

United International University
QUEST FOR EXCELLENCE

Smart Doctor: An Intelligent App for Medical Advice and Digital Health Record

A Thesis
Submitted to the department of Computer Science of
United International University
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For the Degree of
Bachelor of Science in Computer Science and Engineering
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Declaration

This is to certify that the work entitled "Smart Doctor: An Intelligent App for Medical Advice and Digital Health Record" is the outcome of the research carried out by us under the supervision of **Dr. Khondaker Abdullah Al Mamun**, Professor - Department of Computer Science and Engineering Founder & Director - AIMS Lab United International University, United City, Madani Avenue, Badda, Dhaka-1212, Bangladesh.

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In my capacity as supervisor of the candidate's thesis, I certify that, the above statements are true to the best of my knowledge.

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We also want to convey our warmest thanks to Upasham Health Point Pvt Ltd. that they have provided us sample medical test report. Based on those reports, we were able to make progress to our research and became successful to pursue this level of accuracy on our medical report scanning part.

Finally, we would like to thank almighty Allah to make this happen and made the entire obstacle easier for us to pass through, and also obviously to our supervisor for always keeping us motivated.

Certificate

I do hereby declare that the research works embodied in this thesis entitled "Smart Doctor: An Intelligent App for Medical Advice and Digital Health Record" is the outcome of an original work carried out by *Rana MD Shahriare Parvez, Alif Choyon, Md. Hasanuzzaman* and *Ashiqur Rahman* under my supervision. I further certify that the dissertation meets the requirements and the standard for the degree of Bachelor of Science in Computer and Engineering.

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ABSTRACT

Over the past decade, the rapid advancement in information and communication technology has experienced a tremendous change in the health care sector. Especially, most of the developed country has already been experiencing the advantage of digitalization in the medical field. e-Health has a great potentiality to ensure proper healthcare, increase the quality of medical service, accessibility and prevent the loss of medical report. On the other hand, it can also be possible to achieve more accurate medical decision from a medical robot as a second opinion for doctor. A technology-based medical service provider company named Babylon has designed an AI which was able to achieve a score of 81% on its first try of questions from the Membership of the Royal College of General Practitioners exam, whereas the average mark of human doctors based on the logs between 2012 and 2017 was 72%. The thesis on implementing "Smart Doctor: An Intelligent App for Medical Advice and Digital Health Record" is very diverse. This research describes two part of the medical support system. One is the smart bot, which assists non-medical people to primary care or in case of a medical emergency, it provides and suggests medical attention. On the contrary, the second part is about collecting, digitalizing and organizing medical records and history of a patient. Emerging smart medical bot and electronic health record models present numerous challenges to the doctors, physicians, healthcare systems and regulators. The objective of this study is to create an overview of the existing literature on smart medical bot and electronic health record (EHR) implementation, make them available to all kind of people and to identify generally applicable findings and lessons for implementers. Here we worked on a chatbot which can provide medical suggestion based on some questionnaire. Then we have implemented digitalizing medical report using Google Mobile Vision API. The user would be able to save medical report digitally using just their mobile phone's camera and backed the report up into the server.

Keywords: Clinical Staff; Health Information Technology; Computerize Physician Order Entry; Smart Medical Bot; Electronic Health Record; Electronic Patient Record; Medical Support Systems; Medical Records Systems, Computerized; Delivery of Health Care; Patient Care; Information Management;

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1. Introduction

1.1. Background

Artificially intelligent systems have always been a powerful division of research and among them, Biomedical Engineering combines engineering principles, design concepts to medicine, biology for healthcare purposes such as diagnosing, advising and providing important information. The social structure changes based on every new technology and we shape our future on that knowledge including intelligent healthcare systems. Some Interactive systems widely available to users and providing relevant information using different approaches but goals of the systems are to make people aware of their health and the improvement of it but in most of the developing or underdeveloped countries, people are still unaware of their health [1].

The intelligent healthcare system is a huge domain to work with from taking care of patients mentally or physically. It can be a totally automated system or the mix of human experts and automated systems. Based on the specificity patients are categorized and treated.

Our environment, actions, genetic structure, and other important factors lead us to finite lifespan. We are prone to be diseased and in a third world country like Bangladesh environment is polluted at a certain level that every day we increase the chances to develop lots of diseases that could be prevented by knowledge and a little care. Everyday human life suffers for their own ignorance or lack of knowledge, though we have modern technologies, internet-enabled smartphones, small medical devices fits into the palm on our hand [2].

Initial diagnosis has always been helpful to learn about the problems of the patients through questionnaires, examining or utilizing other techniques such as pathology.

One of the effective way to ask question interactively is by sending messages or mailing but that would be a tedious process so we used the technology of chatbot that asks relevant questions based on its knowledge while keeping a friendly environment.

There are a lot of unstructured medical report data that also helps to in the purpose of diagnosis. Those data could be digitized by typing each bit of information manually but that would be an impractical and time-consuming approach. To solve this issue we used the technology of optical image recognition which converts visual information to textual information and we further process them in the cloud [3].

There could be a list of priorities in our life but health should be one of them because if we are not healthy our normal life is hampered along with our productivity. To keep us healthy we

need to do regular checkup or take appointments of doctors and symptoms should not be neglected as it can later be a major problem in our life.

Development of Smart Doctor can be hope for the future as in most of the third world countries people are not bothered with health care system as feeding themselves is one of the indispensable facts. It is not a replacement of doctors rather refers to doctors [4].

1.2. Motivation

Existing health care systems such as Ada- a mobile app, Your MD, Babylon Health, IBM Watson Health - Cognitive Healthcare Solutions other systems are quite sophisticated but they are not optimized for Bangladeshi people, does not refer Bangladeshi doctors and contacting doctors is a tiresome process.

Similarly goes with the EHR systems, for instance, HER, Apollos' EHR system United Hospitals EHR system but they are proprietary property so not available publicly, not so robust and only works in a certain domain [5].

There is a study of the availability of physicians and nurses World Health Organization (WHO) which shows that 3.05 physicians are available for 10,000 people and 1.07 nurses for the same amount of people which should determine the health of Bangladeshi people and the reality is far worse than this since the distribution is not uniform. The population of Bangladesh is one of the densest and 70% lives in rural areas and most of the clinics and hospitals are city-centric.

1.3. Contribution

In this work, taking everything in account is an incremental process of consolidation of knowledge and experience from available resources and interacting with domain experts how would they formalize the problem from an algorithmic approach. The geographical distribution of diseases makes it more challenging as the distribution differs. Knowledge can be collected from different resources and can easily be fed to a model to train it whereas the validity is questionable. To solve this problem, we needed to contact with the domain experts and learn their ways to formalize how they communicate with the patients. So, the knowledge set is amalgamated with experience set and thus a birth of new approach conceived [6].

Simple probabilistic approaches have been taken for classifying a specific class of report and there's been some advantages of classifying it to a certain class as the feature names can be

predetermined. Simple geometric concept has been applied to find out related features and sometimes fuzzy matching of keywords as the accuracy of the classifier is not 100%.

1.4. Organization

Compilation of this thesis is sectioned into 10 chapters where Chapter 5 proposes the Smart Doctor, Chapter 6 covers Smiley Bot, Chapter 7 proposes Smart EHR system. A short description of each chapter is given below:

- Chapter 1 starts with the background, motivation, contribution of this research.
- Chapter 2 gives a brief description of existing systems for chatbot and electronic health record system.
- Chapter 3 generalizes what is electronic health record system and how it works.
- Chapter 4 proposes the Smart doctor its class diagram, activity diagram, detailed design, and its workflow.
- Chapter 5 outlines the Smiley Bot, its purpose, features, working mechanism, use case diagram, flowchart diagram.
- Chapter 6 narrates the Smart EHR, its purpose, features, working mechanism, use case diagram, flowchart diagram.
- Chapter 7 discusses summary, challenges of building smiley bot and smart electronic health record system and future work
- Chapter 8 concludes the work.

2. Review of Medical Advice and Digital Health Record

2.1. Introduction

We live in the dawn of AI where it's just started to intercept with newer technologies and healthcare systems and one of the best ways to interact with users is through artificial entities, chatbots, residing in our phone or other electronic devices constantly serving for 24/7 for the purpose of finding issues or providing relevant information. It can be related to heart disease or depression, the entity will learn from user actions and talking pattern.

Computer vision is another important field of research where a computer understands visual information and optical character recognition is one of the derivates. All the unstructured reports, prescriptions carry importance as each instance of data.

A combination of intelligent entity and OCR takes us one step closer understanding the issues of people and providing relevant information to reduce their sufferings where there is no light of information.

2.2.1. Existing systems for Chatbot

There are some existing interactive, informative, sophisticated health care systems available and study suggests that more than 50% of the respondents think AI will be present in healthcare by 2025. Almost 50% US company believe that the healthcare industry "needs to be convinced further of ROI from AI / ML investments". "Decision support systems" was ranked as the most likely application to be improved by AI (for improving patient outcomes), with an average 4.15 score on a 1-5 scale.

2.2.1.1 Safedrugbot

Safedrugbot was developed on the request of a doctor to retrieve information of drugs through a messaging service that assistant like support to users. It also provides necessary information about the alternative medicines and active ingredients of a particular medicine.



Figure 2.1: Safedrugbot Interface

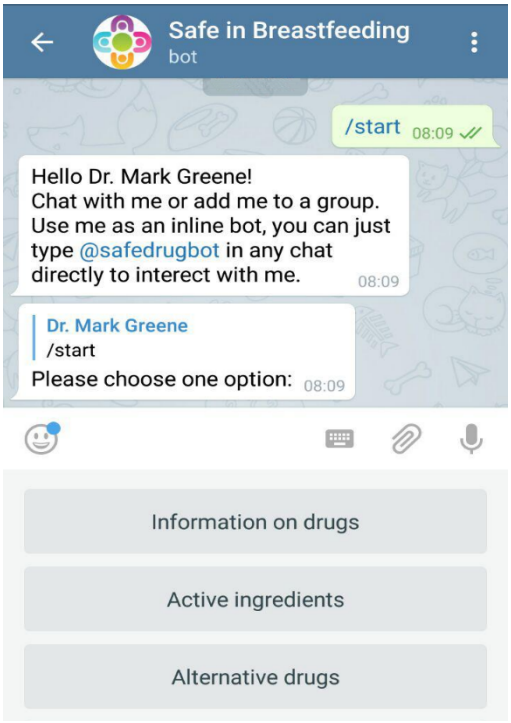


Figure 2.2: Safedrugbot Interface

Key features are given below:

- Information on drugs: Safedrugbot is constantly updating its database including the source from where they collected the information showing related to active ingredient. They also focus on the ingredients available from the nature and how may it interact with a pregnant woman.
- One of the special commands is "Active ingredient" which provides necessary information used in the specific medicine and professionals can get an idea how much compatible the medicine is with the patient. It can also be used to find the similarities of two different branded medicine,
- There's another significant command available that is called "Alternative drugs" which can be used to find out alternative medicines when the specific branded medicine is not available in nearest store. This system will also tell the patient if that certain medicine has any kind of side effects for example: someone can be allergic to a certain medicine and s/he shouldn't take it.

Safedrugbot also encourages to use this app with the help professionals.

2.2.1.2 Izzy

Izzy also is known as a period tracking and women's health bot is available using Facebook messenger that keeps track of the menstruation dates including fertile windows. She asks necessary questions to deliver important information about menstrual health and sexual issues.

Key features are given below:

- Tracking periods
- Reminder of taking birth control pills
- Charming personality

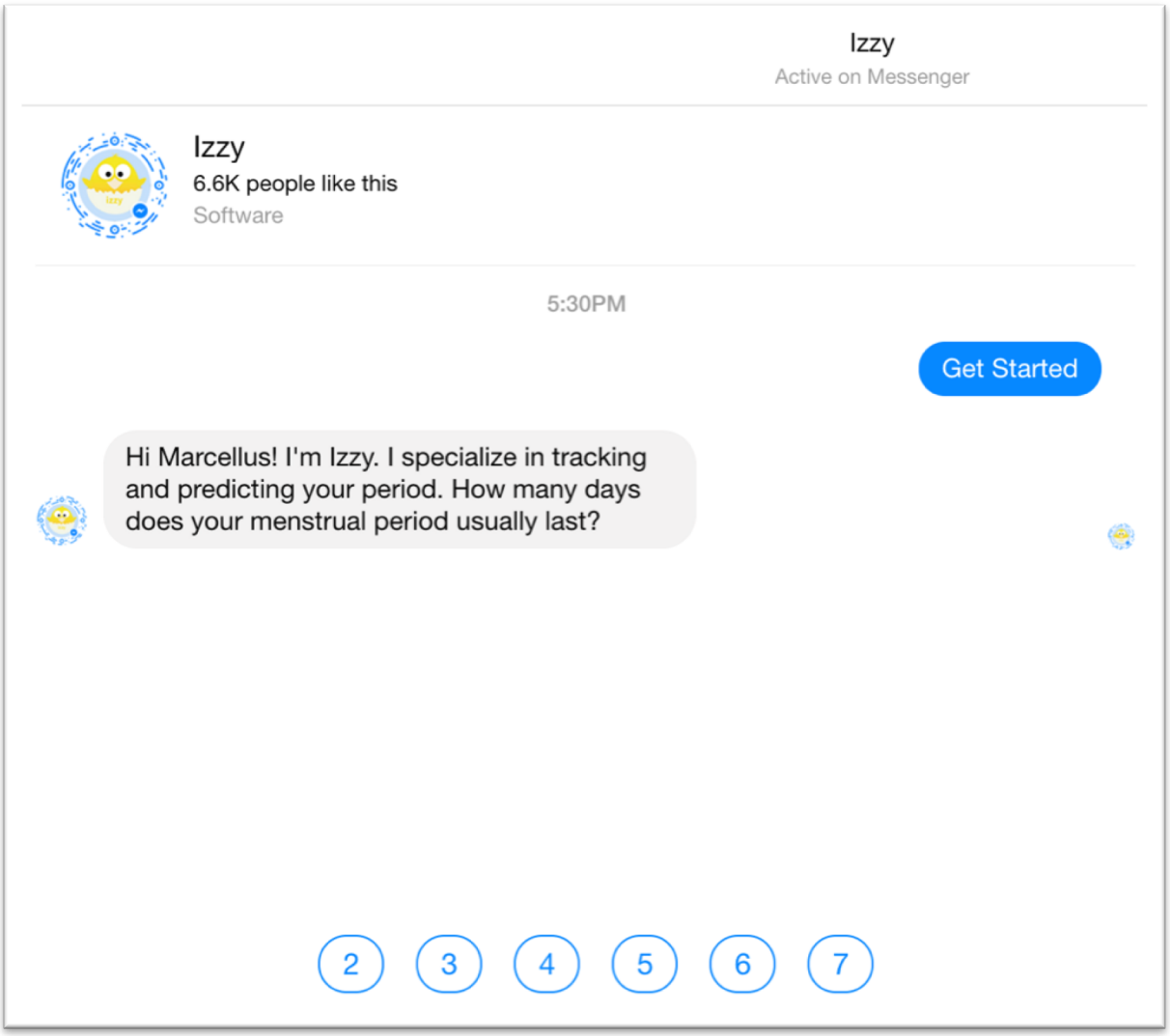


Figure 2.3: Izzy caring for her patients

2.2.1.3 Babylon Health

Babylon Health is a renowned healthcare platform offers medical consultation with the strength of AI based on patient information. There are some other features like consulting with a doctor in video chat. Initially, it asks patients about their problems and symptoms and based on the user information it offers services. Secondly, it refers to specialists for further detailed diagnosis and prescription.

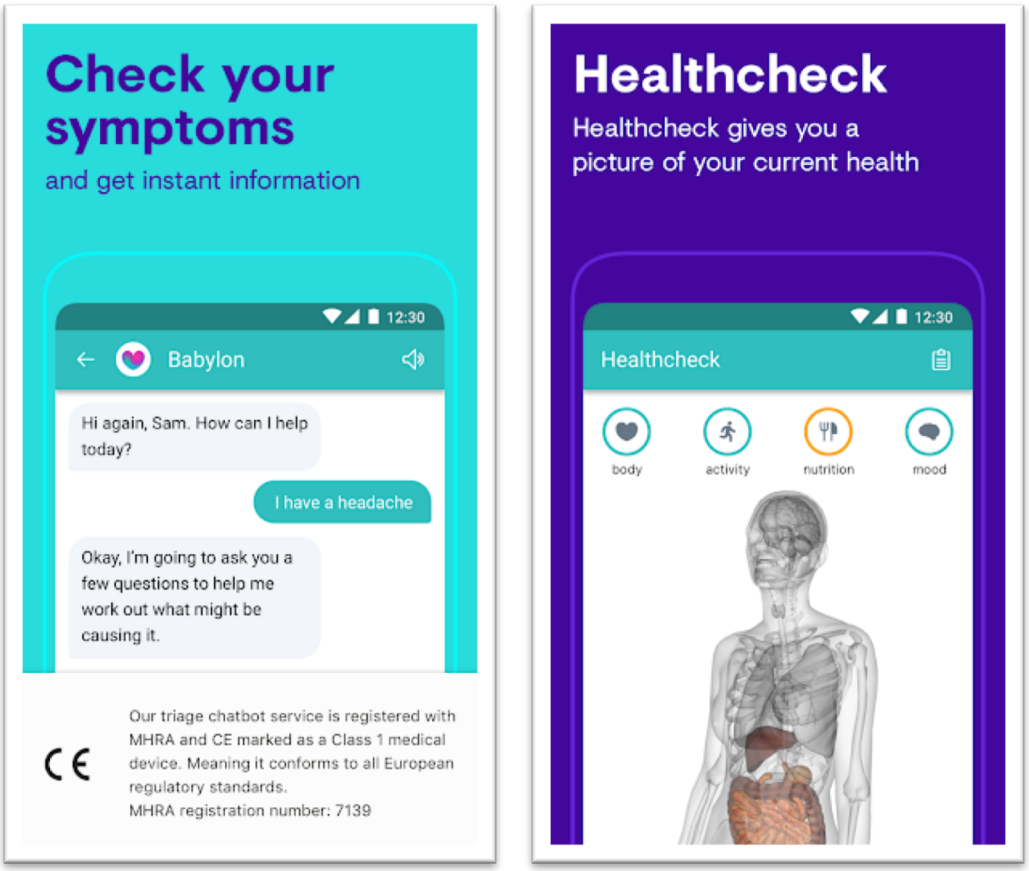


Figure 2.4: Balylon Health UI

Key features are given below:

- Always available to speak with qualified doctors
- Video call and physical appointments
- Electronic Prescription and medicine delivery
- Refers to specialists
- Doctor notes and video appointments are always with you.
- Affordable to seek experts
- AI bases Symptom checker
- Babylon health check, a new checkup tool
- Health monitoring system

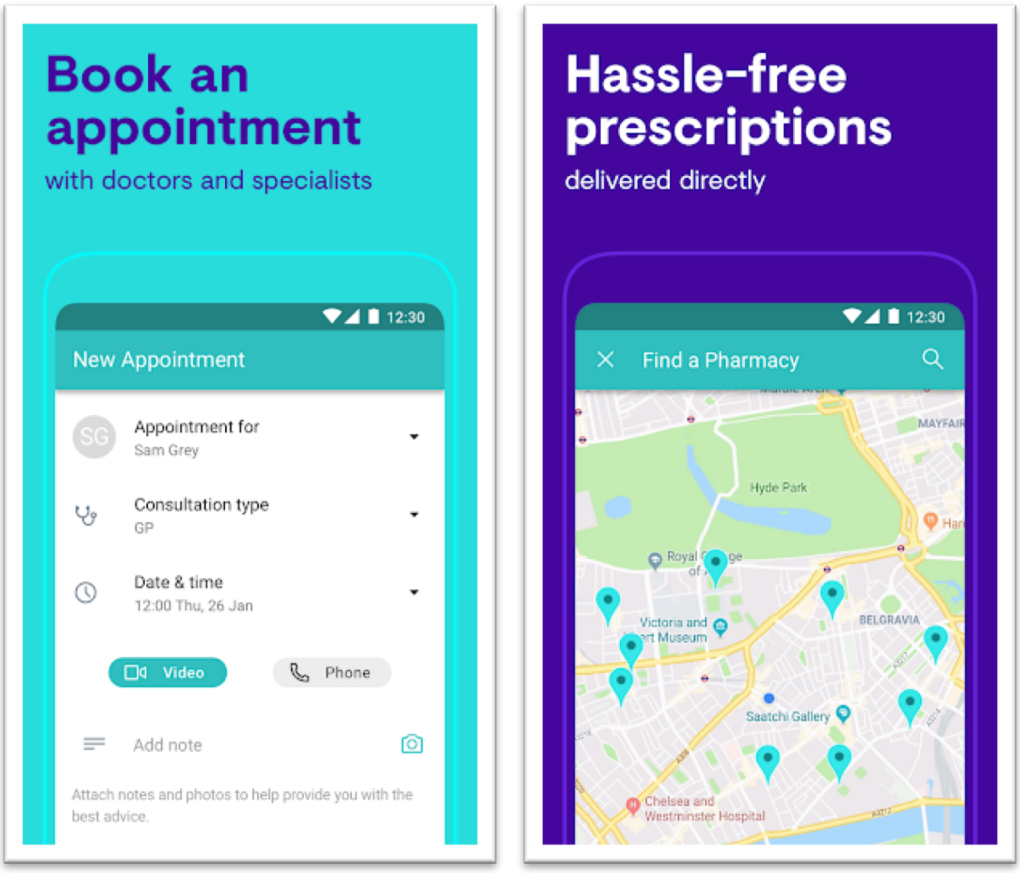


Figure 2.5: Balylon Health appointment and prescriptions

2.2.1.4 Florence

Florence is another chatbot widely available in different social media/app such as Facebook Messenger, Skype, Kik is known as a personal nurse. She reminds patients to take medication when it's time, all she needs the prescription of the patient. There are other significant features, for instance, finding the nearest pharmacy or doctor's office, keeping track of the patients' condition makes her a perfect virtual nurse.

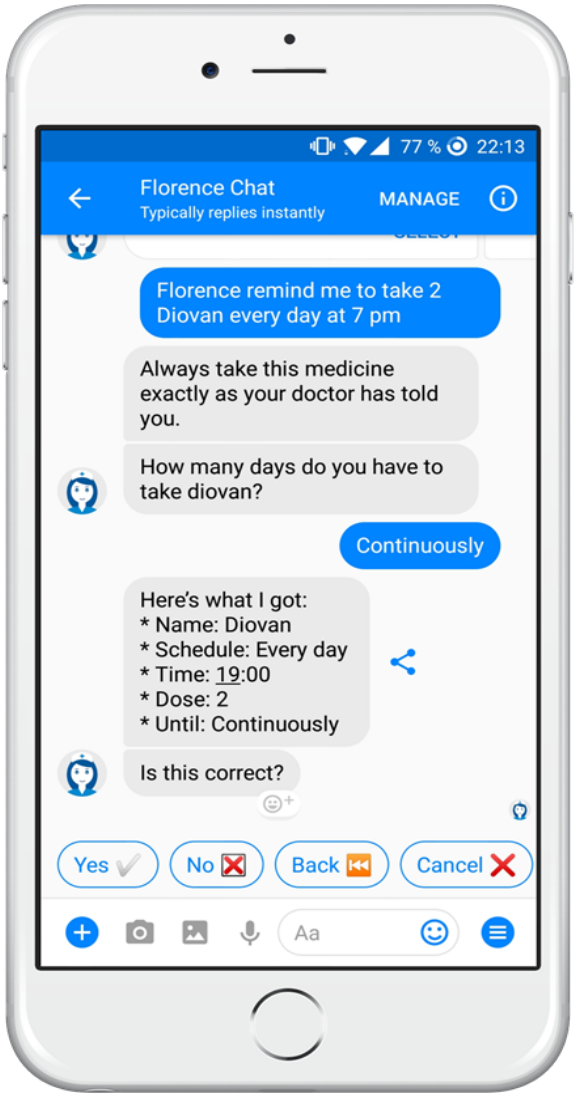


Figure 2.6: Medication reminder

Key features are given below:

- It will remind you to take medication
- It can help you to track your weight, mood and period
- It provides information about diseases
- Finds doctor or pharmacy
- It learns from user interaction

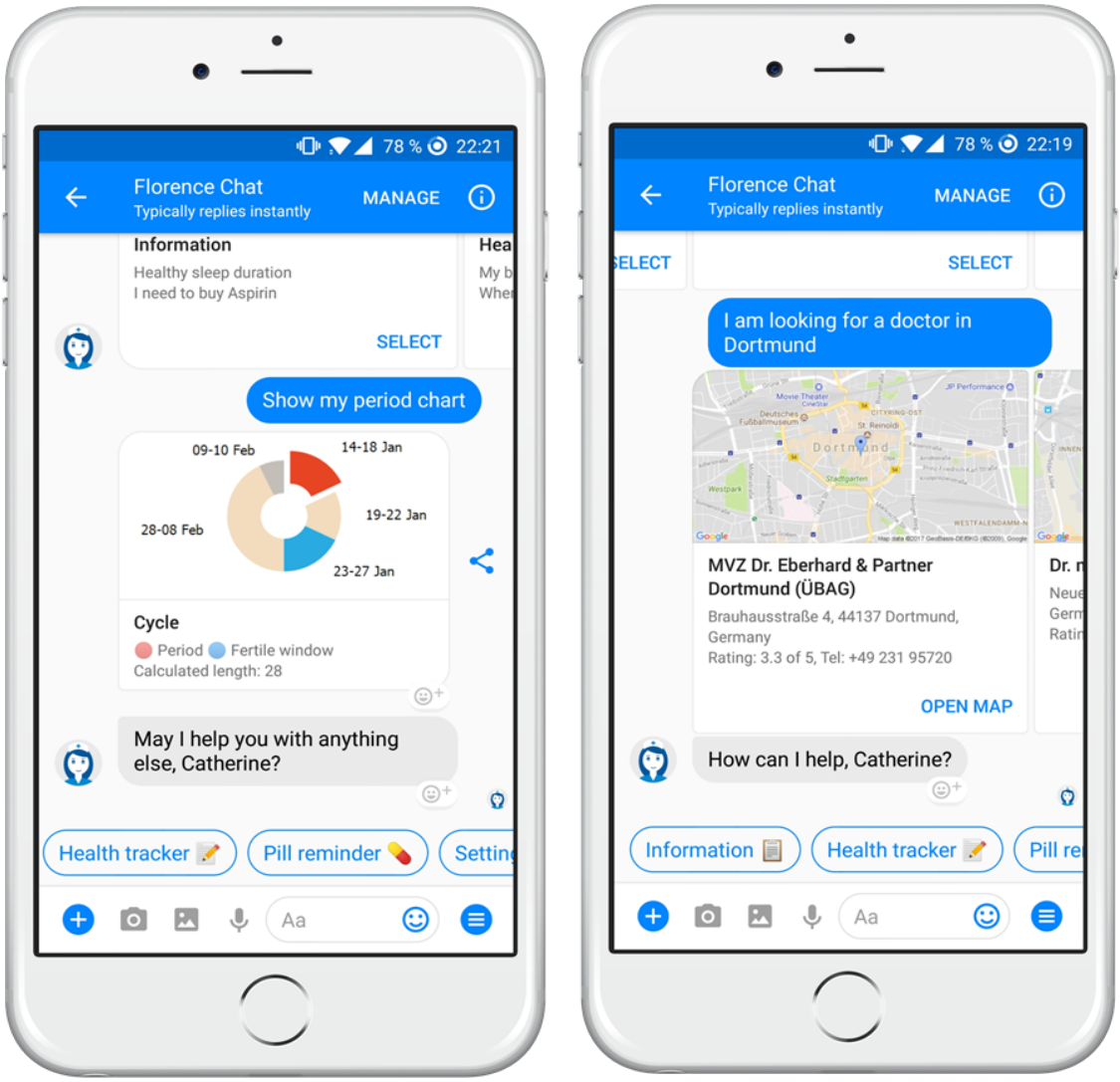


Figure 2.7: Health tracker and additional features

2.2.1.5 Your MD

Your MD is another form of AI that provides relevant health information was awarded for "Innovations that can improve society" in 2017. This service is also available through various communication app such as Facebook messenger, Slack, KIK, telegram. It offers a symptom-based classification of diseases, pharmacies, test centers, doctors' office or recommendations for mental health apps.

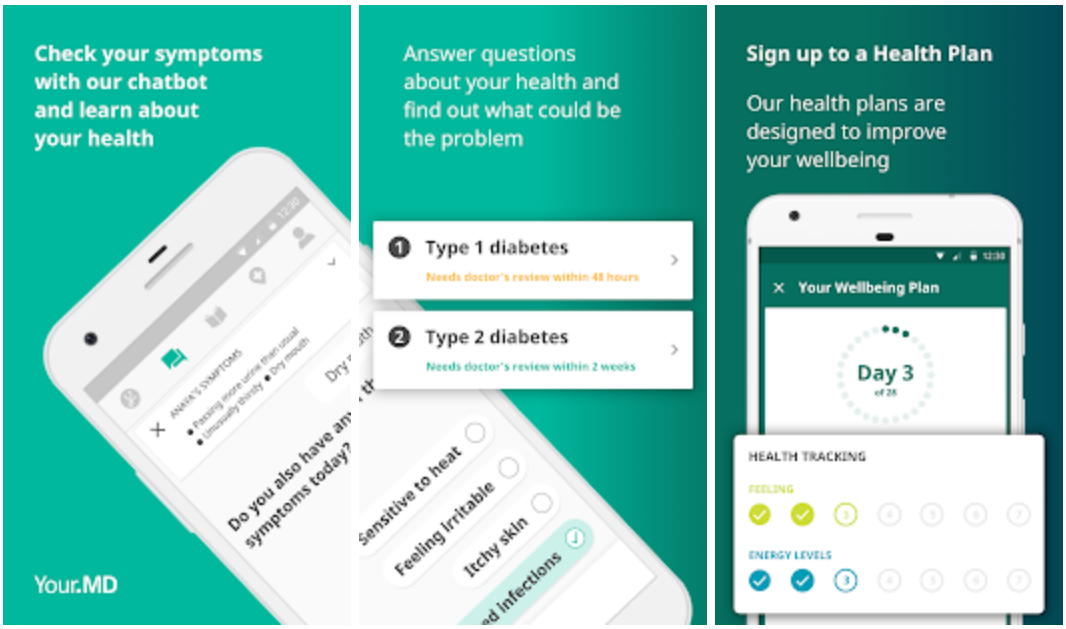


Figure 2.8: Your MD initial UI

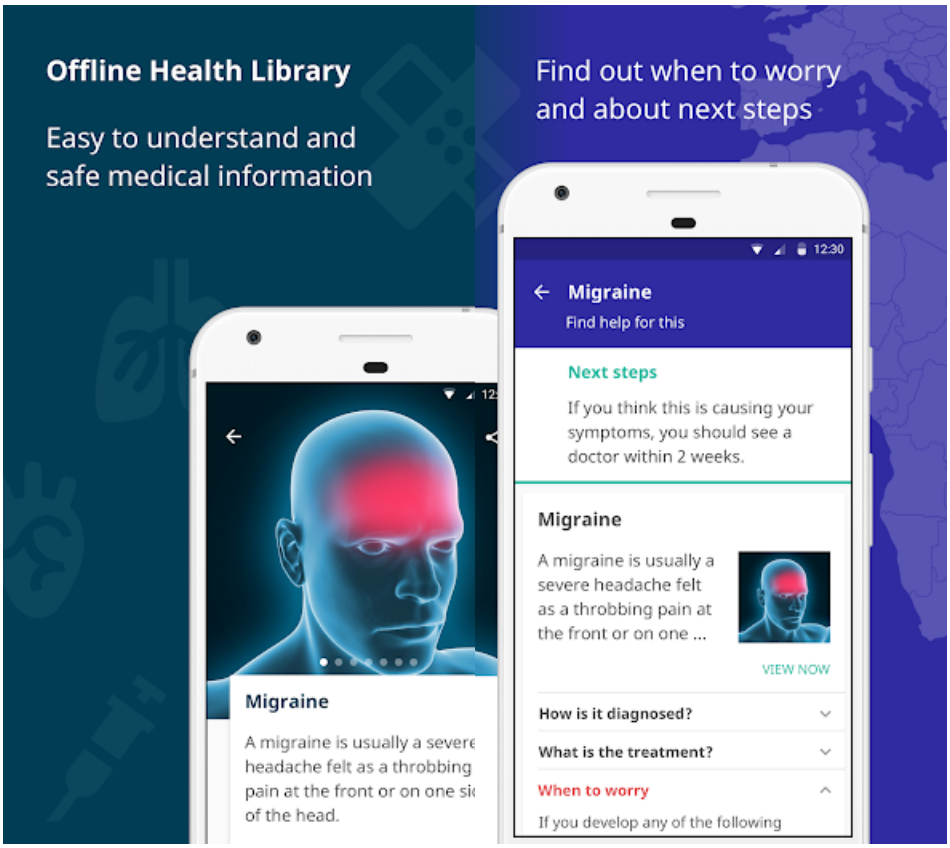


Figure 2.9: Your MD showing information about migraine

Key features are given below:

- Checking symptoms
- Asking questions about health issues
- A library for health information
- Finding best doctors and services
- Symptom tracking, monitoring user pain and mood etc.
- Passionately takes care of certain diseases

2.2.1.6 Ada Health

Ada, a mobile app, intelligent health companion app helps patients to diagnose diseases based on relevant procedural questions using its' vast A.I.-based database. It was designed to be the future of standard diagnostic tool according to Daniel Nathrath, CEO of Ada health. It also helps to track symptoms.

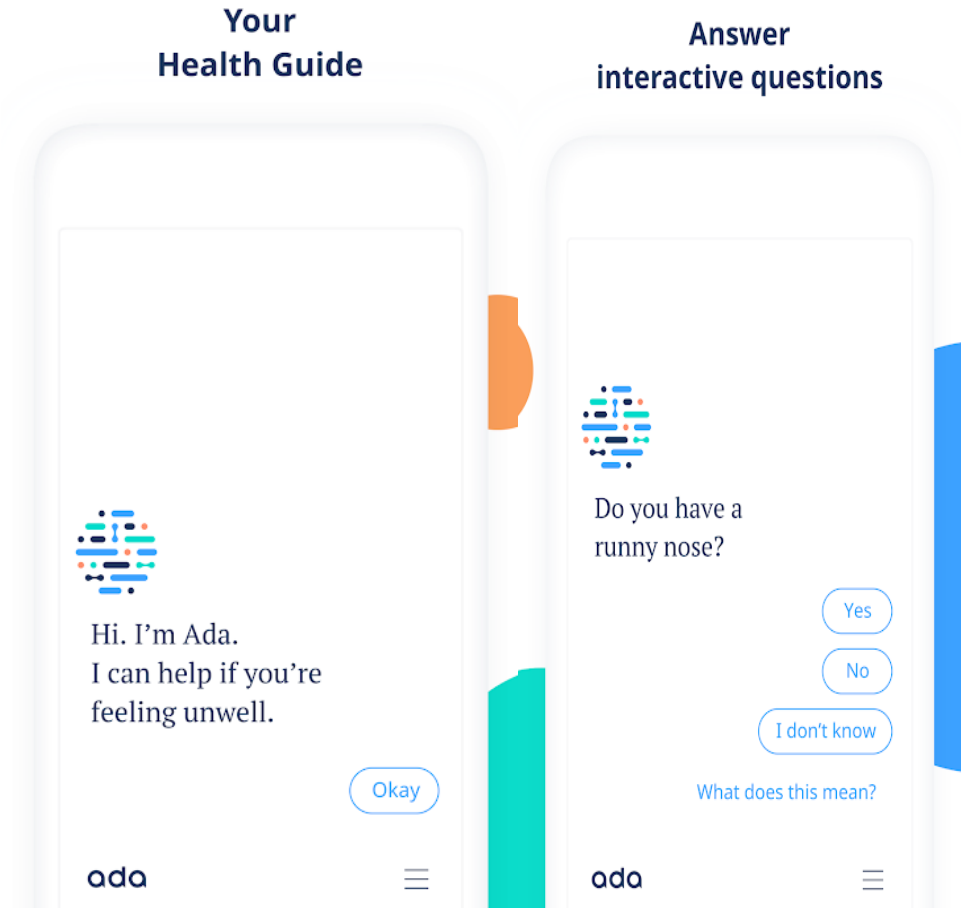


Figure 2.10: Ada asking interactive questions

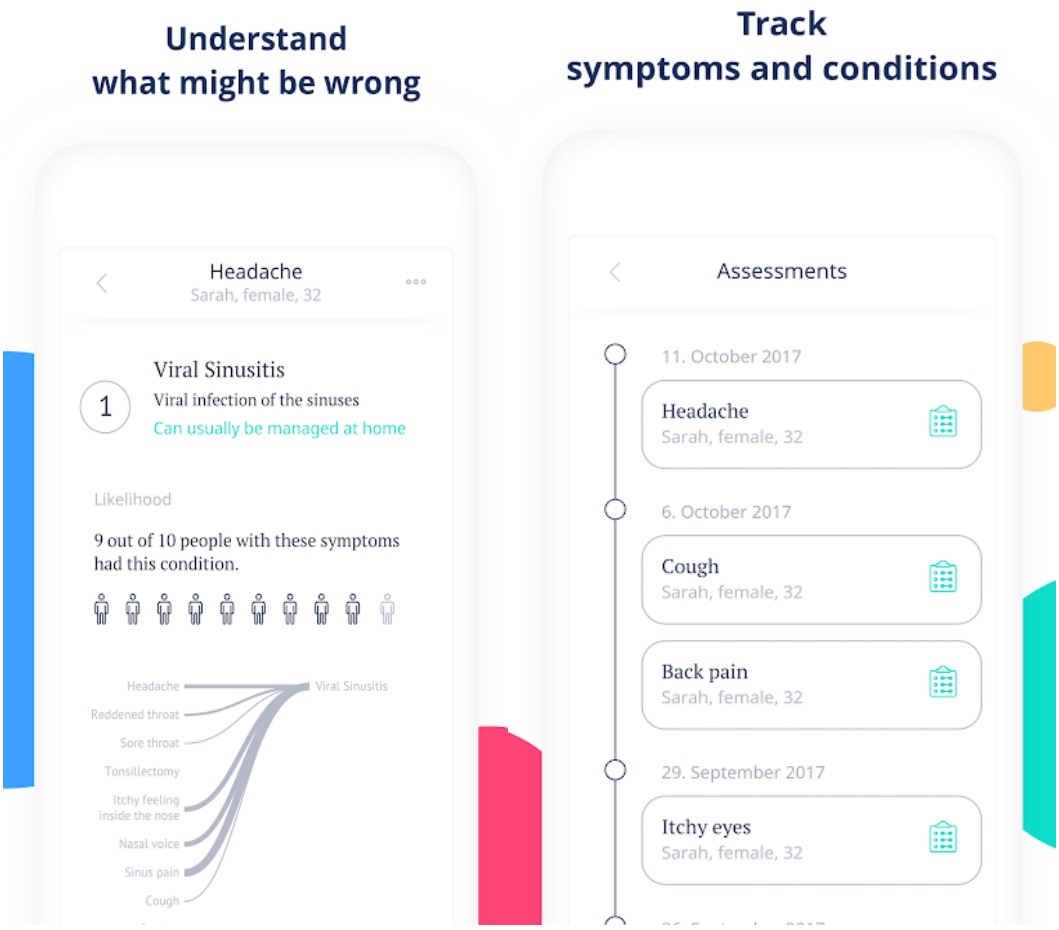


Figure 2.11: Ada predicting diseases based on questions

Key features are given below:

- Friendly UI
- Asks relevant questions like a professional
- Keeps knowledge about you
- Learns from history
- Understands patient health problems
- Keeps vast knowledge about a lot of diseases
- Tracks certain symptoms periodically
- Predicts disease based on statistics and user issues

- Explains questions if user doesn't understand
- Asks question using pictures
- User can input intensity level using sliders
- Keeps mind if you already have certain diseases and your age, sex.
- Developed by experts
- It has a huge database correlated with symptoms and diseases.

2.2.1.7 Ask NHS/ Sensely

Most of the systems are based on textual information where Molly can interact with users through different means like speech, images, video and combining all the data it defines users' symptoms and recommends diagnosis. It focuses on the self-care but refers to doctors when it's urgent for a patient.

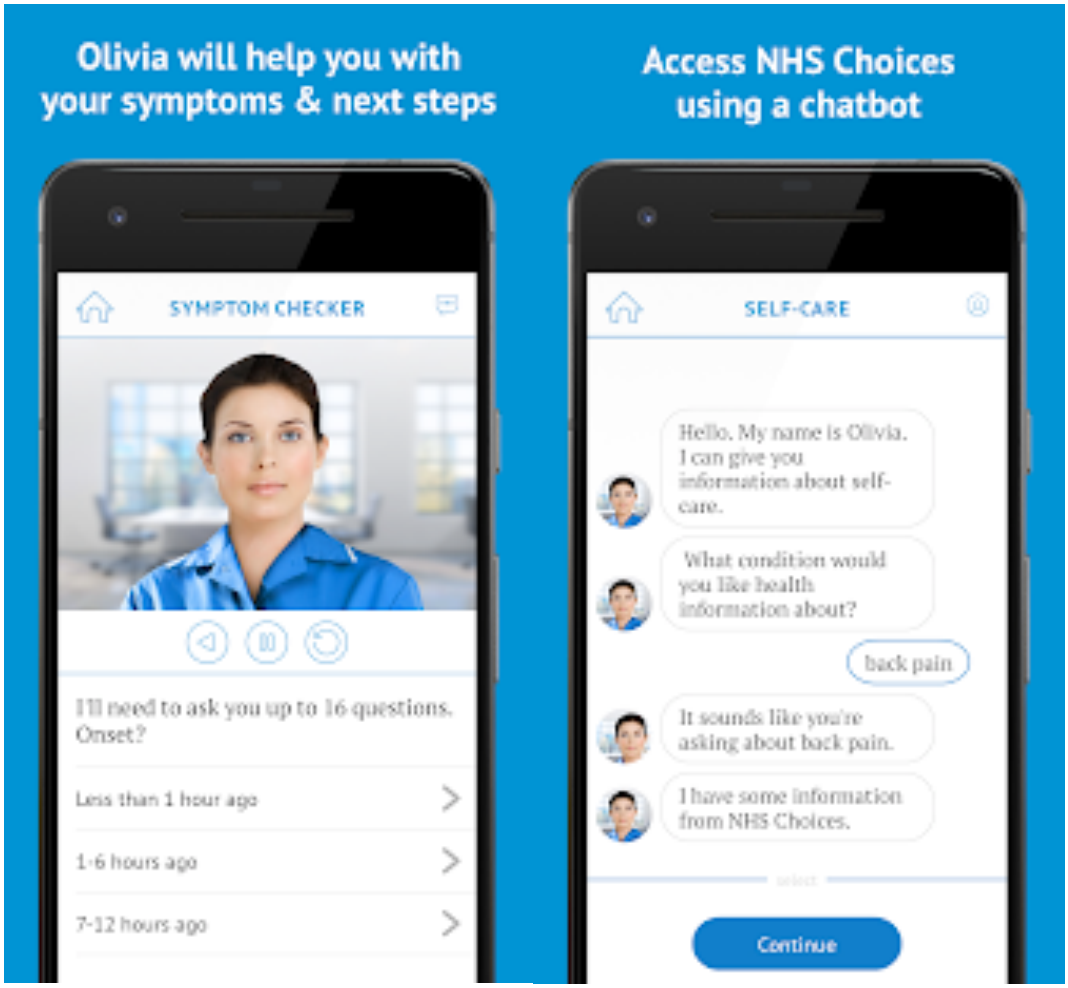


Figure 2.12: ASK NHS initial UI

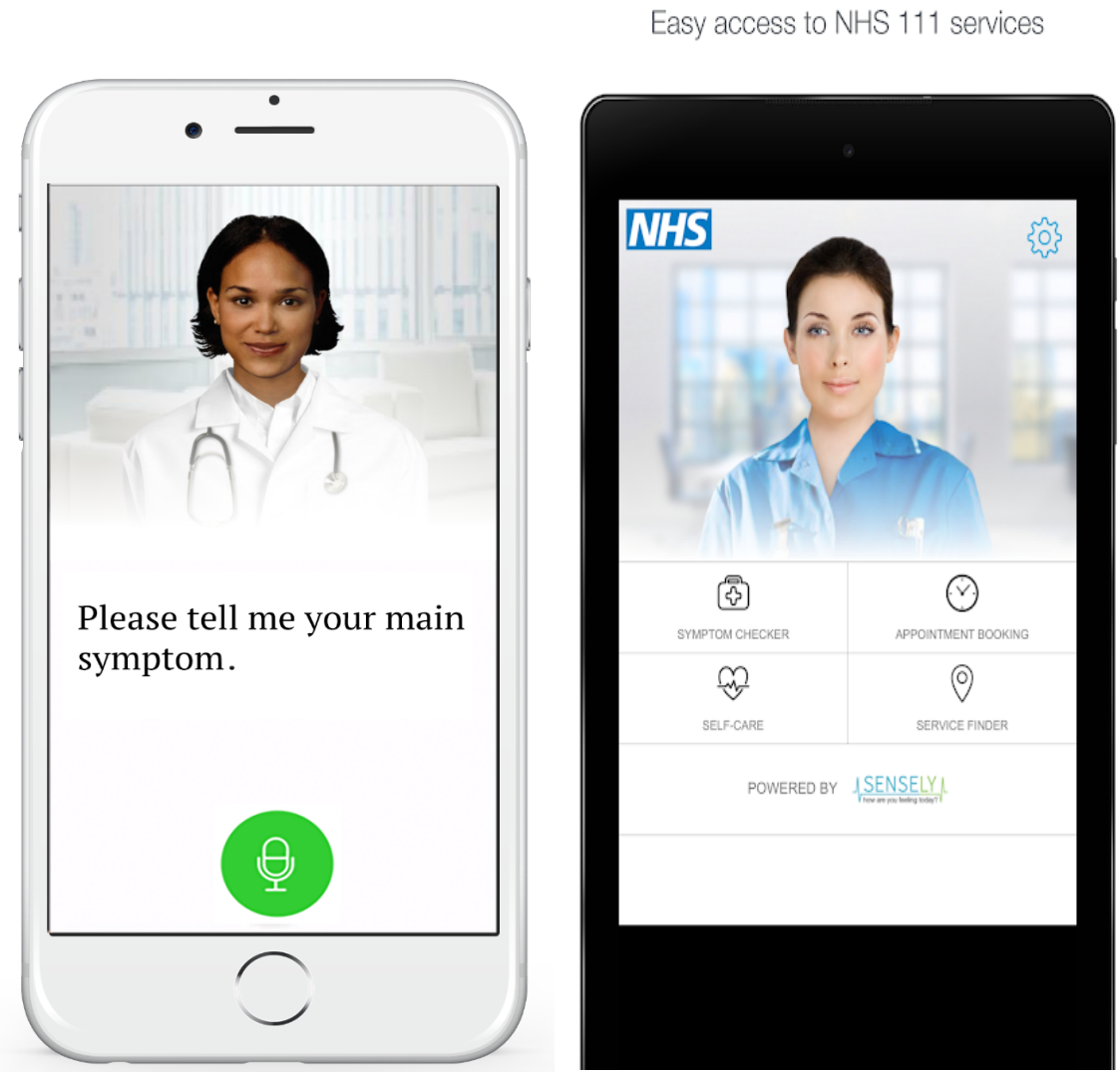


Figure 2.13: Molly is ready to listen to you

Key features are given below:

- Friendly UI
- Asks relevant questions like a professional
- Speech recognition
- Text to speech
- Images and videos
- Data integration

- Device integration
- Symptom triage
- Service locator
- Selfcare

2.2.1.8 Buoy Health

Buoy Health is another web-based chat bot for patients which asks details about medical state and offers medical steps. It is trained on 18,000 medical papers and 5 million patients' example and around 1700 conditions which makes it quite sophisticated.

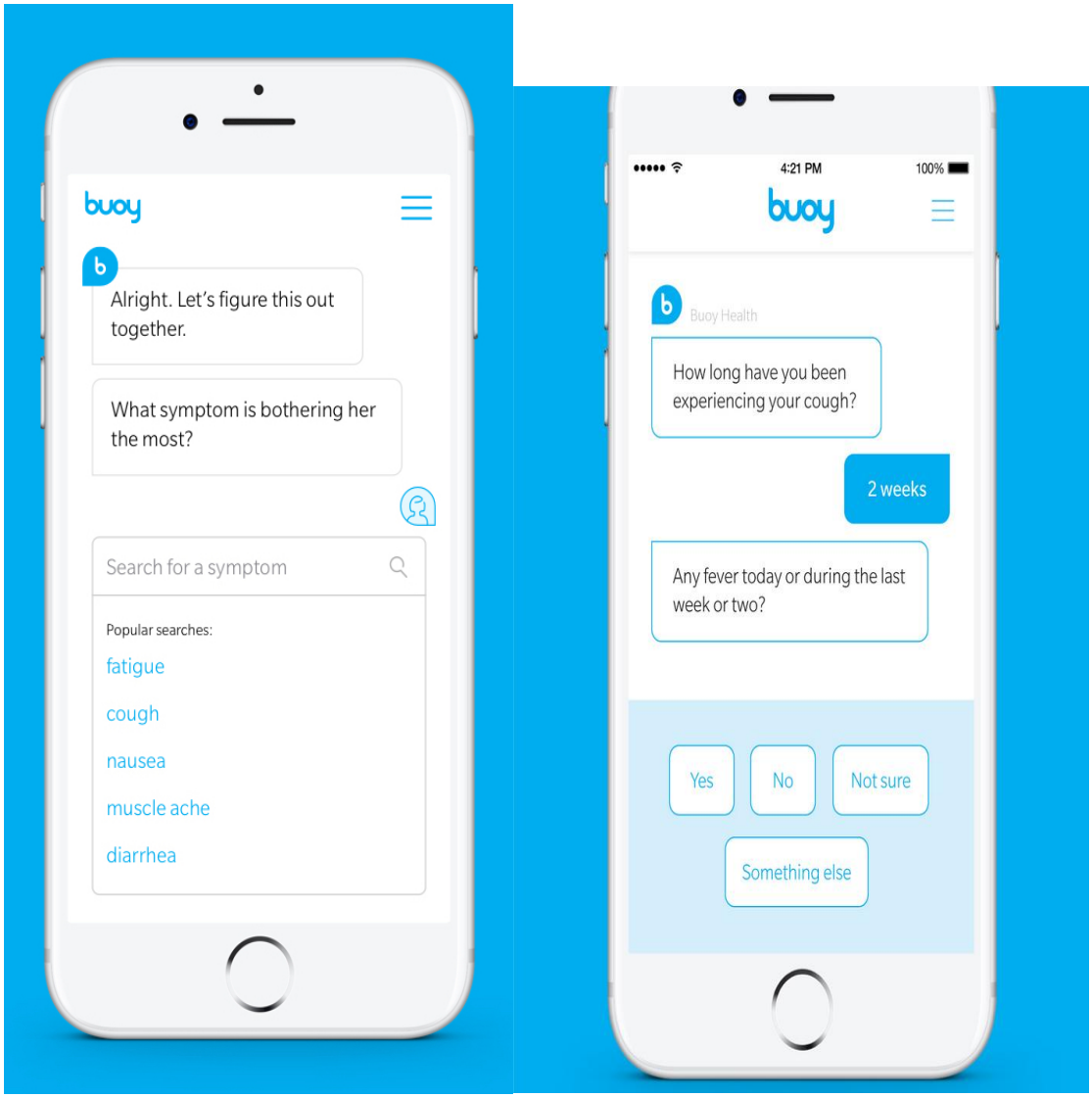


Figure 2.14: Bouy Health is asking interactive questions

Key features are given below:

- Web UI
- Asks relevant questions in a friendly way
- Symptom checker

2.2.1.9 Infermedica/ Symptomate – Symptom checker

Infermedica is another platform of symptom checker standing on the technology of machine learning. It is available on the mobile phone and online where users can communicate with it as a chatbot or voice-based app. It also provides a diagnosis based on the symptoms and provides the appropriate course of actions, recommendations.

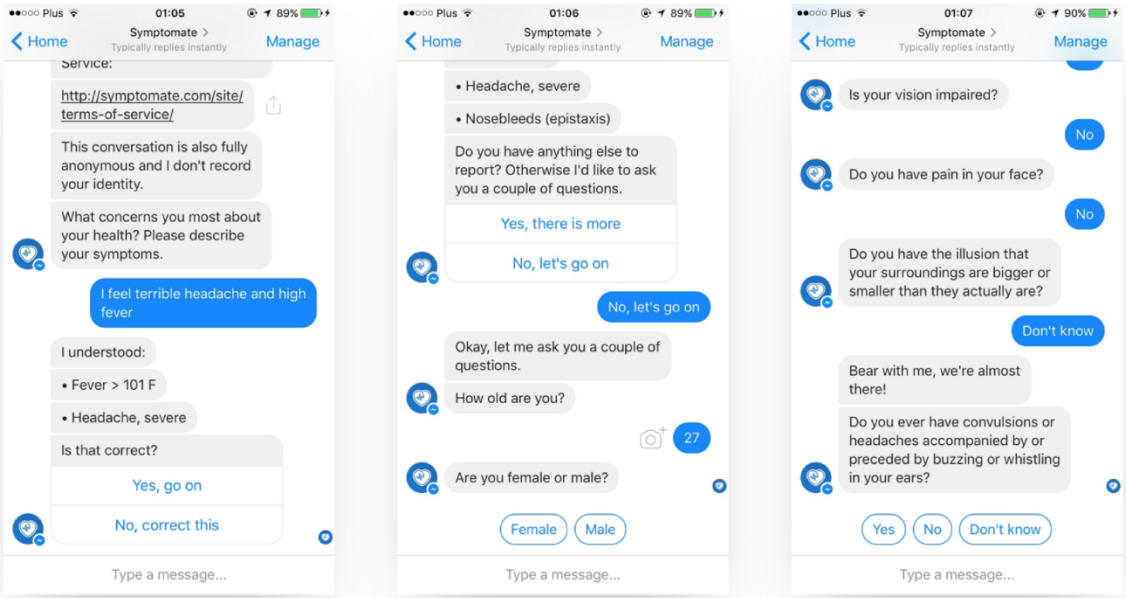


Figure 2.15: Infermedica asking interactive questions

Key features are given below:

- Symptom checker
- Learns from user interaction

- Verified by experts
- Millions of successful assessments
- Available in series of languages
- User don't need to signup
- API availability for developers

2.2.1.10 GYANT

GYANT is a growing healthcare chatbot platform which provides diagnoses with help of doctors by understanding the problems and symptoms of the patients. It also offers real-time prescribed medicine. It speaks Spanish, Portuguese, German, including English and available on Facebook messenger or Alexa. It is also expected to be available in all chatting platform soon according to its' team.

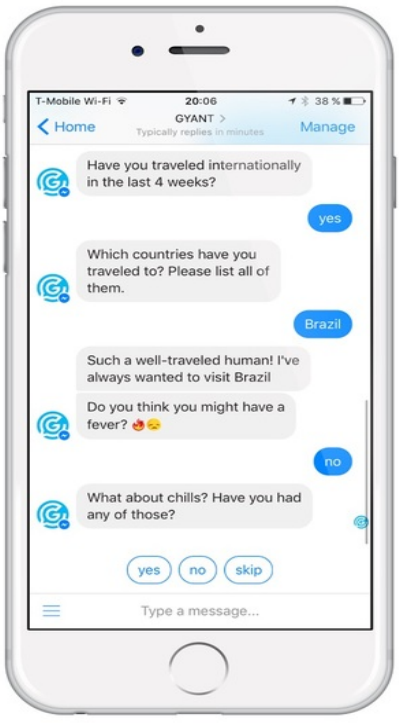


Figure 2.16: GYANT chatting with patient.

Key features are given below:

- Symptom checker
- Learns from user interaction

- Contact with doctors
- Descriptive questions with icons
- Emotional reactions

2.2.1.11 Bots4Health

Bots4Health stated its' journey with a targeted platform to help young women introducing sexual and reproductive health information named "Eva" in 2016. After that they updated the app with a widened target audience and The Neon Project -conversational UX solution transformed into EVA.

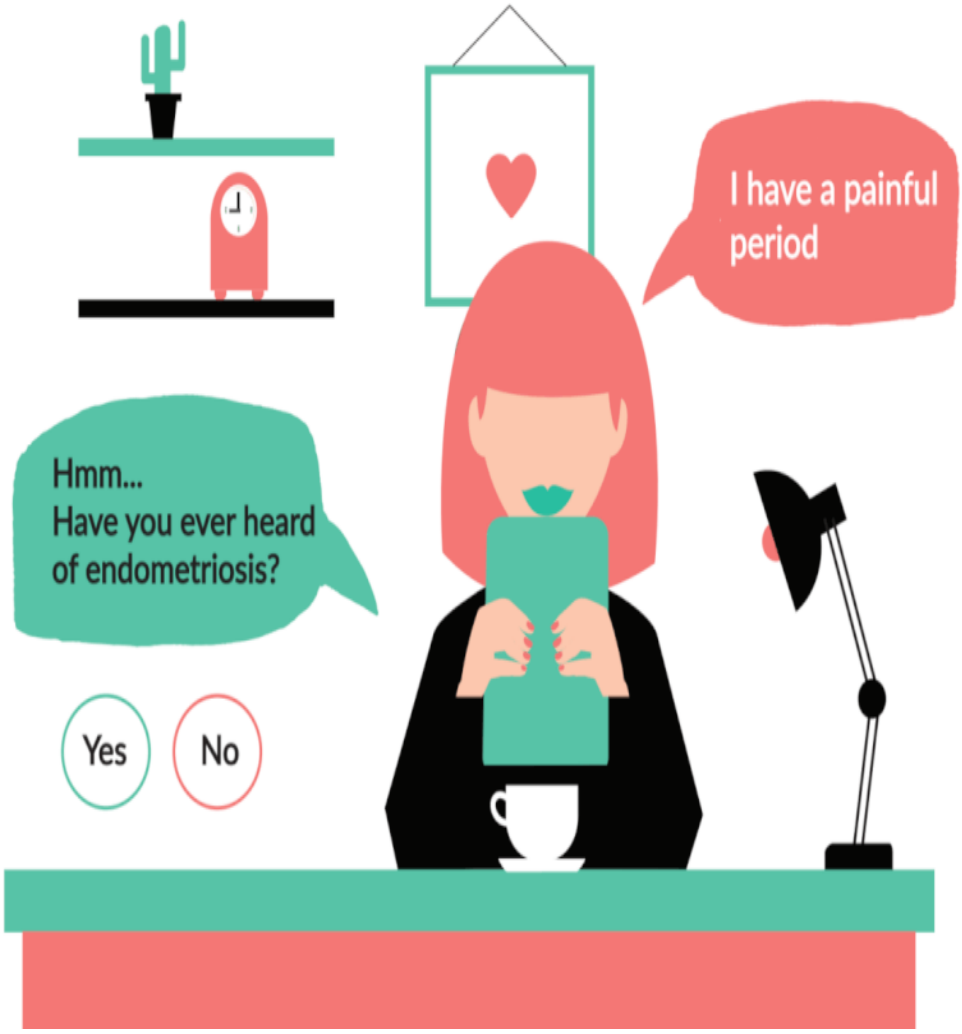


Figure 2.17: Bots4Health Initial UI

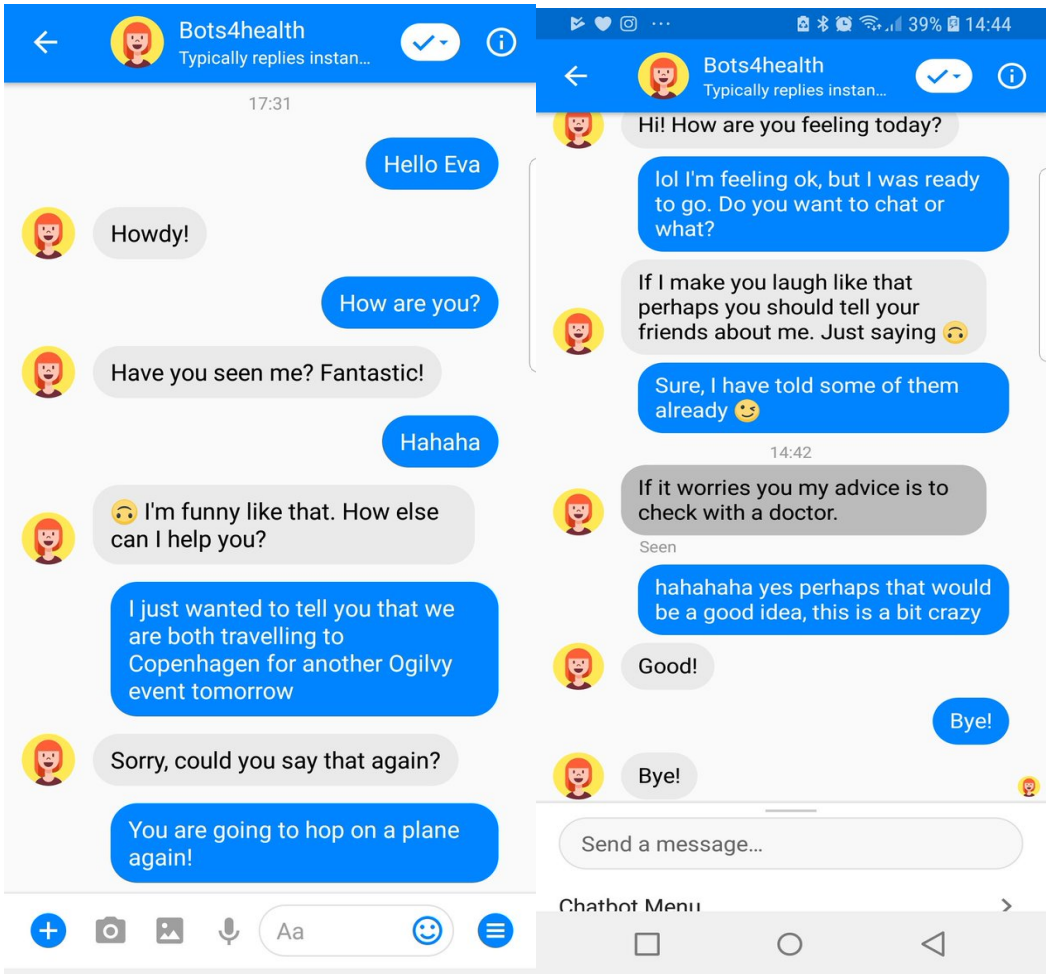


Figure 2.18: Bots4Health chatting in Facebook

Key features are given below:

- Symptom checker
- Friendly and available in messenger
- Different artificial entities

2.2.1.12 Cancer Chatbot

Cancer chatbot is designed for cancer patients providing chemo tips and trips to free service. Caregivers, friends, and family get resources, advice about what to say and how to help cancer patients.

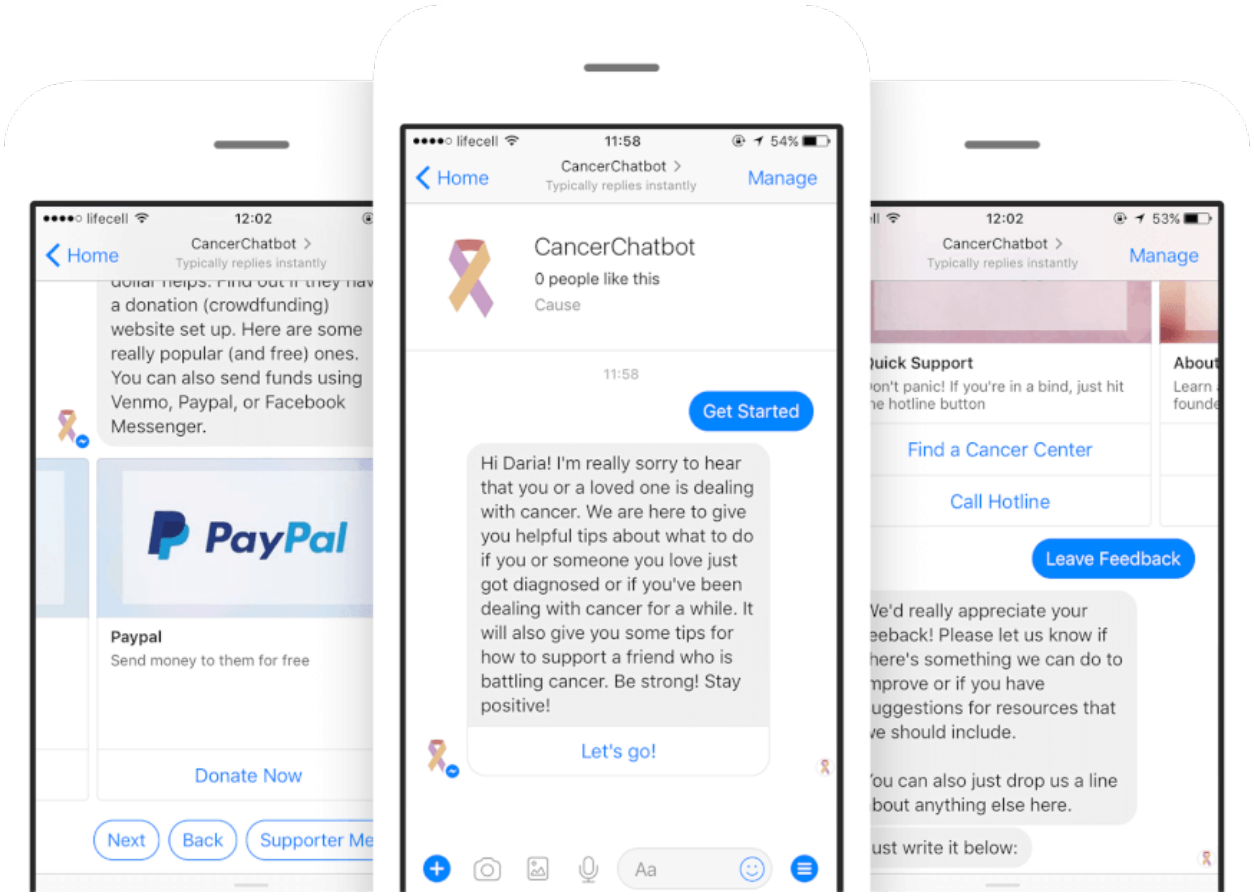


Figure 2.19: Cancer Chatbot chatting in Facebook

Key features are given below:

- Symptom checker
- Friendly and supportive
- Provides information how to take care of patients
- Finds relevant cancer center with phone number

2.2.2 Existing systems for EHR

Many hospitals around the world are already using EHR with their personalized way. Moreover, health IT giants Cerner and Epic appearing to dominate the majority of the industry, other tech giants are also following and developing a sophisticated system. New market research

projects that, from 2017 the EHR market will grow 5.2% by 2021, which will lead $5.2 billion. On the other hand, clinical decision support will grow 12.2% over the next five years.
Among all, here are some renowned existing systems for EHR:

2.2.2.1. ADVANCEDMD

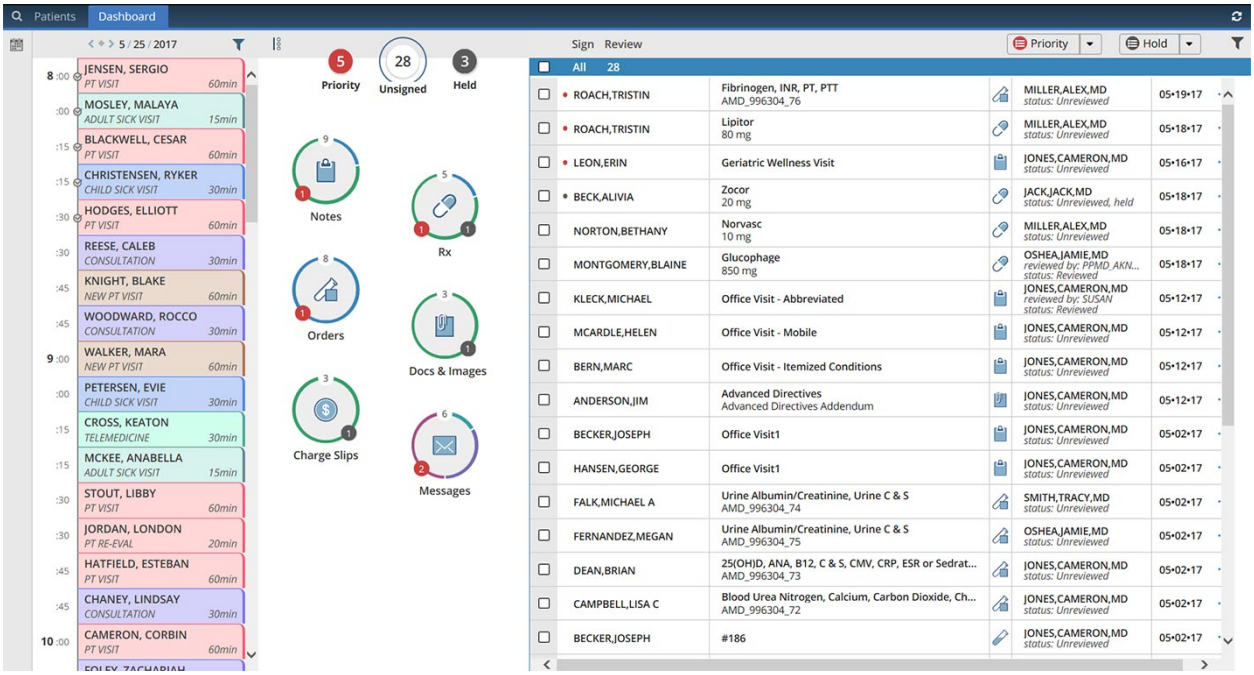


Figure 2.20: AdvancedMD Dashboard

Since 1999 they are providing service on EHR. Among the solutions they provide, some of them are EHR, telemedicine, practice management, patient engagement, analytics reporting, and physician-performance benchmarking. So far, they have served more than 22,500 practitioners across 8,000 practices. They also provide a mobile app for EHR. Their feature of managing information & by converting a manual fax process to paperless is the part of OCR.

2.2.2.2. ALLSCRIPTS

Although ALLSCRIPTS started with their own EHR solution (Sunrise EHR), later they newly-acquired Paragon EHR solution, after buying out McKesson's Enterprise Information Solutions (EIS) business in 2017. Now they are planning in a bigger way to hit the market in 2018.

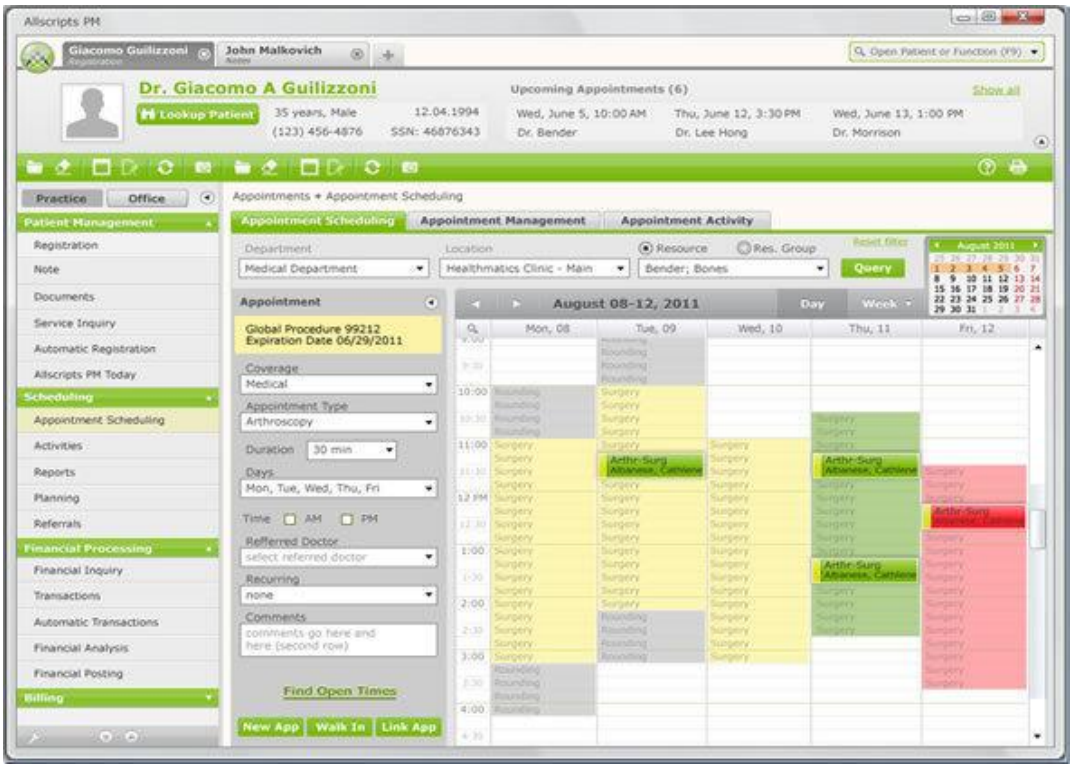


Figure 2.21: AllScripts Patient Profile

2.2.2.3. ATHENAHEALTH

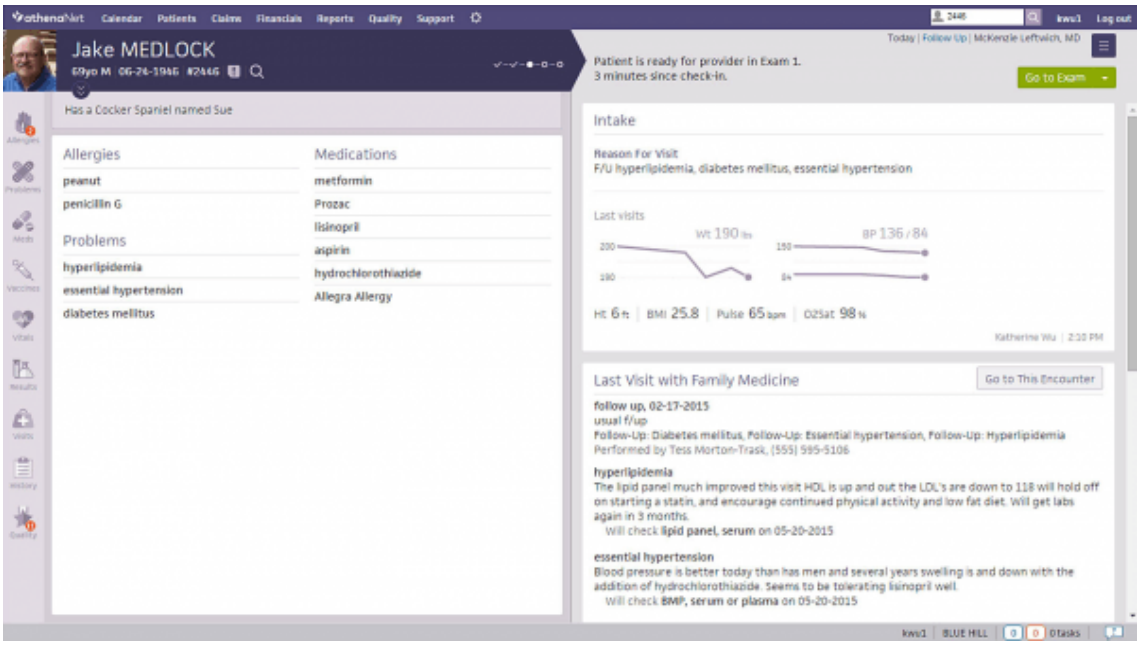


Figure 2.22: Athenahealth Dashboard

ATHENAHEALTH focused on a different way. They provided their solution to meet the needs of rural hospitals, community hospitals, and critical access hospitals (CAHs), which notoriously struggle to keep up with other care settings in advanced EHR use. This way, they also got 5 percent of financial gains over baseline.

2.2.2.4. CERNER CORPORATION

In the enterprise EHR giant, the name of CERNER Corporation pop up frequently. For an example, recently they made a game-changing contract with Amazon to further enhance its EHR and population health management offerings. They have been working for both in the public sector, scoring EHR implementation deals with the virtual assistant and the government sector with the Department of Defense, USA.

2.2.2.5. OpenMRS

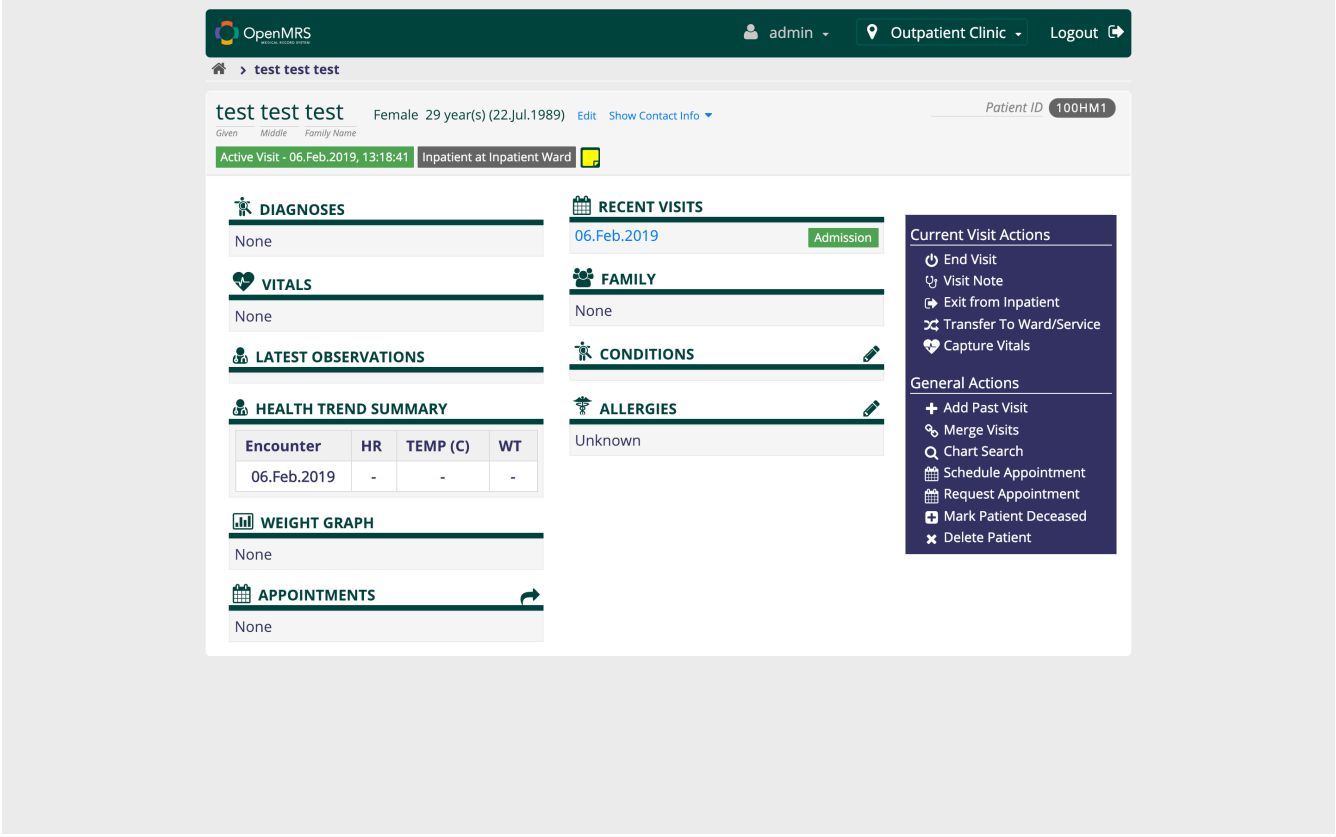


Figure 2.23: OpenMRS Patient Information Page

OpenMRS is an open source Electronic Medical Record system. This system is contributed by community volunteers from many different backgrounds including technology, health care, and international development from all over the world. They are all moving towards their goal by working together as a global community to create and support this software for improving health care delivery in resource-constrained environments.

2.2.2.6. BAHMNI

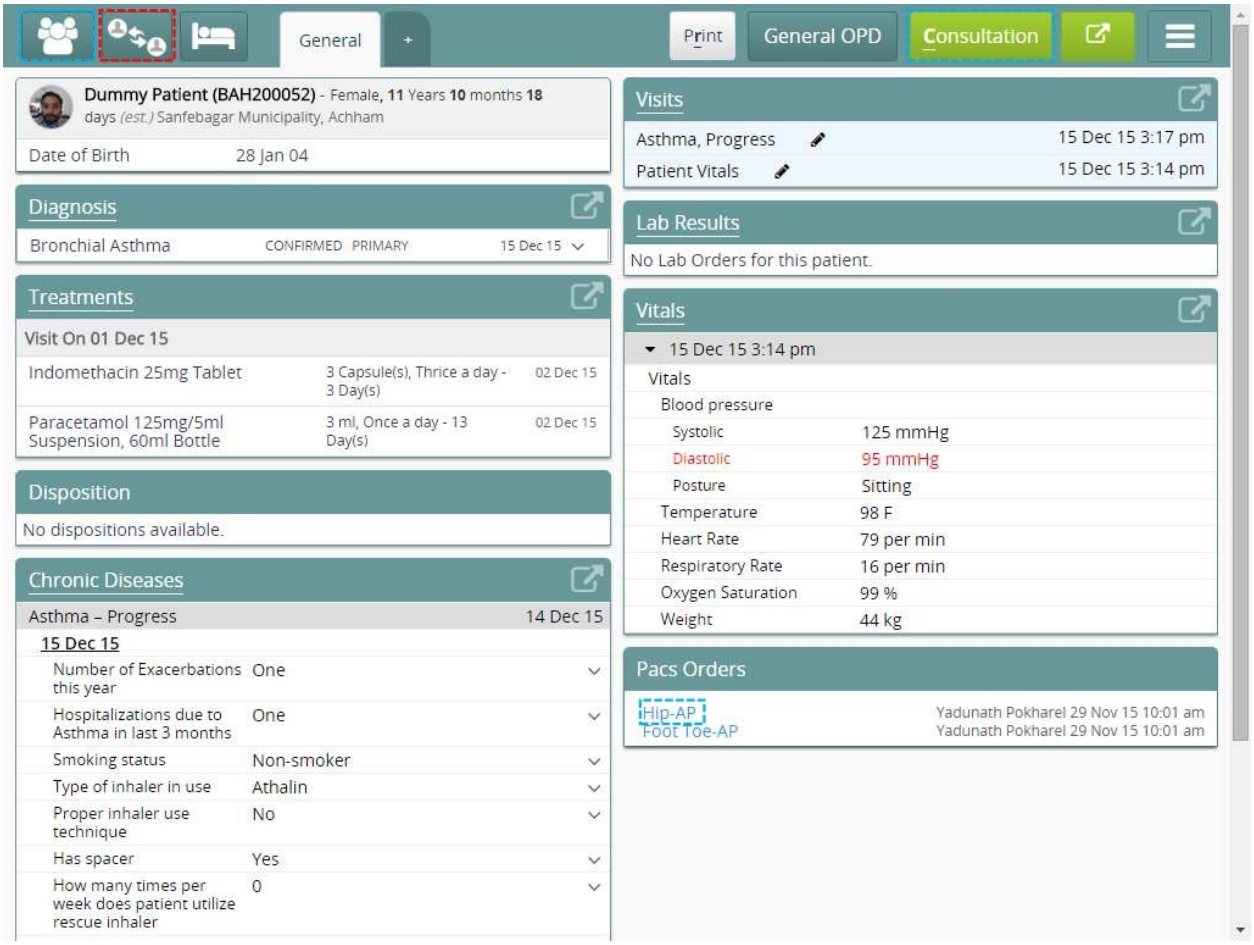


Figure 2.24: Bahmni Patient Details

Bahmni is one of the largest and popular system in the EHR industry as it's a combined and enhanced version of existing open source products into a single solution. It combines OpenMRS, OpenERP, OpenELIS, DICOM and PACS. It's popular mostly because of it's appropriate infrastructure, adaptability, flexibility, intuitively design and it's an integrated solution.

2.2.2.7. CGI

CGI serves more than 230 hospitals (as per record until 2018). This health IT company provides health systems with an EHR solution designed to enable an enhanced patient experience and faster, more accurate, less invasive diagnoses. They optimize their solution such a way to assist in reducing unnecessary procedures and re-admissions.

2.3. Conclusion

There are certain things we realized after studying these existing chatbots and electronic health care systems that most of the applications are regional and dispense information on a specific scenario. As there is geographic difference, the likelihood of a disease dissents. To contrive an enlightened system, we need to accrue empirical data from different sources. This includes creating an intelligent algorithm based on existing knowledge, deduction and also with the assistance of the domain expert.

The chatbots aren't really designed for Bangladeshi people and the referral system always shows international results which will be quite an issue for Bangladeshi people. There's another issue which is communicating with an expert is a tedious process. The studied electronic health care systems also lead some flaws as they are not publicly available and only works on certain domain. Another major fact that those systems are not as robust as they should be as we already have QCR technology with a very promising accuracy.

3. Electronic Health Record (EHR)

3.1. Introduction

According to the definition from Wikipedia, an electronic health record (EHR), or electronic medical record (EMR), is the systematized collection of patient and population electronically-stored health information in a digital format. Electronic health records can be shared across different health care providers and organizations like doctors, specialists, laboratories, medical imaging facilities, pharmacies, emergency facilities, and even school and workplace clinics, so that they can maximize a patient's care. Primarily, the purpose of electronic medical records is improving the quality of care by collecting and storing medical information in electronic format[7]. It provides information instantly in a real-time and patient-centered record to only those persons who are authorized to access those data [8].

An EHR system is built to go beyond standard clinical data collected in clinic, hospitals, diagnostic centers and can be helpful of a broader view of a patient's care. EHRs can contain a patient's diagnoses reports, laboratory test reports, history of medications, history of medical records, treatment plans, allergies, treatment plans and so on.

EHR not only stored in the textual format but also can store various other formats including graph, image, tabular, chart. It may also contain a range of data, including demographics, medical history, medication, laboratory test results, radiology images, vital signs, personal statistics like age and weight, and billing information [9].

3.2. Why EHR

One of the key features of an EHR is that medical record or health information can be created and managed by authorized providers in a digital format and it's also shareable with other authorized person or authorities across more than one health care organization in the sake of patients care. Records can be shared through email, mobile application, web server, enterprise-wide information systems or other information networks and exchanges [9].

EHR systems are designed to store data accurately and helps create a timeline to capture the state of a patient's medical history across time. So it helps a doctor or a specialist to take more appropriate decision. On the other hand, patient does not have to carry all the papers along with. This also reduces the risk of lost paperwork and data replication as there is only one modifiable

file or one source of information available. It's easy to find, operate, assists in ensuring data is accurate and legible and data is more likely up to date [10].

One of the interesting benefit of EHR is, they are more effective when extracting medical data for the examination of possible trends and long term changes in a patient. Moreover, large amount of data (population-based studies of medical records) can help researchers to contribute to the humanity, predict a nations medical threats and generating statistics report. EHRs are more effective and fast due to the digital information being searchable [10].

Although artificial intelligence is not that much advanced yet and it is not an alternative or replacement of a doctor, nevertheless, AI is already helping doctors and specialist to take appropriate decision and sometimes it also can suggest patients to prevent diseases and meet a doctor if necessary [11]. None of this possible without patient's medical record. So here, EHR is playing a vital role.

3.3. EHR in Bangladesh: Current Status, Challenges, and Future Direction

Bangladesh is no more staying behind in the sector of medical system digitalization. As we all know that extracted medical data using EHR can be the source of surveillance for communicable diseases which does need urgent intervention, maintain national epidemiological disease systems, etc, our government has started a new era in the health sector by introducing Information and Communication Technology (ICT) for health service delivery. In 2011, Population and Nutrition Sector Development Program (HPNSDP) 2011-2016 for Ministry of Health and Family Welfare (MoHFW) has been approved by the Government of Bangladesh, which is a 5-year long plan [12].

The Apollo Hospitals Dhaka (AHD) is a joint project of Apollo Hospitals India and STS Holdings Limited. They are an example of synergy of medical technology and advances in IT through electronic medical records aka paperless medical records. To track the patients and staff records, real time movement of high value assets, they are using RFID (Radio Frequency Identification) [12]. It has introduced tele-Health to create a connected community encompassing the patient, family and clinicians for improved outcomes, greater convenience and less expense for all.

On the other hand, both of Square Hospital and United Hospital are have a quite similar health information systems. For their patients, they are maintaining their own database systems,

which has added a new dimension to the development and communication of both the hospitals [13, 14].

3.4. EHR working procedure

EHR workflow starts with the registration of the patient. Respective authorities like clinic, hospitals, diagnostic centers, health insurance company or any other relative field office staff can register a patient through phone-in or when the patient walks into the clinic [11]. Even they can also be registered either by the patient or by their relatives. When a patient is registered, patient is also provided an account in the portal. Patient shares their medical history and documents, can fill-in the questionnaires (if need any) after logging in their account. This greatly helps the practitioners and other interested authorized users to provide service and can make informed clinical decisions for better health care, because this information can be instantly accessed by them in the patient chart during the consultation. Even, EHR can supports template creation for commonly used prescriptions, supplements, lab work, and diagnosis, allowing rapid data entry into the system, which dramatically reduces the time for text entry. In addition, it can capture old medical records by scanner or camera and convert them into text using OCR (Optical Character Recognition) [10].

EHR can support e-prescribing and patient can pick them up at the pharmacy directly reducing the patient wait time [10]. The benefits are, nurse or therapist, post-encounter can look up the chart note and carry out the procedures including medicine, injections, operation theater equipment etc [15].

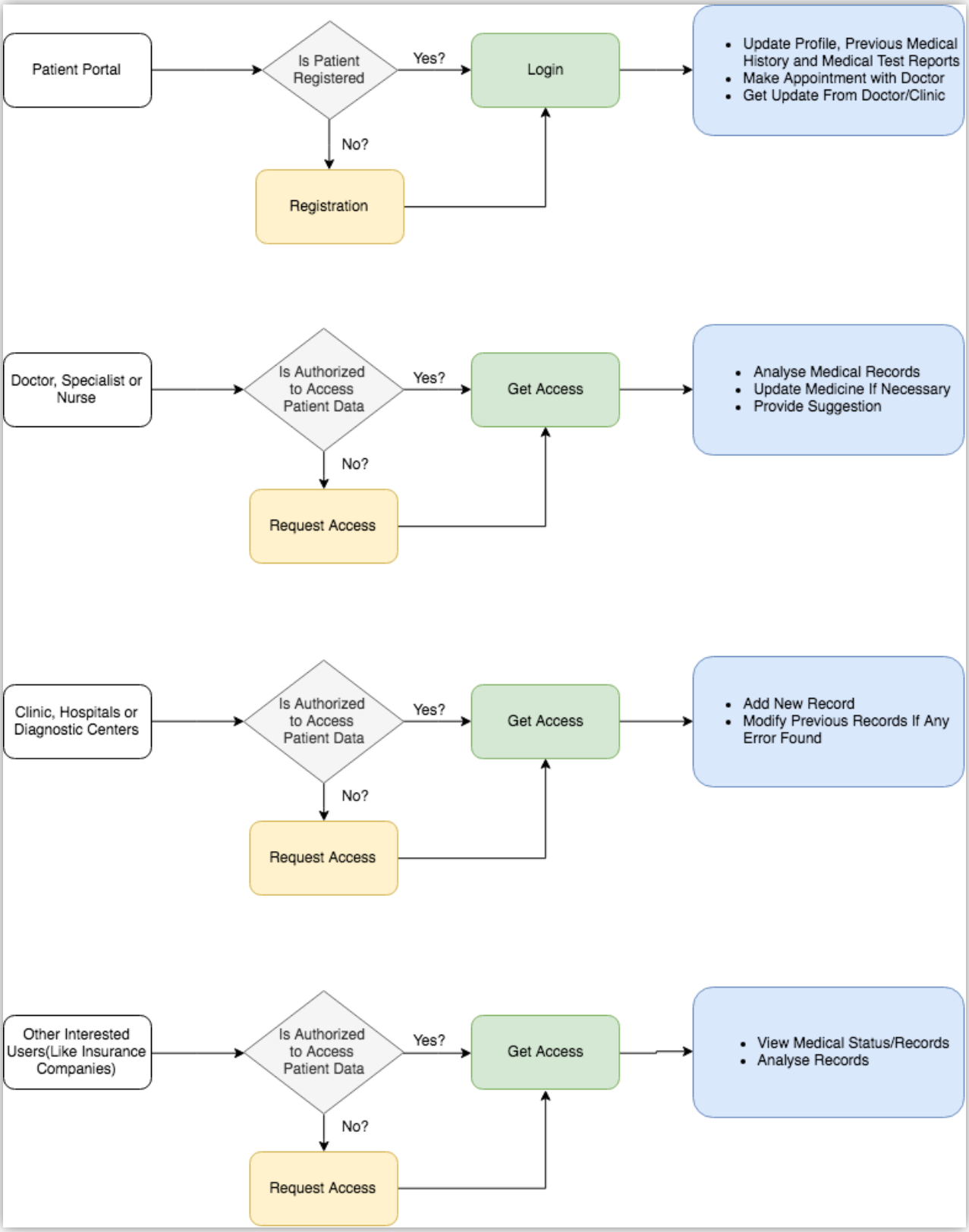


Figure 3.1: EHR working procedure

3.5. Conclusion

EHR has become one of the most important part of health system digitalization as we are still on the process of conversion of analog to digital. Most of the advanced hospitals, as well as developed country already using this feature as mandatory to provide better medical service to the patients. It's not that far that one day artificially intelligence doctor would take place of human doctor and provide better and more accurate health care than human doctors. But to train the AI, we need digitalized data, this is where electronic health record is going to play the vital role.

4. Smiley Bot

4.1 Introduction

Smiley Bot is a medical advisor that predicts diseases by taking symptoms and feelings as inputs from the patient or user. Inside smiley bot an AI driven agent resides which generates predictions based on the provided inputs. Smiley Bot also provides doctor information based on the prediction.

4.2 Purpose

The purpose Smiley Bot fulfills is to reduce ignorant self-medication by lessening the gap between the patients and the doctors.

In a developing country like Bangladesh, self-medication is a crucial problem. This can lead us to several medical situations similar to the followings

- Failure to seek appropriate medication
- Incorrect choice of therapy
- Incorrect route of administration
- Rare but severe adverse effects
- Loss of Life

If we give a closer look to the reasons behind self-medication we can find some common causes such as saving time and money, familiar symptom, lack of awareness etc. To select medication they depend on various unreliable sources. Based on a study in Bangladesh we can find the following statistics.

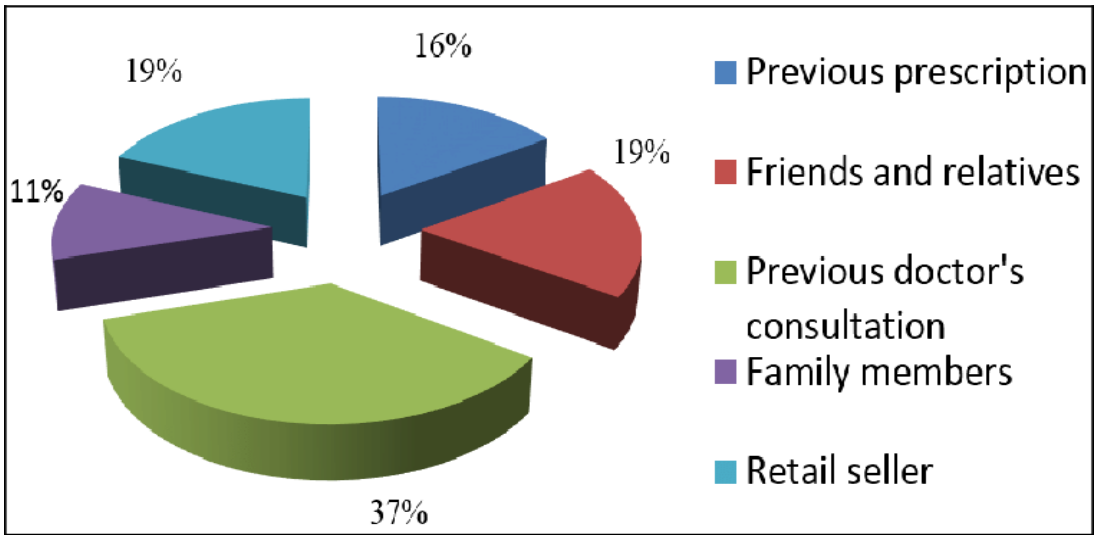


Figure 4.1: Self-medication advisors

In the following figure we can see that, most of the people (37%) uses previous doctor's prescriptions for medication. 19% depend on their family or friends for these decisions and another 19 % depend on the retail seller. This is where the concern comes in. None of the advisers are doctors and this makes self-medication very dangerous.

If we can provide an intelligent agent in place of those advisers we can mostly solve the problem. This is where Smiley Bot comes in. It can predict diseases from symptoms very quickly with high accuracy.

4.3 Features

The primary feature of Smiley Bot is to detect the disease that may cause the symptoms the patients is observing. For this it asks patient some questions about his/her health. The questions are asked using a natural language to mimic human conversations. Throughout the conversation Smiley Bot will try its best to gather as much information possible about the patient. After the user input, Smiley bot will process the inputs and do necessary calculations to generate some likely conditions of the patient. From this prediction the patient will get idea about whether he/she should consult a doctor or not. Smiley Bot does not replaces the role of the doctors. Smiley Bot can also suggest relevant doctor's information such as name, location, contact etc. to the patient. In fact, it

works as a bridge between the doctors and the patients. After a successful prediction it will provide the relevant doctor information to the patient. The patient can also choose to store his/her current condition in the database for future medical needs. Smiley bot also suggests primary treatment of a selected disease to tackle emergency situations. Another point to be mentioned is that, the patient must go through an authentication procedure at the beginning of every use. In a nutshell, Smiley Bot packs the following features.

4.4 Working Mechanism

The way Smiley Bot works is questionnaire. It asks the patient some most common symptoms and according to the replies it makes predictions. All the questions asked by the bot is generated in the conversation runtime. To preserve meaning of the question we had to understand the semantics of each and every symptoms and applied accordingly. Initially the patient is asked with very common symptom. The next symptom to be asked by the bot depends on the answers of the previous answer. Sometimes complex symptoms arises and symptom chaining is done is those cases. For Example: If the patient has pain then in the next question he/she is asked to locate where his/her pain is. This conversation goes on until a reasonable disease prediction is made. Based on the predictions the patient can also find relevant doctors. The patient can always terminate the conversation and move to prediction.

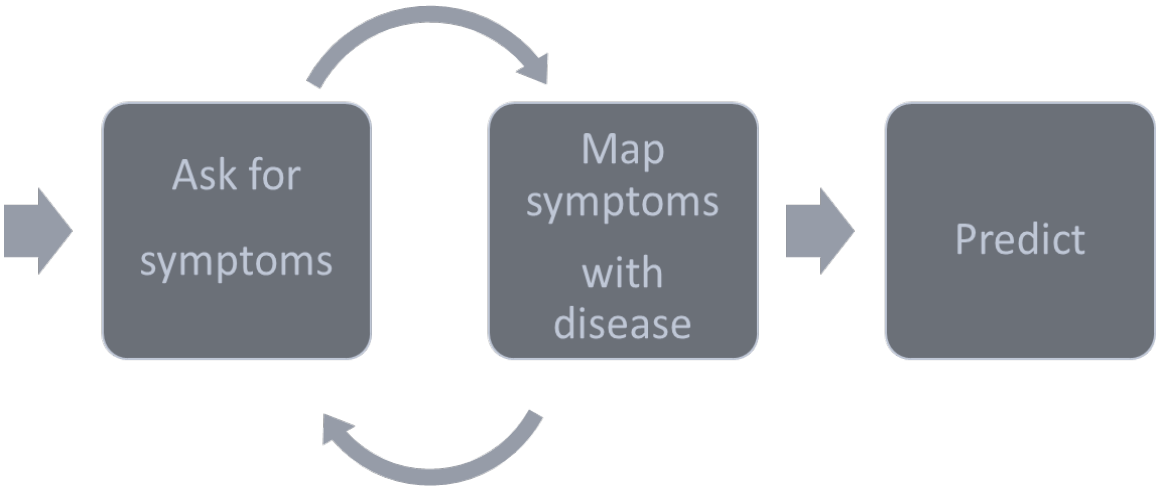


Figure 4.2: Smiley Bot Disease Prediction Mechanism

4.5 Use case Diagram

A patient can find doctor information in Smiley bot. Searching doctor is one of the use cases of Smiley bot. Smiley suggests doctors based on their relative field of works. This leads to its disease prediction use case. To predict diseases it gathers symptoms through user inputs.

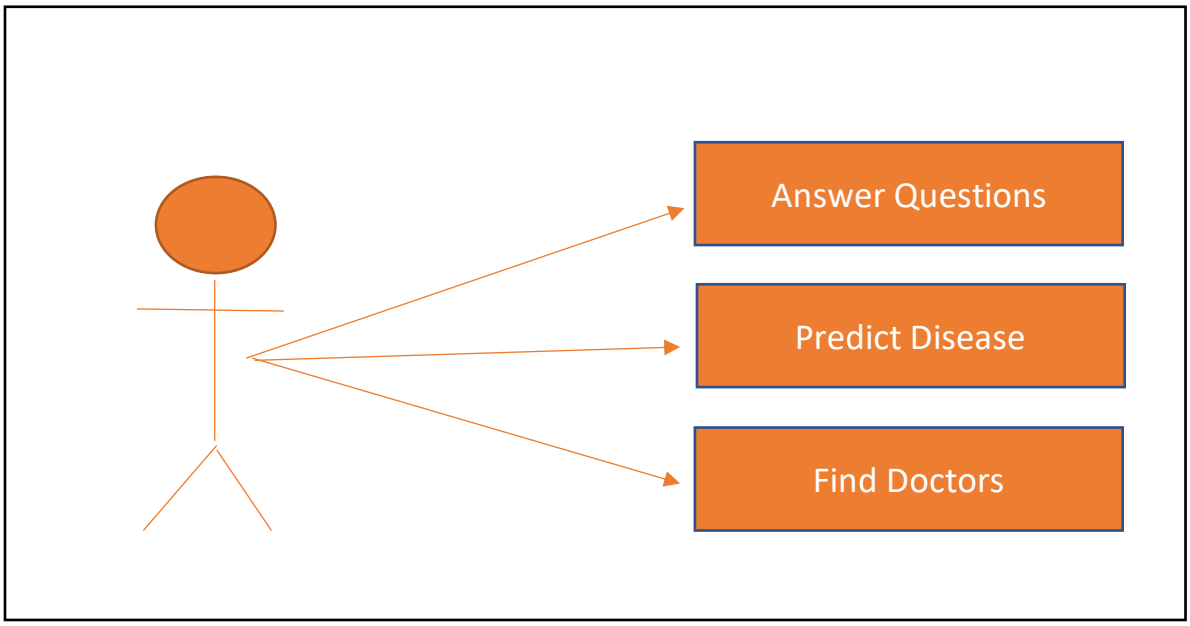


Figure 4.3: Smiley Bot Use Case Diagram

4.6 Flowchart Diagram

The flow chart below resembles the internal disease prediction mechanism of Smiley bot visually. As these are CPU extensive calculations, this program lies inside a powerful remote server and communicates with app via APIs. The diagram shows that, it will ask the user if he/she is having a symptom. Based on the response the algorithm can detect if the there's any additional information needed to be more specific about that symptom and it'll continue to do so recursively. After gathering enough information it will save that symptom in a list and continue the whole process for another one.

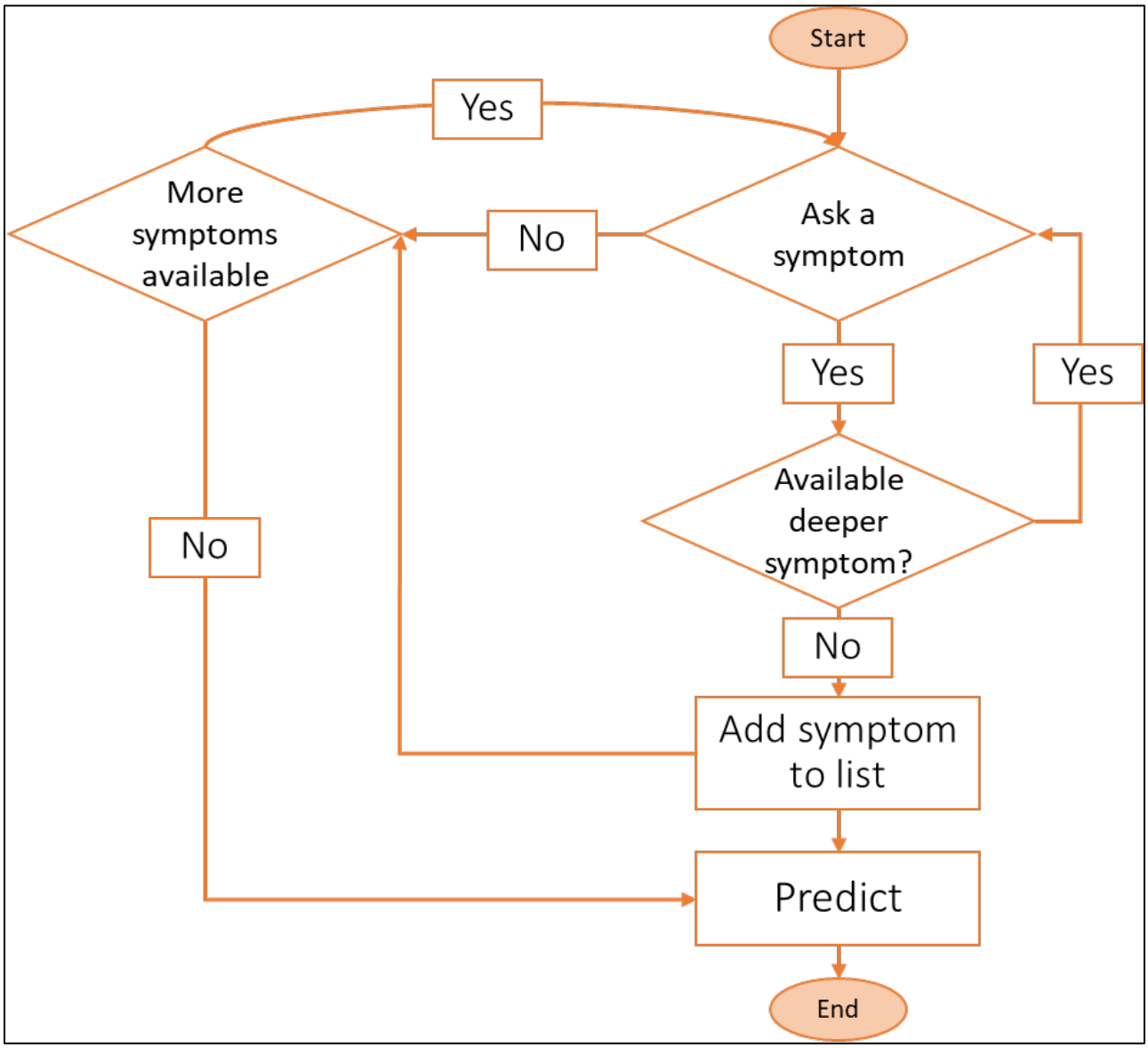


Figure 4.4: Smiley Bot Flowchart Diagram

4.7 App Screenshots

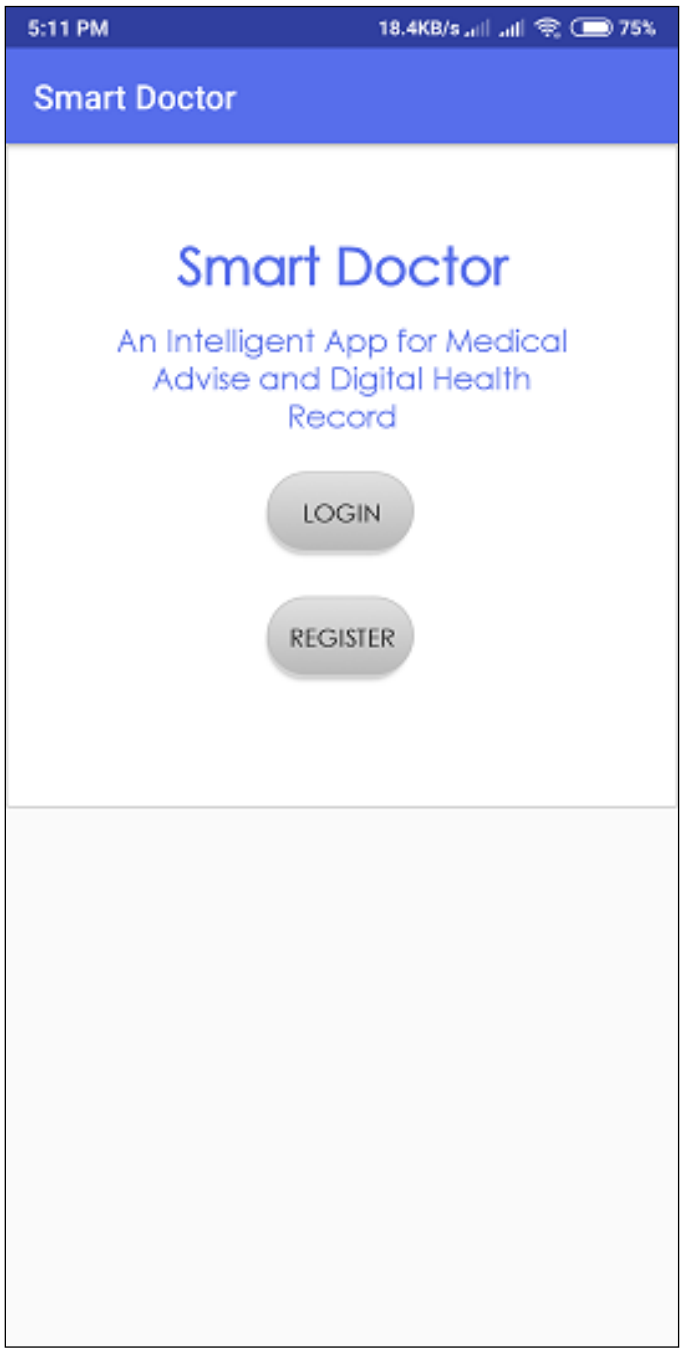


Figure 4.5 shows the authentication options for smiley bot. Only the authenticated users can take service from Smiley bot.

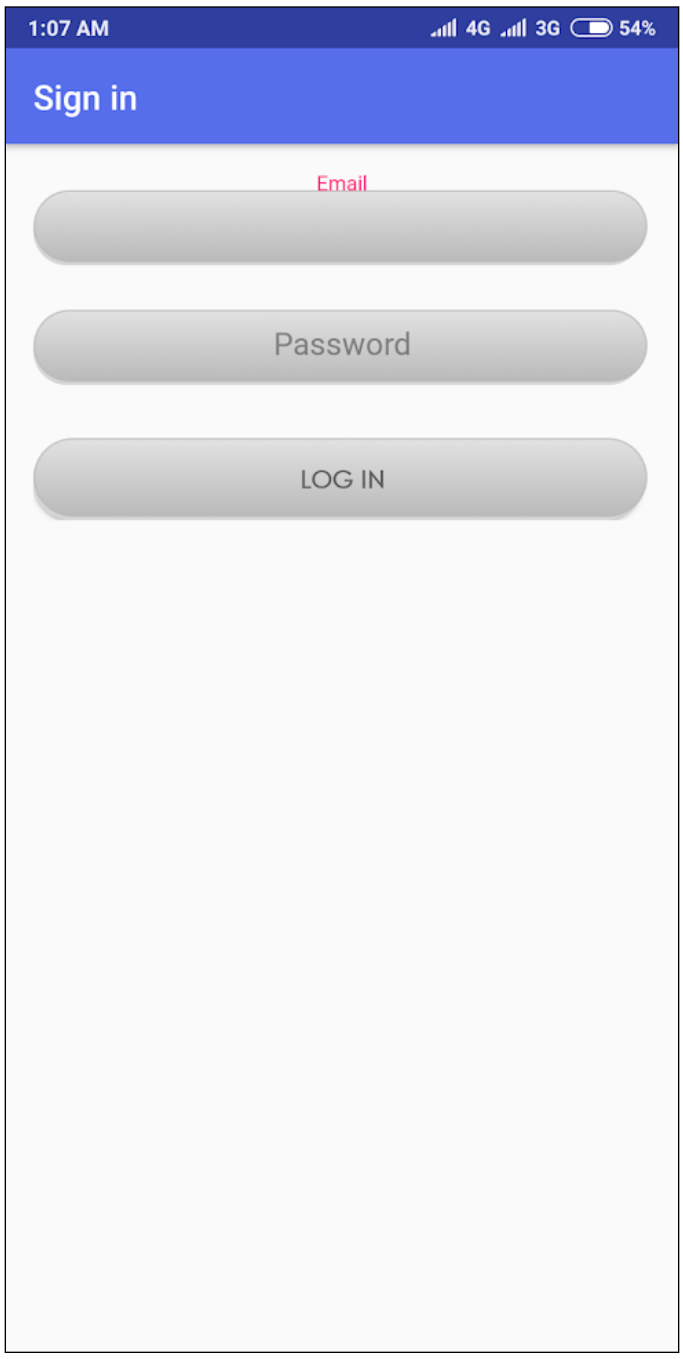


Figure 4.6 shows the sign in page of smiley bot. If a user has an existing account he/she can authenticate him/herself by providing the email and password.

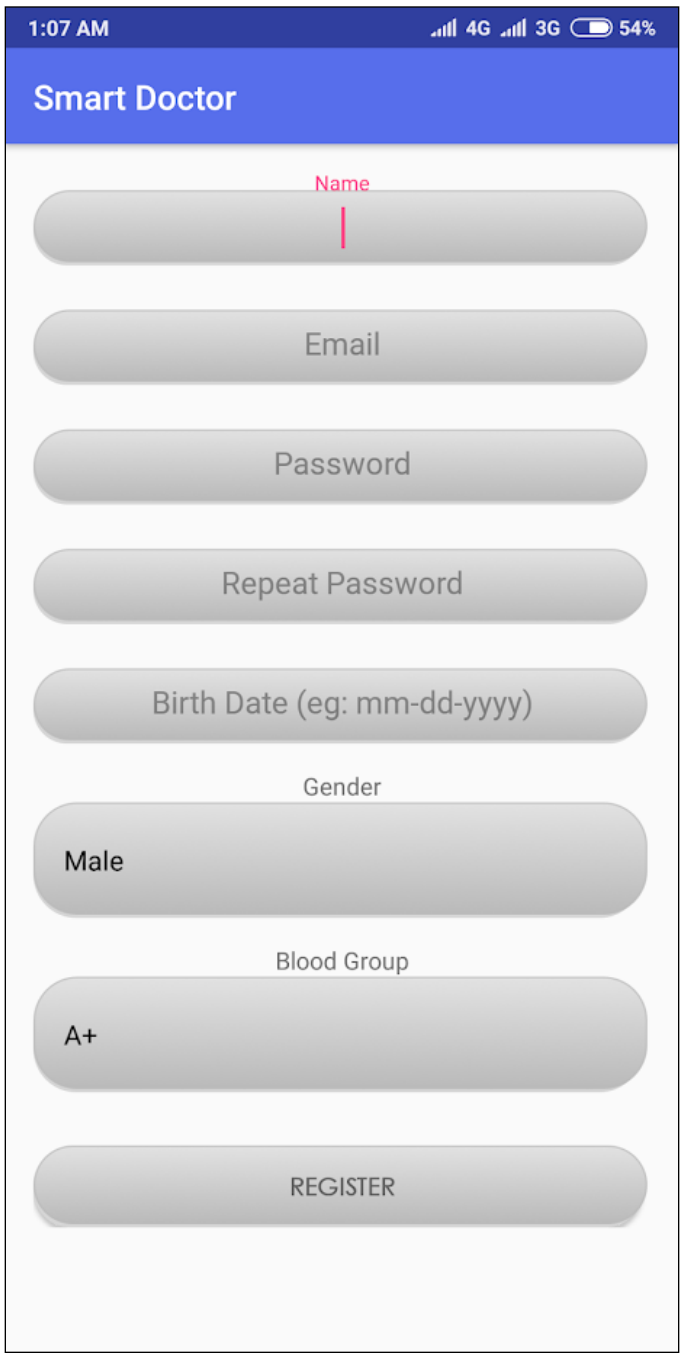
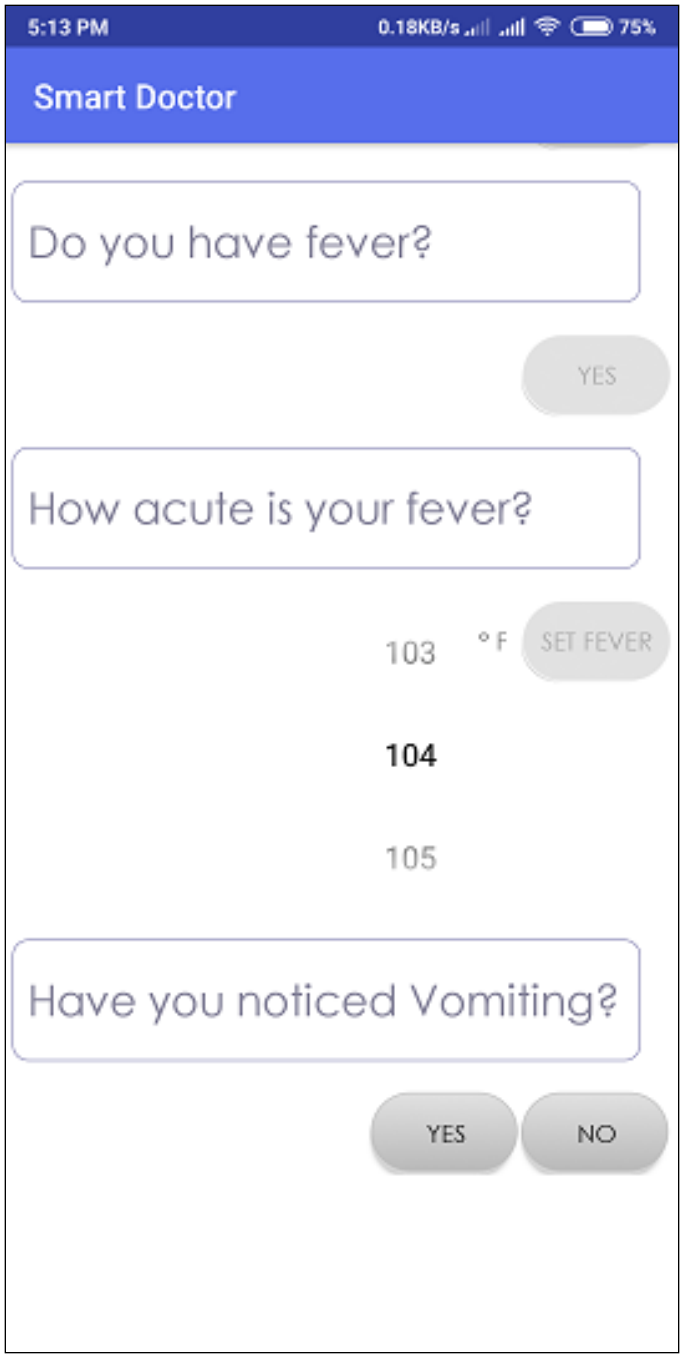


Figure 4.7 shows the registration in page of smiley bot. Here we are collecting a bunch of medical data from the user such as birth date to calculate age, blood group, gender etc. as diseases to make precise disease predictions.



Figure 4.8 shows the conversation page of smiley bot. Conversation starts with really simple questions. And the questions are asked in natural language so the user don't feel that they are interacting with a bot.



In Figure 4.9 we can see symptom chaining by smiley bot algorithm. We can see that the patient is suffering from fever. To make this symptom more meaningful we also need to know the acuteness of his/her fever. That's why he/she is asked for that value in the next questions.

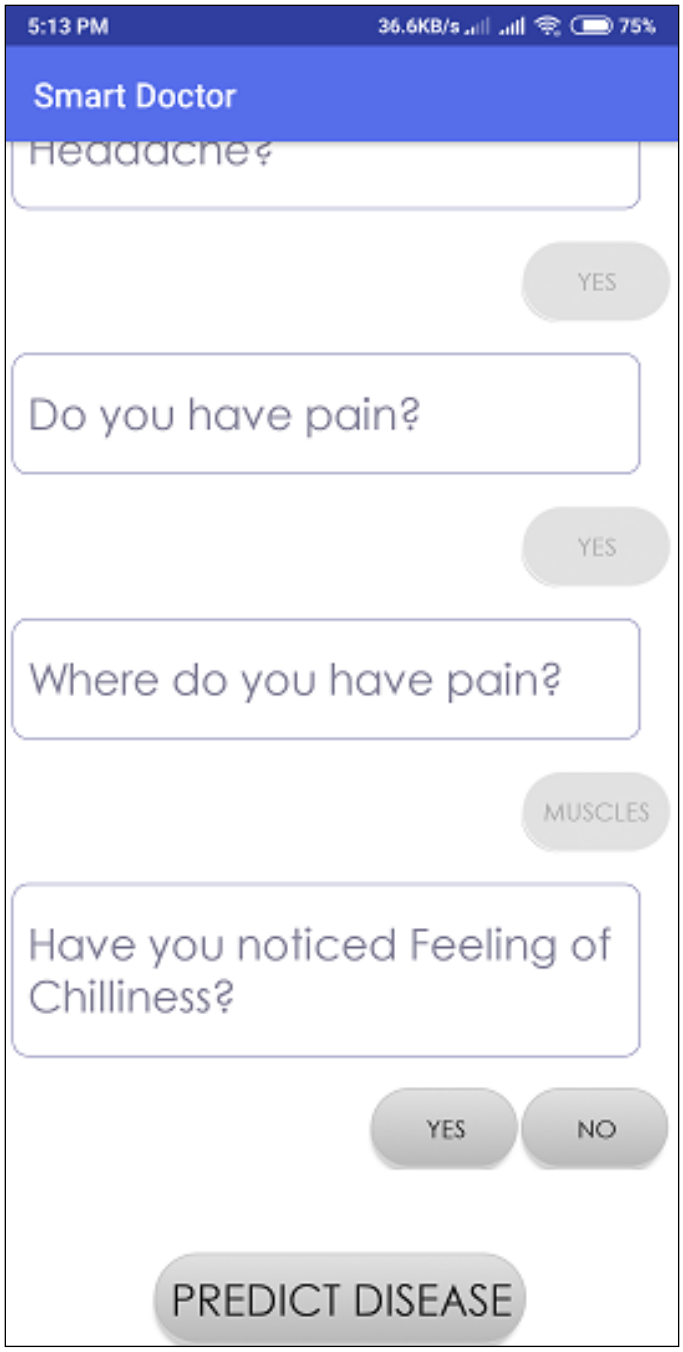


Figure 4.10 is showing a part of the conversation. It also contains an example of symptom chaining.

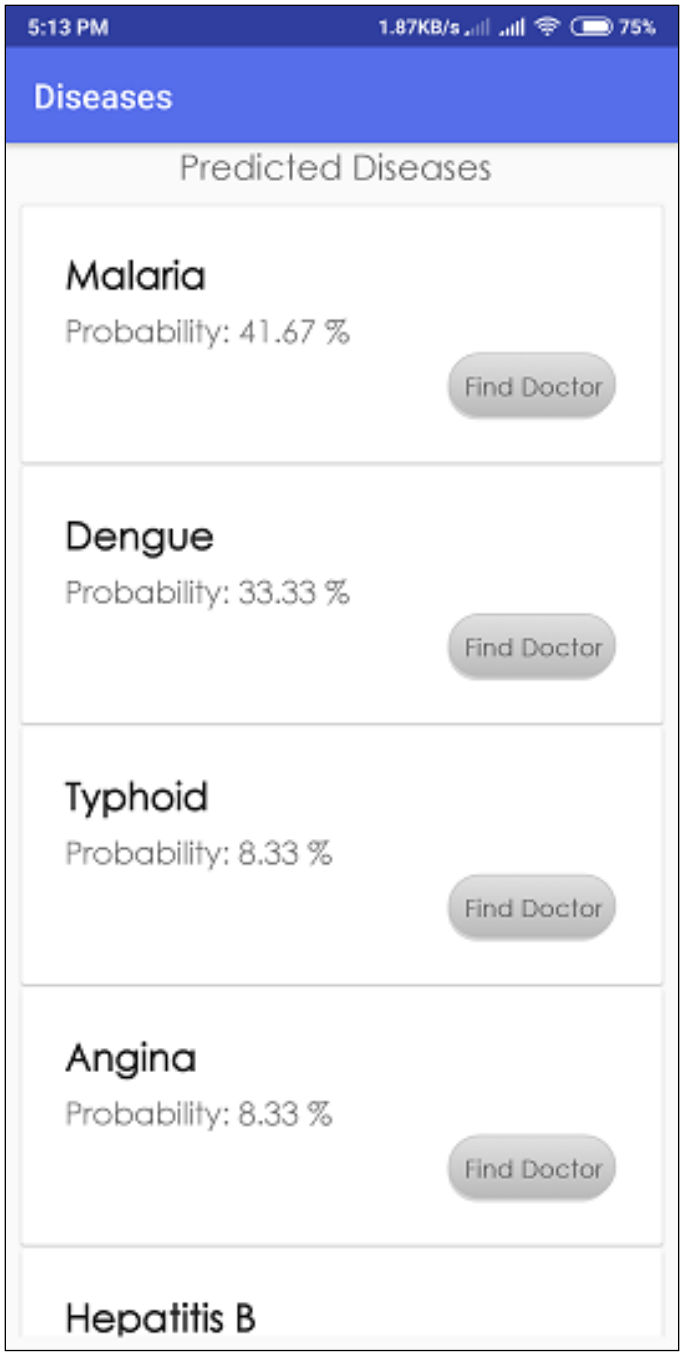


Figure 4.11 is the disease prediction page of Smiley bot. A likelihood percentage is also shown to give user the idea of his/her current condition. The 'Find Doctor' button will take the user to doctor finding page of that disease.

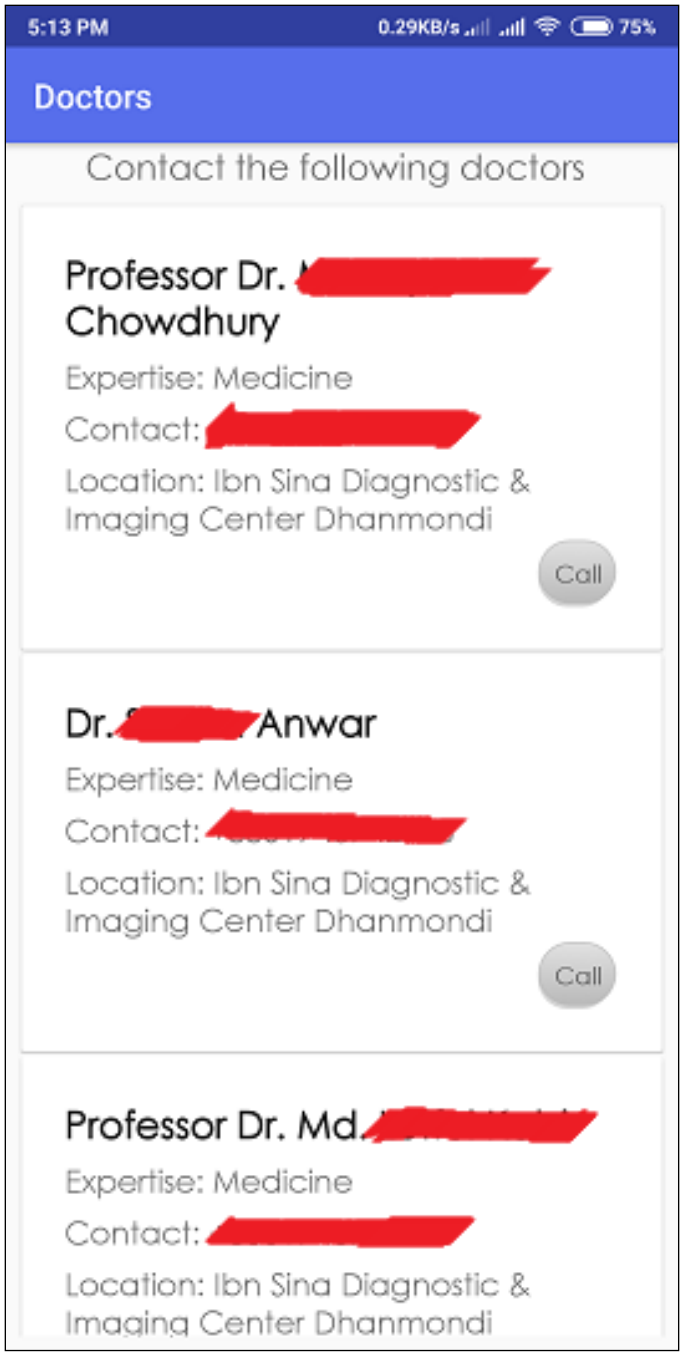


Figure 4.12 is the doctor finding page of Smiley bot. Here the doctor's name is shown along with his/her expertise, contact and location. For censorship issue we've blurred the name of the doctor. The call button will dial the selected doctor's contact number.

4.8 Conclusion

To prevent ignorant self-medication we needed a system that is easy to operate, quick and accurate. Smiley Bot's prediction system predicts disease works reasonably accurate. The whole process from starting the application to finding a doctor takes at most 5 minutes which is remarkable. Moreover it provides the users the relevant reply options so they do not need to type the reply themselves which is really annoying when they are trying to save time. This also makes Smiley Bot very easy to operate. With these features and functionalities Smiley Bot fulfills the criteria nicely.

5. Proposed Smart EHR

5.1. Introduction

Our proposed Smart EHR system is still an ongoing process. After logging in, an user can start capturing medical report or can load and image from the gallery (if the image was already captured with users device outside from the app, or captured by another device and copied/downloaded in users device). After capturing or selecting that image user will see the report in editable text format in a form to check that if there is any field data missing or any error-prone report result detected or not. If there is any error or missing value found, user will be able to correct it by taking a look into previewed image.

Finally, user will be able to save that report for future use. When user will save the report, it will automatically be backed up into the server if the user does have access into the internet, along with a compressed format of the scanned image. In addition, user can always access their data in web server. They can also share their report via email with anyone just using the sharing feature from the app.

5.2. Purpose

The main purpose to develop this Smart EHR is to make EHR easy to access and affordable for the people all over the world [9, 21]. Until the time we were working(year 2018), all available EHR system was available only to the hospital, clinic or diagnostic center authorities. But we all know the benefits of electronic health record system. How does it help to provide more accurate and better medical service to the patient, how easily and quickly an authorized personnel (like doctors, specialist, nurse, insurance company) can access the medical records and analyze them [12, 14]. We wanted them to make it available for all, in the simplest way. Make a simple platform for both patient side and medical service provider side [14]. That is why, the Smart EHR is here.

5.3. Working Mechanism

Our proposed EHR system starts with taking a scanned image of a medical test report as a input. Then it sends that image to the OCR engine. OCR engine generates text from that image and send it to our report type detector. After detecting report type (like CBC, Urine test, Stool test) using keyword count, it sends the whole detected text to the specified function to scan attribute

and values from the whole text and pair them as attribute and value. Here arises two questions. How does we detect which one is attribute and which one is value? The second one is, how does we pair them together, as we know that the OCR engine can't provide text line sequentially from the form format text page? To solve this problem, we use two methods together. Our used Google Mobile Vision API provides text line position coordinates from the image. First we sort the lines based on Y-coordinate. Then we apply keywords saved as regular expression to find attribute and values. Finally we validate them to check that if each values are paired with valid attributes or not. If not, then we perform a search to find appropriate value for that attribute and set with that attribute.

5.4. Use Case Diagram

A user case diagram is a graphic depiction of the interactions among the elements of a system. It's a methodology used in system analysis to identify, clarify & organize the system requirement.

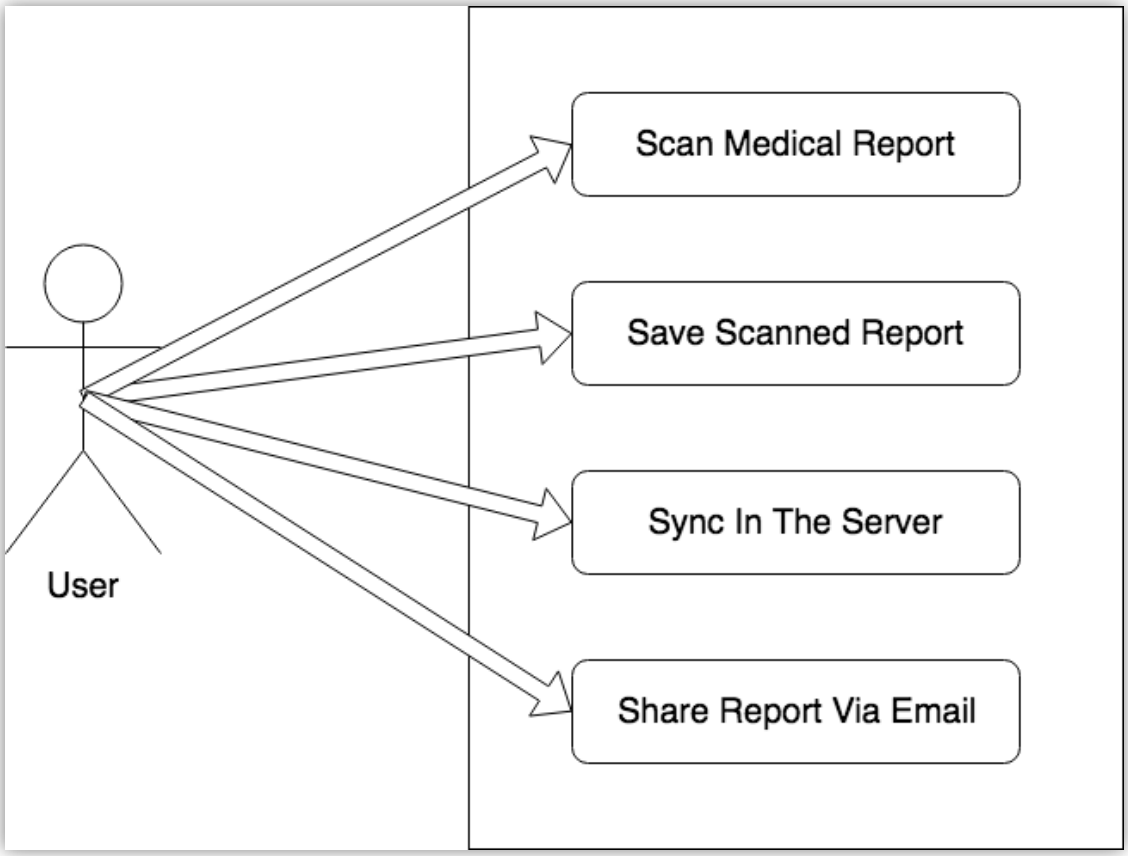


Figure 5.1: Smart EHR Use Case Diagram

5.5. Flowchart Diagram

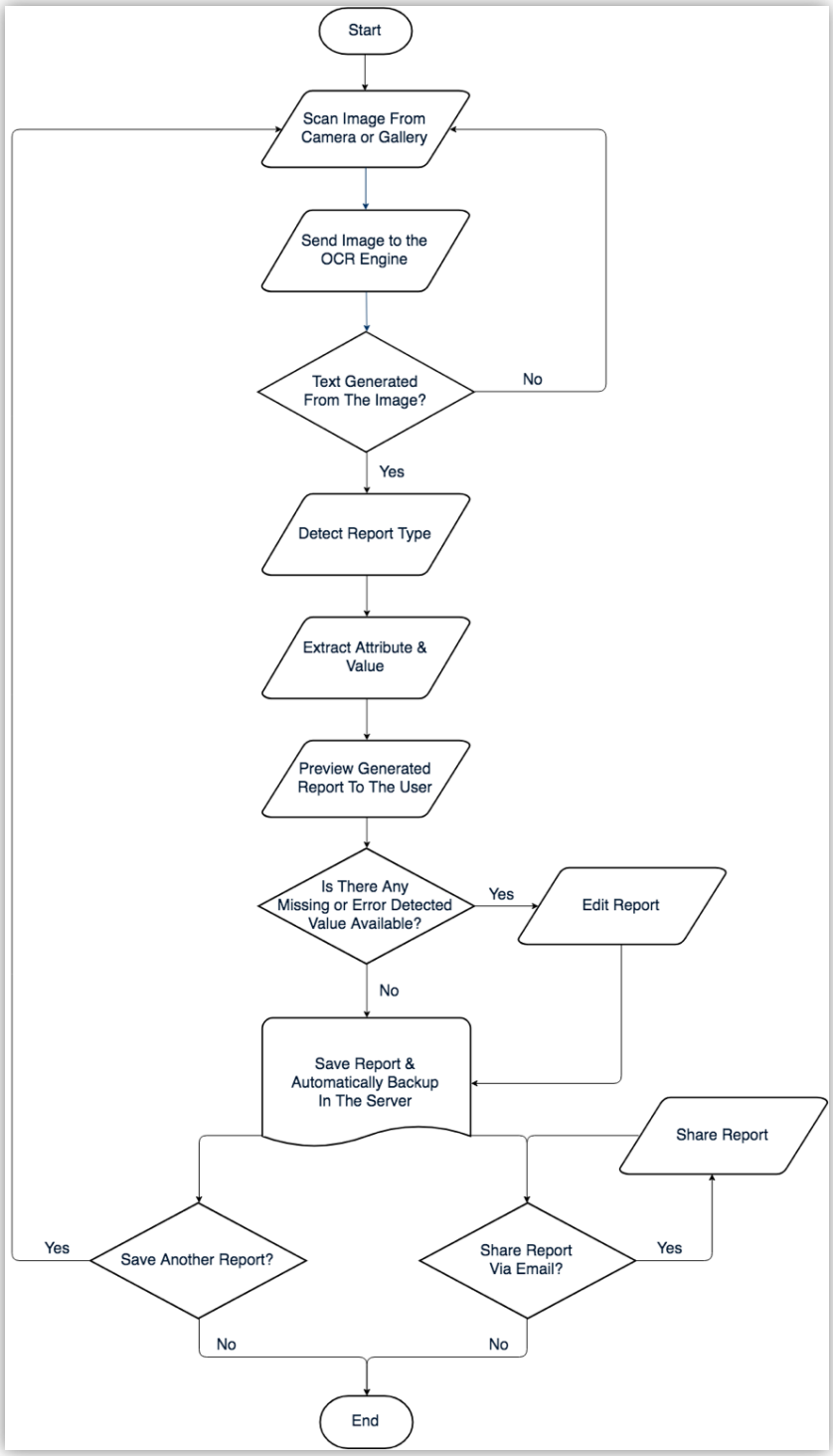


Figure 5.2: Smart EHR Flowchart Diagram

5.6. Features

As we are still researching on obtaining more accurate result from this system and this system is still under development, so far we have been successful to provide features mentioned below only.

5.6.1 Detect Report Automatically

Our proposed system can automatically detect three types of reports. These are CBC, Urine and Stool report. Moreover, this system is not bound only to detect these three reports. It is designed such a way that any type of report can be detected just by providing their keywords and patterns of their values.

5.6.2 Save Report into Local Database

One of the important feature to provide better user experience is to let the user to save the report into their device (both scanned image and digitalized report). In addition, user can edit digitalized report if they need to due to erroneous output from our system.

5.6.3 Sync Report

Immediately after saving the report, it would be synchronized to the server with respect to the user's username so that user does never has to loss their data at any cost.

5.6.4 Share Report

Sharing report via email with doctors or other medical professional makes our system more reliable and user friendly. Whenever a user needs, he or she can share a patient report with medical professional to get medical decision without visiting the doctor physically.

5.6.5 Show Accuracy Rate

Our system provides a rough accuracy rate based on the report it digitalized automatically and how many fields it could detect accurately.

5.6.6 Load Report Image

It's not mandatory that user will have to capture the image with the device they are using. It can be captured with another mobile phone or camera. User can pick image from their gallery to digitalized their report.

5.6.7 Zoom Loaded Image

As mobile phone's screen is not large enough, user can face problem to detect error just looking at that image, so there we have tried to provide a feature to enlarge or zoom an area so that the user can easily detect any error.

5.6.8 Detect and Show Weakly Detected Value

Our algorithm tries to detect any weakly detected value based on position difference between keyword and value pair, missing keyword, missing value and mismatched pattern of value. After detecting them, our proposed system indicate the user about the result so that user can specially provide attention to those fields to detect error.

5.7. Conclusion

We want to make this system more accurate and better for greater good and we will continue our journey towards it. The prototype is already ready and we are working on releasing our beta version to analyze how the end users does respond. Based on their feedback we would work on making this system more likely and acceptable to them.

On the other hand, we are still trying to add more relevant and essential feature for providing better service and user experience.

6. Challenges Faced

6.1.1 Challenges Faced: Smiley Bot

6.1.1.1 Disease Diversity

Diversity of diseases was one of the biggest challenges in our way. To overcome this we had to shorten the domain of our workspace. We focused on the most frequent diseases of our region to be detected by the bot.

6.1.1.2 Symptom Diversity

Different diseases have different symptoms and different patient shows different symptoms even for the same disease. Mapping the symptoms with appropriate diseases was also a big challenge to overcome. We focused on the most frequent and common symptoms of the diseases as they have higher probability to be seen.

6.1.1.3 Natural Language Processing

To make the bot-patient conversation more like a human-human one, we had use natural languages to ask the questions. To make this possible we had to gather and process information about different disease symptoms and study their characteristics to represent them meaningfully to the patient.

6.2.1 Challenges we faced for EHR

It was not as easy as we thought it would be to digitalized medical records. Here are some challenges we faced during our research period.

6.2.2.1 Randomly positioned lines, blocks and words

This was the main and biggest challenge we faced during developing Smart Doctor-EHR part. When we scanned an image, we expected that each report line will be arranged sequentially, line by line from the output of OCR (Optical Character Recognition) engine. But, in reality, our expectation came out false. Most of the form data was positioned randomly. The problem was, the attribute was in one place and the value was in a different place. It was difficult to identify which value would be paired with which attribute, especially if the values were in a similar format (like

nil, or in a similar number range). In the Figure D8.1, a screen shot of a scanned image report and their output generated by *Google Mobile Vision API* OCR engine has been attached. In this screenshot (screenshot taken from Smart Doctor App), the upper part is image, and the lower part is text generated from OCR engine. If you take a look on the generated text, you will find the first line is 'HCT (Hematocrit)', which is situated at 5th line of the image. On the other hand, the value

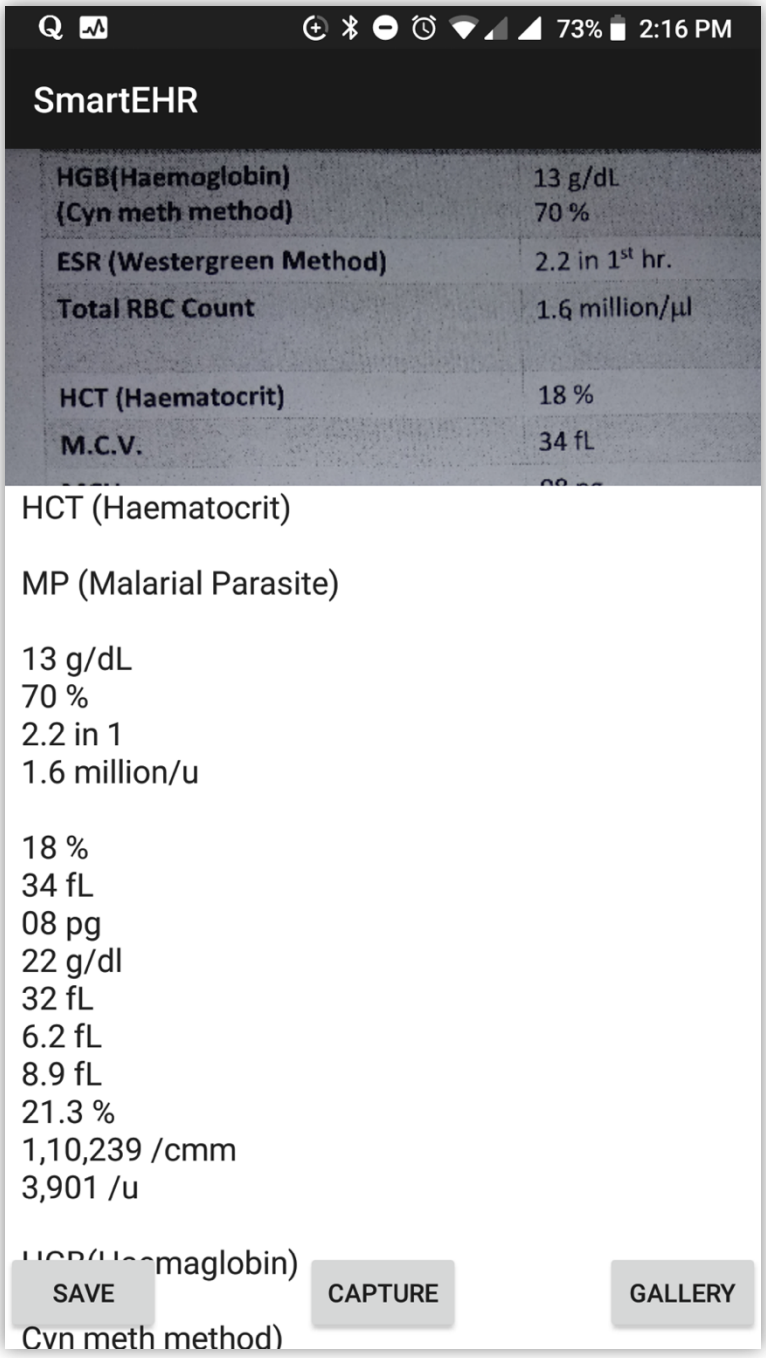


Figure 6.1: OCR engine generated raw output from a scanned image.

of this attribute is has been found on 7th line of the OCR engine generated text, whereas we expected, at least it would be either in the same line of *HCT (Hematocrit),* or on the immediate next line. But none of this does happen. All the attribute and values are randomly positioned.

6.2.2.2 Erroneous Parsing and Classifying

The second largest challenge was, pairing attribute and value. We used Regular Expression to detect attribute and values. But not always it could detect which line does contain attribute and which line does contain value.

6.2.2.3 Large image size

Although at first it does not seem as a problem, but it was. Not only for further analysis and research purpose, but also to provide better support to the end users of Smart Doctor app, we had to keep the scanned image along with the generated digital record. Nowadays, almost all smartphones with good camera captures an image with a size of around 5MB. It's good, but the challenge is, when we are going to keep a backup of that report on our server. Not every country does have the advantage of high speed internet, so each report upload could take a long time to upload. On the other hand, if the end user is using mobile data, there is an issue of data cost. Moreover, large size of image does need large server.

6.2.2.4. Low and blurry image quality

Not all the end users does have a good smart phone to capture a good quality image, specially the users from rural area. As our system is dependent on OCR system, and OCR systems does need a clear image quality, so without a clear and high quality image it's very difficult to get better accuracy.

6.2.2.5. Adjust camera orientation

OCR engine adjust image orientation if it's slightly dis-angled, but not if it's 90 degree or 180 degree rotated. When an user capture an image of a report, that image might have been captured with a wrong angle orientation due to their camera holding position or if the smartphone's auto-rotation feature is enabled. So, before sending that image to the OCR engine, it was important to fix the image orientation. Otherwise, the OCR engine could not detect any text.

6.2.2.6. Collecting sample report

To begin our research on digitalizing medical record, the one thing we need to collect was sample medical record to analyze them, know how reports are organized, which values are available, what are the types of attributes and so on. To get idea on how we can solve this problem and to test that is our system is working perfect fully or not, it was very important to collect as many reports as we can. We contacted to many hospital and diagnostic centers authorities by visiting there physically and requested them to provide us some real medical test report copy (without mentioning patient name), but for some unknown reason, most of the authorities refused to help us. Finally one of the hospital agreed to help us and provided some sample report. We are very grateful to them, because with those sample reports we could start working and could came up to this outcome.

6.3.1 Limitations: Smiley Bot

6.2.1.1 Symptoms Weights

Different diseases have different symptoms but not all the symptoms are equally important to take under consideration. Some of the symptoms are more important than the others. As this kind of data is very hard to find, we are unable to implement symptom weights in our system.

6.2.1.2 Disease Prediction

Our working database was very small as we do not have an automated system to collect them. So we had to collect and digitize them manually which results to a very small set of diseases. A large database could point out more information and flaws of the existing system.

6.2.1.3 Conversation Language

As Smiley bot gathers symptoms from patients via conversation, it uses a natural language. But as the natural language processors are still evolving, sometimes it produces some unexpected outcomes.

6.3.2 Limitations of Smart EHR

Like all other systems, our system does also have some limitations which we could not overcome them yet or could not manage time and resources to overcome them. Here are some limitations on this system:

- So far, only three types of report(CBC, Urine test, Stool test) can be detected. Although, the system is developed such a way that any kind of report can be detected if necessary specification is provided.
- Can't work on blurry image.
- Low accuracy on low quality image.
- After capturing image, image cropping feature is not available.
- App does not support landscape mode.
- After saving a report once, updating report on the mobile device does not update on the server.
- Deleting a report from mobile device does not effect on the server backup file.
- Does not detect patient's personal information (if provided in the report) except name and age.

6.4.1 Future work planned for Smiley Bot

Smiley Bot is currently is in its infancy. This is just the beginning of automated heath care era as well. A lot of work needs to be done to make it to perfection as dealing with human life is a very sensitive field of work. The first task in our mind is to gather a reasonable sized database to learn the algorithm resides at the core of the prediction system. After that we must weigh the symptoms so that it becomes more and more accurate day by day. The following points can have the highest priority in terms of future development.

- **Multilingual support:**

  Currently Smiley bot only communicates with users using international English language. To serve people of different regions and culture, it is essential to add multilingual support to Smiley bot.
- **Local terms:**

  Different medical terms are spelled different in some places. Mapping these terms, and using them properly will make symptom gathering more accurate.

- **Using previous data:**

  A user can save his/her medical data in 'Smart Doctor'. Smiley bot can use these data to take next predictions to the next level. As we know that, many diseases show different symptoms on different conditions. Using previous records of the user predictions can be improved. As we have very small amount user hence very small amount of user-data, it is not usable in the prediction algorithm yet.

6.4.2 Future work planned for EHR

This is not the end of our work. We just have started our journey. Due to short time, we just have reached to this point. We want to go beyond this. Here are some plan which we want to implement in near future:

- Image preprocess to pursue more accurate result.
- Detect almost all kind of medical report to digitalize them.
- Create a bridge between mobile app and the server to keep backup.
- Make mobile app responsive and more attractive by upgrading user interface.
- Provide support for IOS platform.
- Provide a message in a simple language based on detected report about the health condition of the patient.
- Provide some suggestions to prevent any diseases if necessary. For example, if a patient's Hemoglobin level is low, the system will suggest to eat calcium rich foods like green banana, beans, milk so that the Hemoglobin level increases.

7. Conclusion

Smart doctor is in the phase of textual aura trying to figure out patient issues by interacting showing different options however sometimes we need more precise diagnostic data to classify certain diseases those were in a same group or family of diseases. The smart EHR, on the other hand, can be further enhanced with the help of computer vision technology to classify handwritten prescriptions or varieties of reports. With the advancement and the availability of medical diagnostic tools, we will be able to determine our health issues more quickly. Smart doctor has reduced amount of database which can be improved in future versions [26].

There could be other enhancements that could be done such as communicating over voice, video or images to precisely predict diseases and the system can be self-evolving with the help of doctors as it could learn based on the decisions doctors made on crucial situations and help could reach to patients through a smartphone via a mobile network [27]. Predictions can be dramatically improved with help of third-party peripherals that may fit in a school bag and services can reach rural areas where people have a little knowledge of what to do [28].

Limitations we can add here is smart doctor has a limited knowledge hub and designed as a deterministic system where a patient may have a complex situation that the system may never understand because of the stochasticity of reality [29]. Similarly, smart EHR currently works only in the English version and a lot of unstructured data such as prescriptions are handwritten in Bengali. To solve these situations the system should be more adaptive and simulative [30]. Smart doctor can also be an information source of a network for doctors while prescribing medicines and simulation of drugs can be done based on the patient history is a simple task for machines.

Our work made enquiries about learning the patterns how patients describes their problems in a diverse way and also classifying, digitizing different types of printed hard copy of reports [31]. The knowledge hub and developed procedures was a product of incremental work of careful feature extraction with the help of oracle and building reasonable model for classifying diseases [32]. We also saw that our app works like a charm in a few minutes with an engaging friendly user experience and interface with the users in a phase of testing [33]. This work creates a milestone solving two major issues about providing necessary information as well as digitizing hardcopy report for further analysis in the cloud and which will get more accurate with the availability of data that would lead important information for patients or doctors.

This work also includes collecting structured data manually by talking with a number of patients and physicians and development of a knowledge base for classifying diseases and digitizing reports [34]. This kind of work like carefully choosing important features by domain experts lead us to more human like interactive system like “Smart Doctor” which will get better by the time.

8. References

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