De Benoist B(2013)	Research product
Portability	✓	✓	✓
Non Invasive method	×	✓	✓
Number of symptoms accessed	Blood Test	Hb measurement	Based on 5 - 10 symptoms and image of fingertip
Mobile Application	×	×	✓
IoT implementation	×	×	✓

Table 1.2.1: Comparison between earlier devices and created device

The above table 1.2.1 shows the differentiates of the earlier products of similar products that made by the team. The main features are added to the product of this

project are mobile application and IOT implementation. It displays the separate results and saves the results of each patient. It is categorized with the patient and able to modify the results once a week or once a month with the help of related doctor.

1.3 Research Problem

Anemia is the largest and most affected disease in the world. It mostly affects in the African and South East Asia countries. Since 2008 results of the WHO report, Sri Lanka also affected by the Anemia disease.

Population group	Prevalence of anaemia		Population affected	
	Percent	95% CI	Number (millions)	95% CI
Preschool-age children	47.4	45.7-49.1	293	283-303
School-age children	25.4	19.9-30.9	305	238-371
Pregnant women	41.8	39.9-43.8	56	54-59
Non-pregnant women	30.2	28.7-31.6	468	446-491
Men	12.7	8.6-16.9	260	175-345
Elderly	23.9	18.3-29.4	164	126-202
Total population	**24.8**	**22.9-26.7**	**1620**	**1500-1740**

Table 1.3.1: Anemia affected level in 2008

Source: World Health organization (2008)

Based on the table 1.3.1 there are pregnant women and young children are affected by the anemia in Sri Lanka. The young children are affected by this disease by women. Because women in pregnancy level if they affected by the disease it directly affects to the born babies.

The accuracy is the main problem to detect the disease. The mobile application and image processing level help to increase the accuracy of the result. The mobile

application needs to increase the results of the accuracy. There are some products only with specific symptoms to detect the disease. The multiple disease helps to detect the disease with the best accuracy level to finalize the results. It gives the best accuracy to complete the test.

1.4 Research Objectives

The objective of the project is to detect the anemia disease. The main objective is to detect anemia by getting the photo of the fingertip and sends to the image processing level. It sends the results to the server and it directly connects to the mobile application to show the results. It shows the results by a mobile application.

The mobile application's objectives are the deep knowledge about the anemia symptoms to detect the anemia by mobile application. The mobile application connects with the data server with the connection IOT. It combines the patient's details, doctor details to get the results with the help of mobile application. The results given the best accuracy with the connection of questionnaire about symptoms and the results of the image processing. There is the option that directly connects the device to operate by the mobile application. The main part of the mobile application is the connection with IOT platform.

The mobile application is named as "Doc-Detector". It is an android based mobile application for Anemia analysis doctors. The application offers various operations such as questions based on symptoms, details of Patients, viewing results of the disease level and the date of the next meeting session for the patient and doctors. These services are conveniently grouped and developed specifically for use on the Android device. All the operations can be performed when an internet connection is available. Administrator of the application can register the Doctor to the system to all services provided.

The mobile application has the separate database to save the data of the results, patients and doctors details. Most of the mobile application database connects with the local database and it has the SQL connection and structure to the database. In this project, the mobile application has the separate server to save the data within the

database. The project is chosen the Firebase database because it is No SQL database structure and it is real-time database helps to store and synchronize the data. The database is the fast and very secured hosting. The Firebase is Backend-as-a-Service (BaaS) that offers the developers a wide spectrum tools and services to develop high quality apps at a much faster pace [6]. This database can connect their applications with backend cloud storage and APIs rendered by the backend applications.

2. Methodology

2.1 Methodology

The mobile application for Detecting Anemia disease which will useful for Doctors to maintain the statistics, specific disease affected patients, patients' specific details and the disease level updates. At the present there are two devices related to this main project but there is only a project includes the mobile application. It has only measurement details but no other details. In this project, the mobile application has all features that mentioned above. Earlier it is very difficult to contain the details of specific patient with Anemia disease.

In this project, includes all specific details and disease related ideas to reduce the level of disease. It mostly helpful for the doctors who maintain their details and updates about their disease level. It contains Anemia disease reduction level of each patient. The mobile application is going to build to helps to identify the patients separate and able to update their disease level once a week or once a month. It is much easier to cure/ reduce the disease level.

In this application, admin registers the doctors only. Doctors will admit the patient's details to the application and it automatically saves in the database of the application. The doctor can update the patient's disease level with the help of hardware product. The questionnaire is fixed and only for first time entry. If doctor requires, able to do the questionnaire part again. Then the results will update to the database and directly sends the disease level to the patients. This application helps for doctors and as well

as patients. The whole data are saved within the Firebase DB and it is the out server. It directly connects with API Key knowledge and the system requires to communicate with the server via HTTP. API uses to send and receive the details and messages that the program can accept the message.

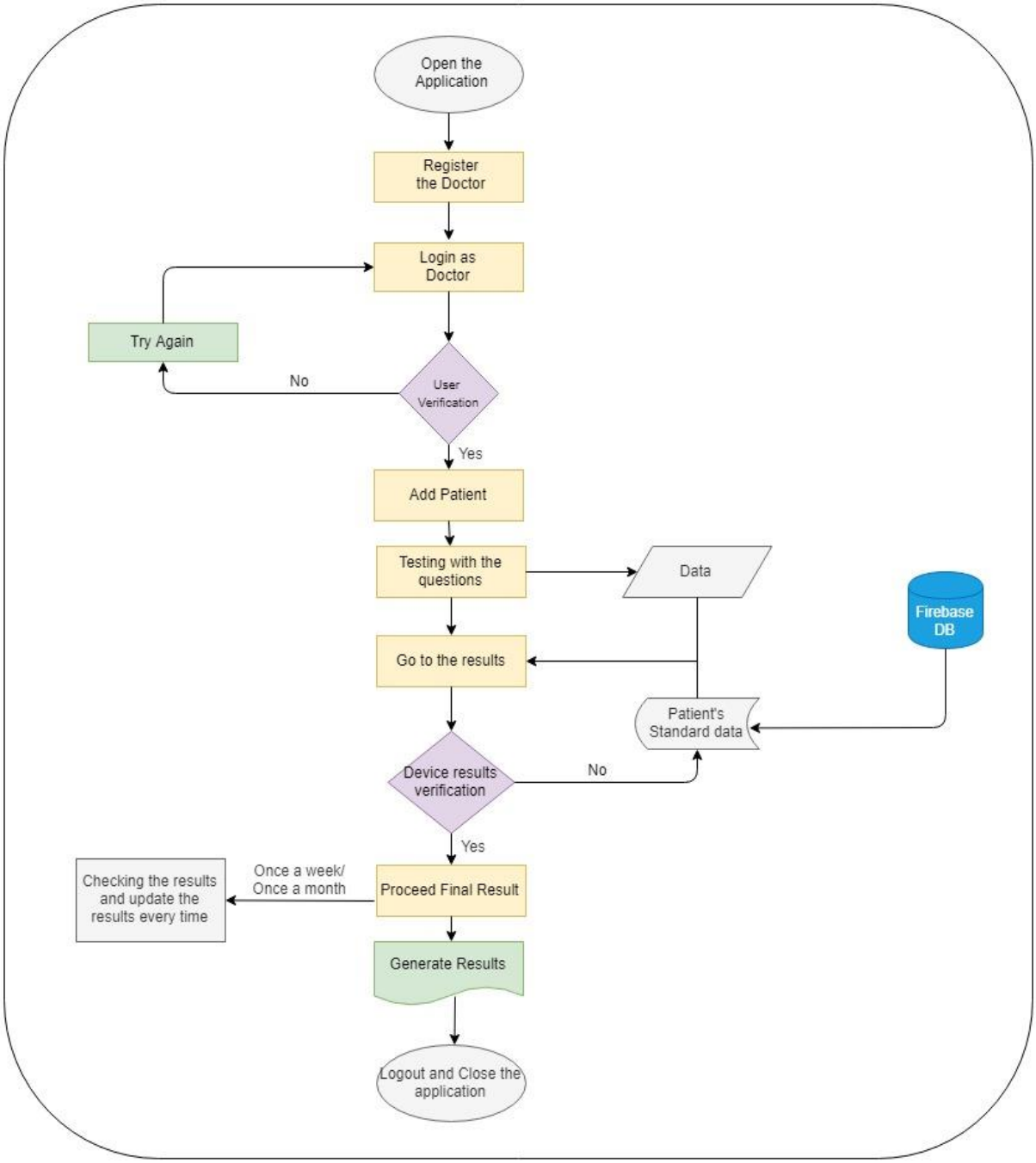


Figure 2.1.1: Flow Chart of the Application

The flow chart system shows how the mobile application development made as in the correct process. It shows the whole application main categories as a doctor. These are the basic elements done by the mobile application process.

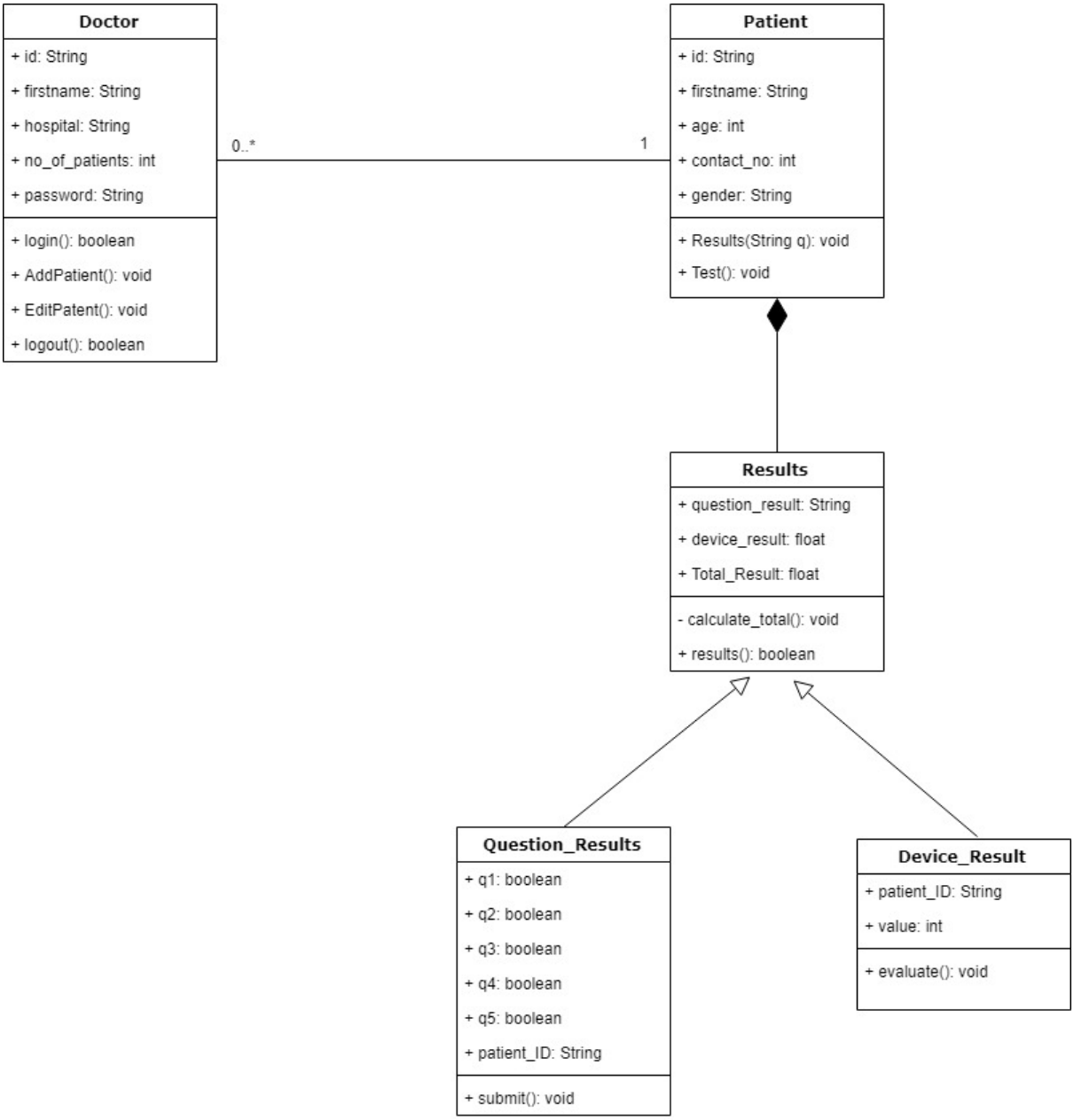


Figure 2.1.2: Class Diagram

The class diagram shows only the Patient, Doctor and Results connection. It shows how the results separate from the Results as Question_Results and Device_Result. Then it shows the patient-results combination and the doctor-patient combinations in the diagram. The model has the attributes and methods that implemented in the application and modified in the regarding database. The admin communicates with the doctor and machine status aggregates with the admin.

The following external interfaces and functions are held in the mobile application in the procedure:

External Interfaces

- Welcome Page
- Login Page for Doctor and Admin
- Patients Info Page
- Patient Register Page
- Patient Personal Details
- Questionnaire Page
- Results Page
- Doctor Register Page
- Doctor Info Page
- Device Page

Functions

- Login – Admin
- Login – Doctor
- Add Doctor
- Edit Doctor
- Delete Doctor
- Add Patient
- Delete Patient
- Update Patient
- Logout

These interfaces and functions are designed in the mobile application to run the results and make the data clear to the doctor view. All processes are under Admin panel and it always directs to the Admin. According to the order of Interface and functions, it clearly helps to fulfill the requirements and fill the blanks of the mobile application detected request to collect the data of doctor and patient level. The details can be captured in the back-end server to save the data in the server.

The mobile application is always need to connect with the internet for setting the data to the cloud database. Otherwise, the mobile application doesn't work properly and device doesn't take part with connection of IOT with the application. Otherwise, the application is unable to communicate with the device.

2.1.1 External Interfaces

The user interface shows the system of the mobile application methods below. It clearly shows the user-friendly method and easy to find the way to use the mobile application. The mobile application is now only available for Android devices and android platform.

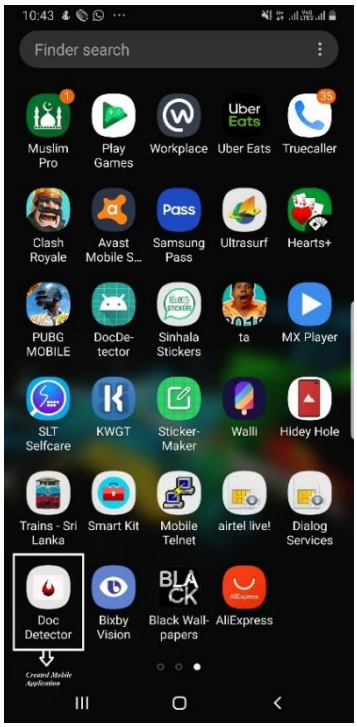


Figure 2.1.1.1: Shows "Doc-Detector" Android mobile application

2.1.1.1 Welcome Page

After installing Doc-Detector, and running the application first time can able to see the first page with two buttons such as Doctor and Admin. After clicking any button, user will be redirected to the login page. This is the basic and main page of the mobile application.

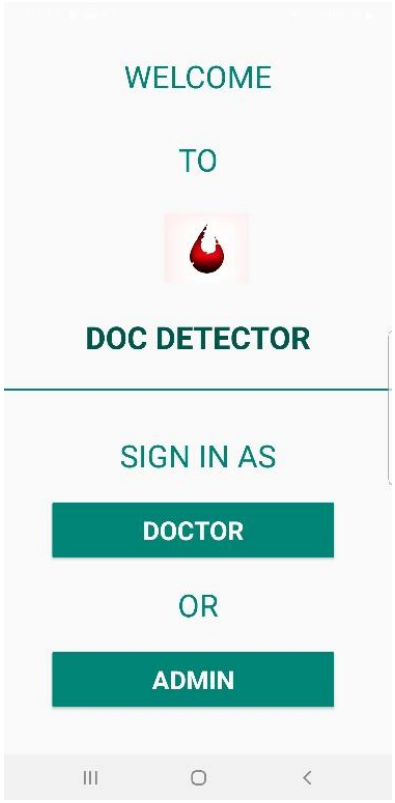
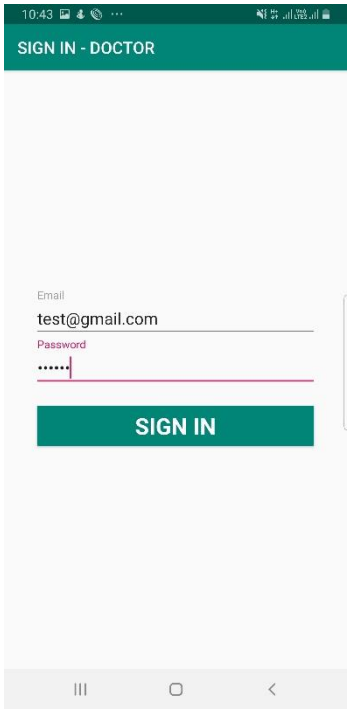


Figure 2.1.1.1.1: Welcome Page

2.1.1.2 Login Page for Doctor and Admin

After clicking Doctor or Admin button, it will be redirected to the login page with Username and Password. It is for who could not remember the password to login to Doc-Detector. The Admin login page has additionally Login with the direct server connection option.



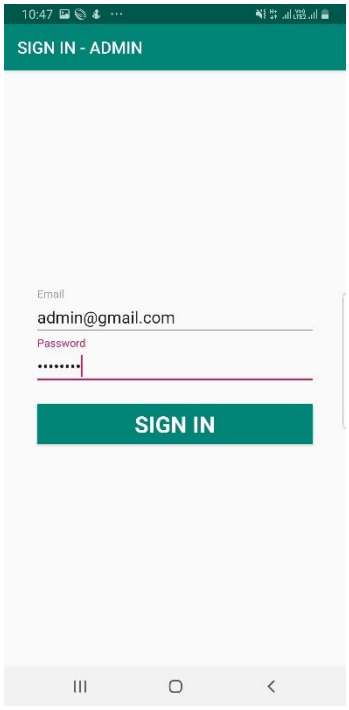


Figure 2.1.1.2.1: Doctor UI Login Page Figure 2.1.1.2.2: Admin UI Login Page

The both UI have the similarity and there are separate data structure in the back-end service. Both are differentiated with the firebase database. The Admin has the priority with the authentication level in the firebase database. Doctor has the basic structure of the database in the fire base.

2.1.1.3 Patients Info Page

It is below to the doctor's login page. After login with the doctor's login, it will be redirected to the system. It shows that doctor's patients available in the system. In this page, there is a Add_Patient button to register the patients to the below doctor's system. Every patient has four options such as test, results, edit and delete options in the system. The options are set the patient's database with the set of data in the server. It directly connects with every patient with related doctor panel in the database.

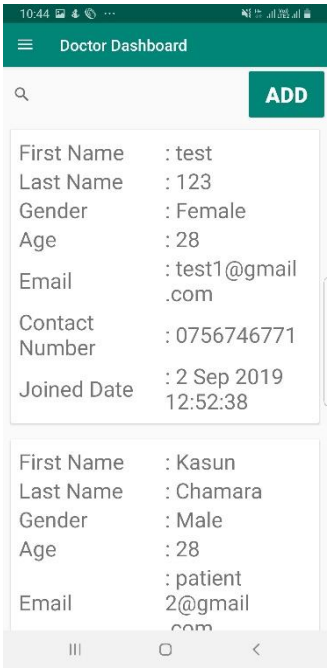


Figure 2.1.1.3.1: Patients Information in the Doctor UI

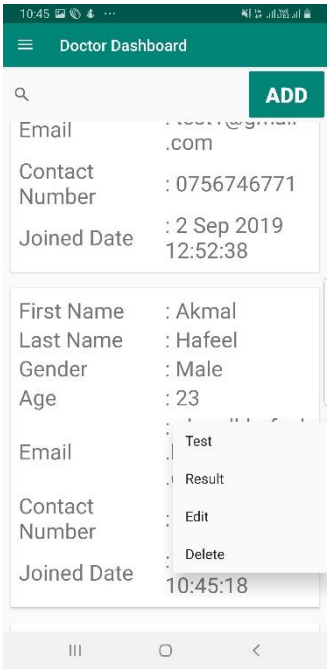


Figure 2.1.1.3.2: Options in the Doctor UI

2.1.1.4 Patient Register Page

Doctors who can register the Patients in to the system. After filling all required fields, is clicking the Register button in the bottom of the fields to register the patient. Then it will be redirected to Patients Info Page.

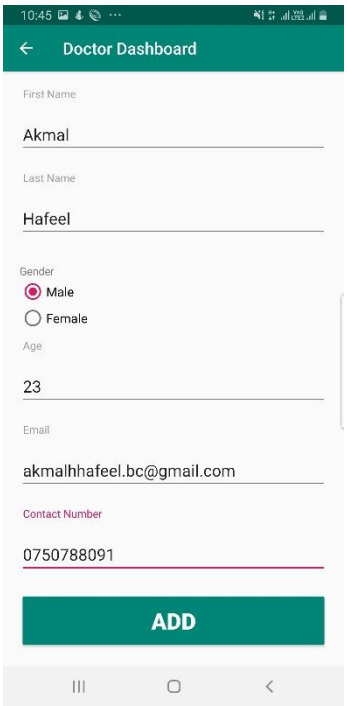


Figure 2.1.1.4.1: Adding Patient

In this case, patient's ID is encrypted and automatically generating for the security purpose of the doctor and the system. The firebase saves the data in to the database.

2.1.1.5 Patient Personal Details

It describes the patient's details and able to add the information with the help of patients. The patient details are able to edit and submit in the application. The UI is able to edit the patient's details easier in the application.

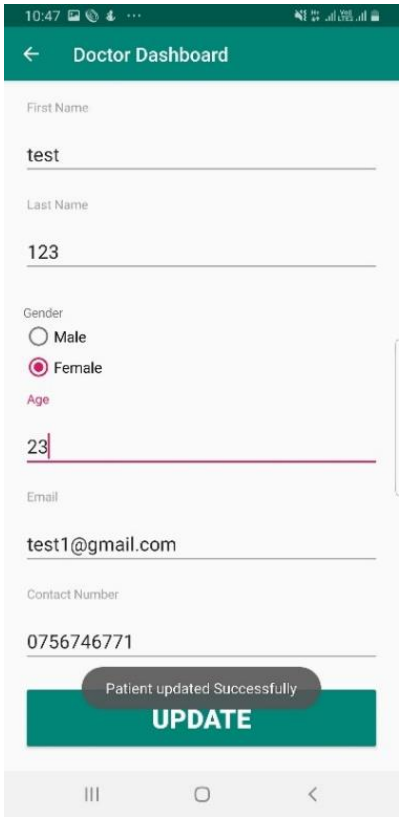


Figure 2.1.1.5.1: Patient's Personal Details

2.1.1.6 Questionnaire Page

It includes the questions related to the disease level and able to click the Options to the all questions. After finishing the questionnaire, it will be redirected to the Results Page. Every question's result saves in the database for machine learning algorithm part to fill the results. After submitting the results, it popup the message as "Answers are saved". In this threading time, it saves into the firebase database.

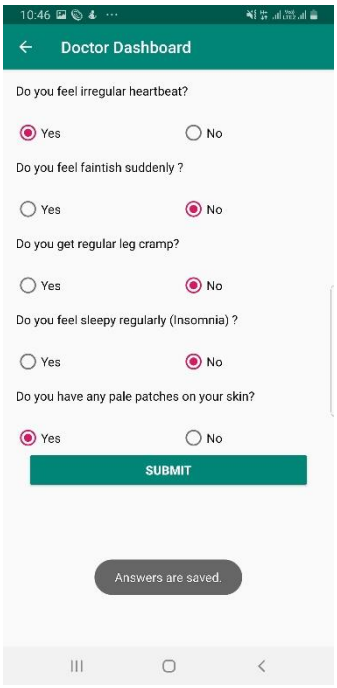


Figure 2.1.1.6.1: List of Questions

2.1.1.7 Results Page

It displays the results of Questionnaire and the device image processing level of the disease. After that, it displays the total disease level of the patient. It has Update button to update only the device results in the application.

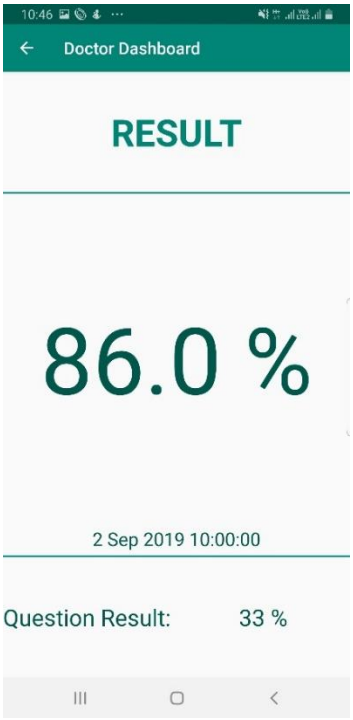


Figure 2.1.1.7.1: Results User Interface

The result directly saves into the firebase database and automatically pushes to the application's results page and it shows last updated or modified date in the application. The questionnaire result displays separate segment in the User Interface of the results.

2.1.1.8 Doctor Register Page

Admin who can register the Doctors in to the system. There is Add_Doctor button to register the doctors. After clicking the button, there are few required fields to fill by the Admin with the help of Doctors. After filling required fields, click the Register button to submit the details. Then it will be redirected to the Doctors Info page in the Admin page. There is automatically generating the PIN no for each doctor. It is the primary key of the doctor when needs to update or delete the details of the doctor.

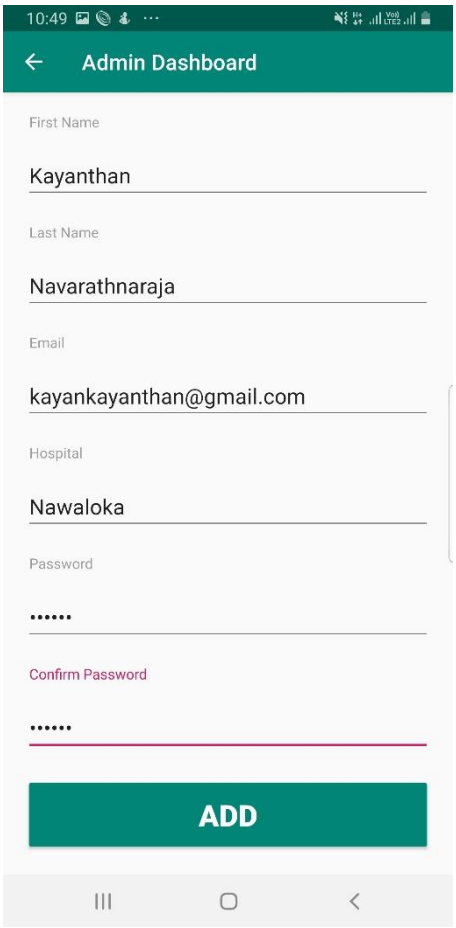


Figure 2.1.1.8.1: Registration Page of Doctor

2.1.1.9 Doctor Info Page

It has all details regarding about the doctors who has registered with the system. Admin can view the details of the Doctors and able to edit the details with the Edit button in the Page. This page has Edit_Doctor and Delete_Doctor buttons to add, edit and delete the doctors.

Figure 2.1.1.9.1: Doctor Information UI

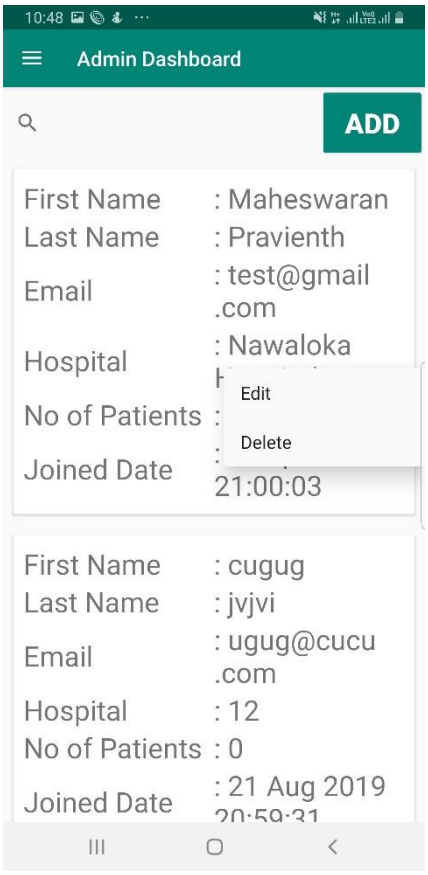


Figure 2.1.1.9.2: Doctor Info UI Options

2.1.1.10 Device Page

It shows the status of the device whether On or Off. This User Interface is in the processing and it shows the basic and only one device results in the set. It shows only for the connected device. This status page is only able to view for Admin. It shows the accurate status in the mobile application. It connects with the device with API key and turn on and off the status of the device.

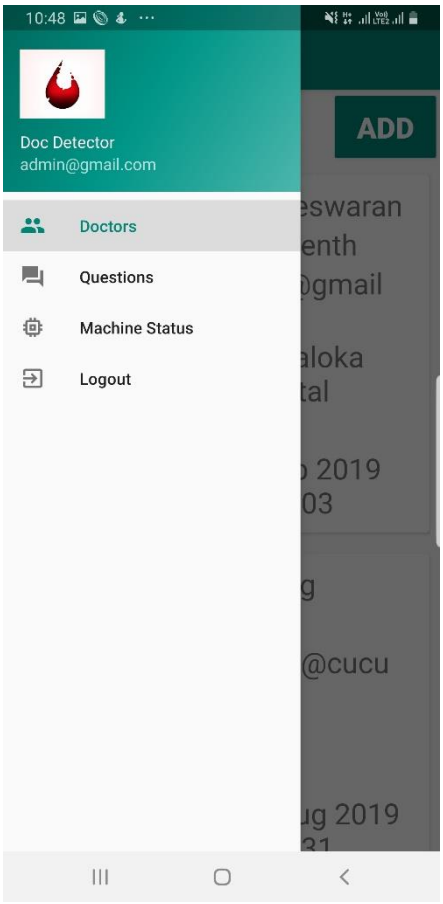


Figure 2.1.1.10.1: Machine status located in the Menu Bar of Admin

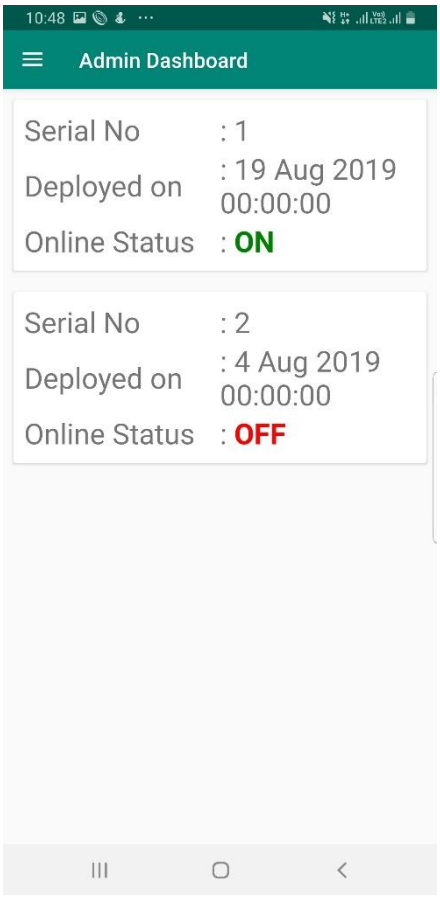


Figure 2.1.1.10.2: Status Page

2.1.2 Functions

The whole functions are working less than ten seconds. The application is automatically logged out when there is no response from the user. The only one person is able to handle the mobile application simultaneous time. The below given functions are used in the mobile application.

2.1.2.1 Login – Admin

It is used in Login button situated in the Admin Page. In this login, Admin can login to the system and able to view the doctor's details and alternate the details of doctors.

2.1.2.2 Login – Doctor

This function is helped to login the application and able to update the relevant tasks. In this login, doctor can login to the system and view and alter the details of patients. He/ She can create an account for the patient in the system. This function is located in the login button of Doctor Page.

2.1.2.3 Add Doctor

The function of Add Doctor is in Add doctor button in the Admin page. In this button, Admin can enter the doctor with required fields in the system. After that, doctor can login to the system.

2.1.2.4 Edit Doctor

Admin can edit the doctor details and save it to the system. This function is able to change the whole details of the doctor and easy to change the data in the mobile application.

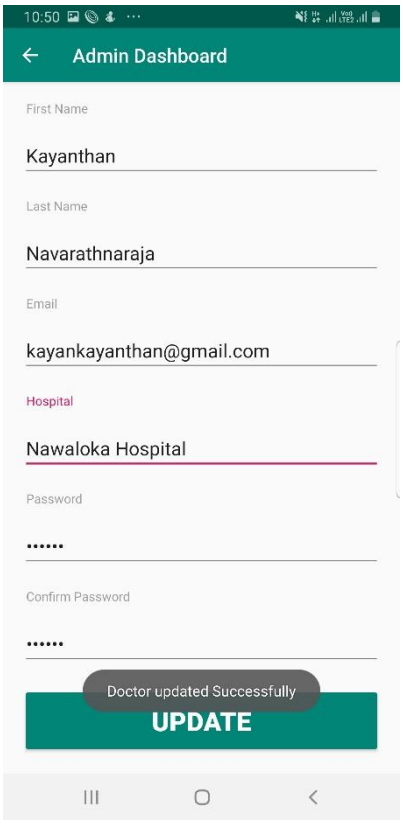


Figure 2.1.2.4.1: Updating the Doctor

After updated, the UI has popup an alert to the user as “Doctor updated Successfully”. Data saves within the threading section in the database.

2.1.2.5 Delete Doctor

This function is directly deleting the doctor when the doctor is requested. The function is located in the Admin page if need to delete, need to give the PIN no to delete the doctor in the list of the mobile application.

Figure 2.1.2.5.1: Deleting the Doctor in the list

After deleting the doctor, it shows the alert as “Doctor deleted successfully” in the mobile application.

2.1.2.6 Add Patient

This function can add the patient to the patients list. Doctor needs to fill the required details and register the patient.

2.1.2.7 Delete Patient

Delete the patient in the list by a doctor who handled him/her. If the doctor no needs to handle the patient, the doctor is free to delete the patient in the list.

2.1.2.8 Update Patient

The doctor is able to update the patient's details when patient's requirements needed. It is easier to update the patient data and easy to view on the patient's info page.

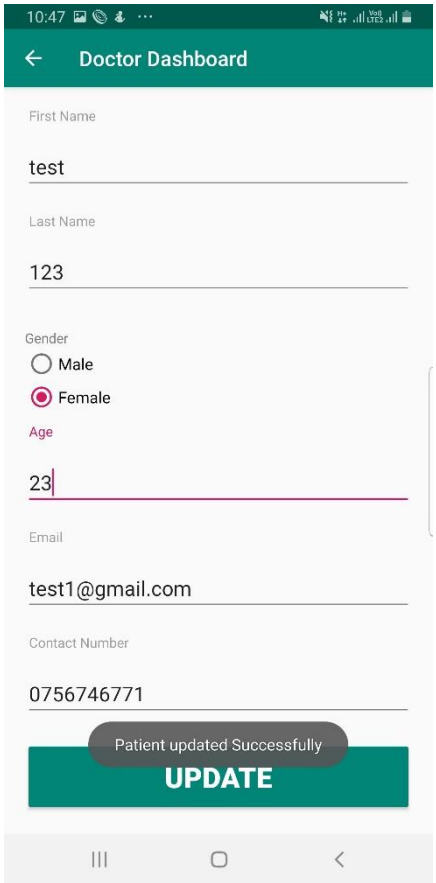


Figure 2.1.2.8.1: Updating the information of the Doctor

2.1.2.9 Logout

The function helps to logout from the system for doctor and patient. It shows in the menu bar in the side of the user interface of admin and doctor panels.

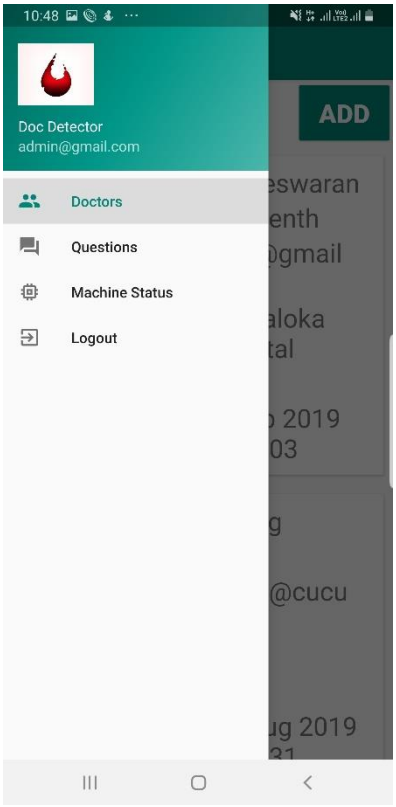


Figure 2.1.2.9.1: Menu bar of Admin's Page

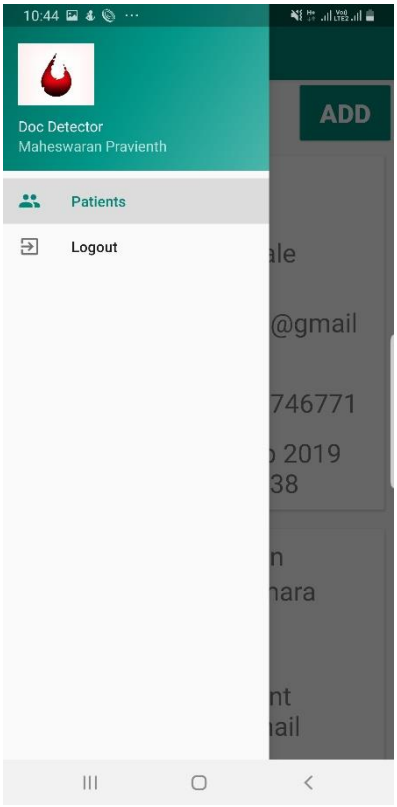


Figure 2.1.2.9.2: Menu bar of Doctor's Page

2.1.3 Creation of Database

The database is the main component in the segment. The database has NoSQL basis and document-oriented database and it based on cloud Fire store to save the data. The database doesn't need a structure to build for the application. It is random and user friendly to the user/ admin who is going to update or rebuilt the database for the mobile application. The database connects with every segment of the mobile application users. The fire base database has three segments such as collection, document and field. These three segments combine with each other with the format.

The Firebase cloud store is directly connecting with the device which checks whether it captures to build the image processing scenario to take the snapshot. The database is the main segment of this project. It syncs the whole section of the team members. The mobile application questionnaire saves the results and the image processing saves directly in the database and machine learning data processing captures both data and

predicts with the algorithm. Finally, the final results only save after the prediction of each patient category. The database needs authentication to show the data and it is able to use for selected users.

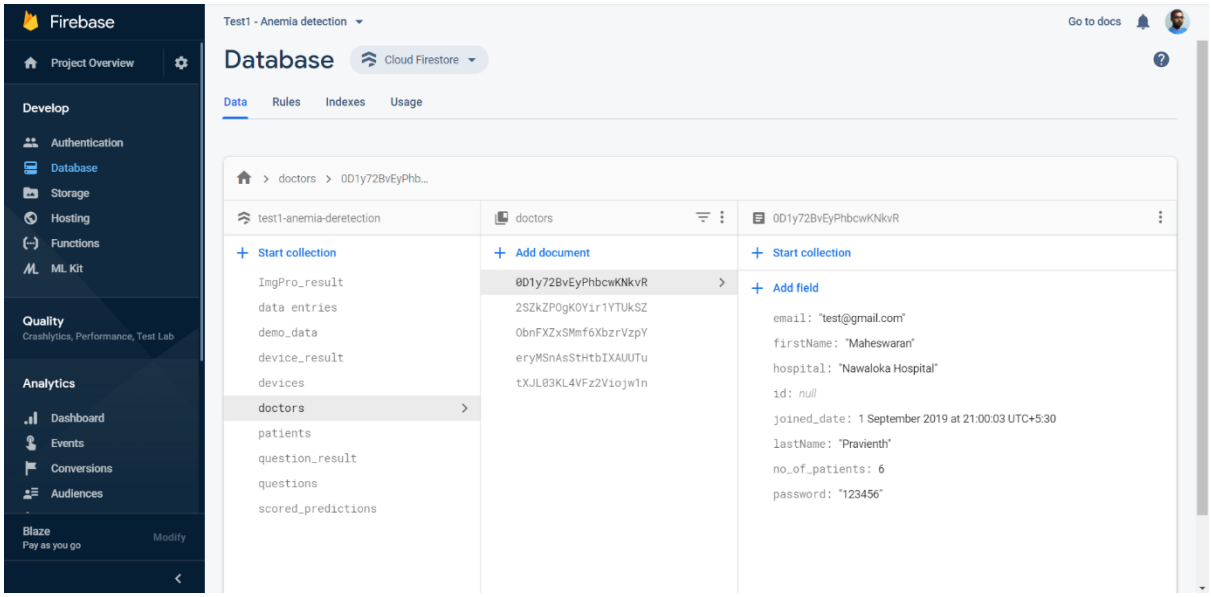


Figure 2.1.3.1 Firebase database Overview

2.1.4 IOT Connection of the device

The IOT connection is the trending communication with all smart devices. In this project, the project connects with the IOT integration through Wi-Fi. It helps to transfer data very fast and transfer hundred megabits within a second. It is working with the internet protocol standards and works within a 50m radius session. The IOT architecture is used in this project as showing the status of the device connection whether its on or off.

Figure 2.1.4.1 IOT Architecture

The device status shows in its IOT cloud and it attaches with the firebase database. It directly sends to the database and save within the selected collection and it replicates the result in the mobile application's status page.

2.2 Commercialization aspect of the component

This project was built on a commercialization concept. The sugar machine although requires an invasive method it has been able to capture a larger market due it's accuracy rate. If the accuracy rate is high, then the accuracy of the product can be increased. In order to increase the accuracy rate of image processing the team has used the following concepts where the keras deep learning method is used where the accuracy rate is higher than usual method. The symptoms that is also taken during the construction of the device also needs to be taken into account when it comes to the commercialization of the product. The device only inputs one symptom while the other component of the total system which this the app inputs some information regarding the anemia patient is, where the input is taken from the questionnaire where the user has to answer the relevant questions. This also increases the accuracy of the device further in the process of detection of anemia.

2.3 Testing and Implementation

The testing part is held on the questionnaire page to finalize the results only in the mobile application. The results of the questionnaire are published on the results page. Another one, there are perfect on the adding doctors and patients in the mobile application. The processes of generating automatic ID for doctor is automatically generates in the doctor database. The pages and functions are tested with the relevant patient for questionnaire area. The implementations are to be connect with the device to ON and OFF the device with the mobile application. The IOT connection is directly done with the data server. The information is very secured and it is automatically saving in the backup server with the connection of IOT and all details are on the security tunnel connectivity.

3. Results and Discussion

3.1 Results

The development of the mobile application is conducted with the android studio and it is the reliability and with secure. The main results of this project are showing the final calculation of the predicting results between image processing and the question results. It shows in the results page of the mobile application.

Figure 3.1.1 Showing the final results

The above-mentioned figure 3.1.1 shows how the results extract in the session. The question result shows separate to identify whether how the patient has symptoms with the related disease. The patient results automatically save in the database and it will automatically update when the doctor gets snapshot once again with the patient, but the question result does not update whether any modification with the question results.

The device which is connect through the IOT segment and it shows the status of the device in the Doc-Detector mobile application. Machine status segment is directly including in the mobile application with the connection.

3.2 Research Findings

In this project, the individual research is mainly focused on the mobile application creating with the IOT connection. The main factor is the Internet of Things (IOT) communication detecting status within the android mobile application. Now a days,

IOT is the newest technology in the society. Every device sync with the internet community to use it for the client's simplicity. IOT architecture defines the set of collection of platforms to identify the sets of data and communication level of the device.

3.3 Discussion

Firebase Database

The application's database is used with the firebase. It is NoSQL approach, document-oriented database and there isn't a specified set of rules to combine with other classes. It is the cloud-based fire store and it is the main communication process of this project. Cloud Fire store is firebase's newest database for mobile application development. It builds on the successes of the Realtime Database with a new, more intuitive data model. Cloud Fire store also features richer, faster queries and scales further than the Realtime Database. All elements join within the database for the easiest activity for the connection. The database has three data models. There are,

1. Collection
2. Document
3. Fields

In cloud fire store, store the data documents and organize the documents into collections. there are no tables or rows. Instead, you store data in documents, which are organized into collections. Each document contains a set of key-value pairs. Cloud Fire store is optimized for storing large collections of small documents.

All documents must be stored in collections. Documents can contain sub collections and nested objects, both of which can include primitive fields like strings or complex objects like lists. Collections and documents are created implicitly in Cloud Fire store. Simply assign data to a document within a collection. If either the collection or document does not exist, Cloud Fire store creates it [4].

4. Conclusions

In this paper, the research project is discussed about “IOT Device to Detect Anemia”. A way to track and check the disease called Anemia by using image processing, machine learning algorithms and the mobile application technologies. The report describes how to evaluate the disease and use the mobile application to detect the disease with the help of doctor.

In this research element, android mobile application is developed to check the skills and detects the symptoms of the disease for the affected patient, and based on the questions in the application. The proper way and setups used to build the mobile application. In this project, discovered new symptoms of the disease when applying the questions and got the deep learning systems of the disease. The core functionalities of the project is taking photos, setting to image processing and predicting via machine learning algorithm and the results are successfully implemented in the Doc-Detector application.

The successful factor in the applications are the Firebase connections and the IOT implementation methodology to the application. Firebase database is allowed secure and cloud database structure to succeed the mobile application rather than the locally implemented database. It is helping to synchronize with the other core functionalities in the application and the entire project. Internet of Things is extracted the project in to another level of implementation. It sets the easiest way to monitor the device within the mobile application.

Software development for mobile application sector is the complicated process and developing software product for client. It is taught to understanding the requirements, managing the work, designing user interface, back end implementation, evaluating and testing processes to manage the software development. They are accord to better management of the software development. The challenges of the software implementations are designing the set of tables in the database, understanding the requirements of the team and testing process of the model application.

4.1 Future Work

- Introducing the mobile application in the cross platform such iOS users are able to find the application. So far, the mobile application is only available for Android users.
- Planning to get the image of the patient's finger tips within the local camera of the smart phone.
- Planning to use the mobile application to patients for their self-testing. So far, the mobile application is only available to use for doctors who registered with this application.
- The application is planning to schedule how to predict the disease for each patient with the food, habits and behavior basics.

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Appendices

- Work Breakdown Structure of Mobile Application Development