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MediSmart: An NLP driven intelligent medical assistant

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***Abstract*---**Health Care is one of the most primary aspects of one's personal life, where it is once deteriorated can never be restored forever. In this pathetic situation the people face immense difficulty in managing their health-related reports, documents etc. Another emerging problem in the health life is despite providing all the necessary advice in the prescription, there are still many suggestions & recommendations given by the doctor are not documented. Therefore, we propose a solution which demolishes the burden of carrying files or reports all the time to visit a doctor. This paper aims in implementing the MediSmart- An intelligent Medical Assistant, a system that comprises all the patients' history, consolidated report along with most important information suggested by the doctor orally is recorded (voice prescription). Since the approach is patient-centric we intend to implement the MediSmart Document Collection System, which collects patient personal information, hospital specific information, EHR and Voice records of doctor's advice. Later, the EHRs are summarized, and a consolidated medical report is presented using NLP techniques and simultaneously, the voice record is also summarized to help patients keep a track of the oral prescription provided by the doctor. To make the system fully modernized we aim to build the MediSmart Card that contains a QR code scanning system to ensure authentication with high privacy. Finally, to make all

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the features visible to the patient we intend to build the MediSmart Mobile Application that helps to view all the health-related documents of a particular patient.

***Keywords*---**natural language processing, flask web application, cloud storage system-firebase, flutter based android application, voice prescription.

Introduction

Due to tremendous development in the technology, numerous advancements are made in the healthcare sector that prove their capability to foster the lives of people around the world. Though this technology is highly evolving, unprecedented amount of information is still piling up every day. Hazardous consequences on clinical physical records can occur due to various reasons like omissions, errors etc. which might ultimately question the patient's safety. Visualize a scenario where a patient is suffering from a particular health issue and has been admitted in a hospital. While discharging, a huge record containing a bundle of files is handed over to the patient which comprises medical history from the time of diagnosis to treatment. Later when the patient is suffering from some other health issue and decided to consult a doctor, it is mandatory for him to carry the whole set of medical records right from his first consultation till date. It is a pathetic situation where such kind of records get piled up for every consequent visit. At the same time, it is very difficult for the medical practitioner to review such a huge bundle of clinical notes for a single patient.

Since age is directly proportionate to health issues, it is evident that records will be mounting up more drastically than earlier stages of life. Similarly on the other hand doctors find it very difficult to view every patient's record to diagnose their issue. Statistically, "of 22,889 surveyed patients who read their own records, 4830 (25%) found mistakes. Almost 10% were classified as very serious, 42.3% as serious, and 32.4% as somewhat serious" according to Physician's Weekly Blogger, Skeptical Scalpel [21]. These numbers clearly indicate that physical records are often prone to huge number of errors which might be caused due to human negligence while interpreting the data. Therefore, the above issues can be resolved by digitalizing these physical records and fostering a system that can facilitate patients as well as doctors to view the records electronically. Electronic Health Record (EHR) contains data about a particular patient that includes their problems, treatment, medication, and other health related information in a digital format. It enhances the ability to digitalize large medical records and makes it easier to store and retrieve patient's specific information from the system. Furthermore, there is a prominent need to safeguard the patient's data while exchanging medical information. Privacy and security to this data is ensured by verifying and authorizing entities to specific sector of administration in a clinical health center or a hospital.

Though the data is digitalized, and Electronic Health Record (EHR) facilitates necessary information about a particular patient, a critical issue arises in the context of huge medical history where practitioners are solely responsible to view

and diagnose every patient using this information. An approach that provides a solution to this problem is to consolidate the data present in the Electronic Health Records (EHR). This clinical summarization of health records can provide concise information about the patient's past treatment and medications. According to Rimma Pivovarov.et.al, [14] technologies like Natural Language Processing and Apache Hadoop (a Big Data Framework) provide promising results during the process of summarization.

Due to the outbreak of COVID-19, remote health monitoring started to play a pivotal role in the healthcare sector. On-premises data storage or physical storage causes overload of overwhelming data, while on the other hand Cloud facilitates an option to store the patient's information on a flexible and scalable environment. The hospital administration has the access to either create a new record for a new patient or update an existing record respectively into the cloud storage. This method makes it feasible for both the patients and the doctors to view information about their medical history and fortify remote health check-ups. For instance, a blockchain framework can be used to store Electronic Medical Records (EMR) in the form of a ledger using cryptographic functions according to Akanksha Saini.et.al. is one of the ways to store healthcare data into the cloud [2].

Whenever a patient is consulting a doctor, only necessary medication is prescribed physically on the paper. While other information like diet, physiotherapy related exercises, etc. are just prescribed orally. Due to this reason, the information is often forgetful and neglected by the patient. Later the patient might face a critical situation where he tries to brainstorm the doctor's note but fails to recollect it. Although significant inventions are drastically increasing which use internet services, voice is the prominent way of conveying information either in between humans or to interact with computers. For instance, Alexa, invented in 2014 [22] aims to provide numerous features to the public where it reminds the users about prioritized events in time. Similarly, adoption of voice-based prescriptions can prove to eradicate redundant paperwork, provide accurate information and are time saving. Not only it helps the patient to playback again and follow doctor's advice but also it curbs the method of paper prescriptions comprising illegible handwriting of doctors.

An integrated system that provides features addressing all the previously discussed issues is highly desirable. This paper provides a system that proposes to eradicate the physical records and incorporate EHRs along with summarization of patient's health data. An efficient voice prescription is aimed to be built that records doctor's advice and present key points about the discussion to the patient accordingly. Alongside, to integrate all the above features at a place, the MediSmart Card is proposed to be built which can be used as an access card to retrieve all the medical information about a particular patient. Simultaneously, the MediSmart Mobile Application provides all the health-related documents of a particular patient, where it is very feasible for patients, doctors and hospital administrators to view and edit the information respectively.

Literature Survey

Wei Li.et.al [1] reviewed several methodologies by using big data analytics and IOT that improves efficiency of applications which use machine learning techniques. This facilitates the researchers to pick the right topic for their research. They also focused to integrate IOT with all other technologies to make daily lives easier. Akanksha Saini.et.al [2] attributed concepts related to blockchain and cloud storage to establish a control over the patient monitoring system. An access control framework is aimed to be built which uses ledgers where the electronic medical records are stored in the cloud to curb congestion in the network. G.Jaya Lakshmi.et.al [3] proposed a method by using IoT Cloud Architecture. Primary objective was to project the necessity of wearable sensors as rudimentary to monitor patient's health conditions in real time. Using wireless media various data sensors have been collected to save them in the cloud.

Jay DeYoung.et.al [4] designed MDS dataset to extract data in health records. Data and models are formulated in both structural and plain text to access their quality for the generated summaries. To boost the performance of the system and improve the efficiency automatic accessing pipeline movements are required. Md. Milon Islam.et.al [5] captured 5 sensor's data from the hospital and developed a scheme with error percentage having a threshold limit less than 5%. The system will benefit medical practitioners during crises because data can be analysed in less time. Adarsh Kumar.et.al [6] proposed an approach using blockchain 3.0, IOT and mining optimization that ensures protection when there is a malfunction in central system. Key observations are data maintenance and security. Guojie Yang.et.al [7] proposed an approach which uses a centralized approach that follows a mechanism in hierarchy to divide the health monitoring devices into various clusters. Energy conservation of devices in different states is administered and the transition is monitored.

Adnan Tahir.et.al [8] in view of healthcare scenario, reviewed various cloud storage mechanisms. Limitations of cloud storage included compliance, security, and implementations. It stated that there are no current methodologies that addressed the availability and reliability issues. Solomia Fedushko.et.al [9] proposed a methodology using imputation methods in health care fields that which are improved through processing large arrays of information and maximizes automation. On the other hand, Error rate at the time of data collection is high i.e., 20-30%. Dhanush Kumar S. et.al [10] proposed a holistic approach that curbs the necessity for helpers and help the visually impaired students to perform chores on their own using Deep Learning. On the other hand, testing can be done by giving voice input with long texts and check the conversion of voice exactly as spoken by the user. System can face time-out errors when there is a low bandwidth on the internet. Min Chen.et.al [11] designed a system that monitors its user's physical health. It uses cognitive as well as edge computing methodologies to make computing resources efficient by using approaches driven by data.

Ayushi Trivedi.et.al [12] reviewed various techniques and applications that use functions which act as mediators between two parties who are trying to communicate. These applications mostly used either speech to text or text to

synthetic speech to carry out acoustic communication without hindrances. On the other hand, computational efficiency for large database is less, can be expensive, and doesn't work well between languages with different word orders. N. Moratanch.et.al [13] used sentence fusion and fuzzy logic-based approach to capture redundant information in huge amount of text. Extractive text summarization methods helped to improve coherency, focus on features at the training level. Abandoning linguistic features marks as a drawback to the project. Rimma Pivovarov.et.al [14] mentioned the drawbacks in existing methodologies used for summarization of EHR. Various approaches were suggested to aggregate similar information, they are either by word level, concept level or statement level similarities. It is also mentioned that due to tremendous eruption of data from different sources informatics community starts to face challenges to interpret useful information. Prerana Das.et.al [15] used various quantization methods like MFCC and Feature extraction to find euclidean distance which is utilized while complementing anonymousacoustic signal to existing database. But there is no scope for storing the previous records.

Chinatsu Aone.et.al [16] proposed a methodology using machine learning algorithms that resulted summarization features for various document sources. To retrieve documents with high data, generic summaries are applied according to the evaluation metrics. Techniques in Machine learning can be used to enhance performance by uncovering various combination of features. Jiwei Tan.et.al [17] generated a multi sentence summary by introducing an algorithm that is hierarchical. Future work is to investigate the neural abstractive method on summarization task. This process proves to be difficult as it lacks training data. Xiaojun Wan.et.al [18] designed Cluster based Markov model to project information at cluster-level. The datasets that are chosen for experimentation proved to show efficiency on the summarization models. The future scope is open to explore other link analysing and detection methods to find theme clusters. Jennifer Liang.et.al [19] used clinical notes to perform effective text summarization. A pipeline is presented which is extended beyond NLP and incorporated data that is structured unlike unstructured notes that are not feasible to extract data and are time consuming. Overall, an increment in the experimental results is seen which proved that analytics are necessary to predict a relation in high-level clinical data. A. Laxmisan.et.al [20] used 12 different EHR systems, to prove that there is a wide variation in the summarization results. It was noted that the systems had the ability to integrate and organize only simple information. Future scope can be extended to invent approaches that are easy to use and provide interpretations appropriately.

Proposed System

Though previously introduced patient monitoring systems work effectively, they still question the patient's privacy and data storage vulnerability. They focused only on specific aspects like how IoT can help to monitor patient's data or how EHR can digitalize health data, etc. But we would like to propose an integrated system that can facilitate multiple number of uses both to the patients, doctors as well as hospital administrators yet, a patient centric design. To eradicate the use of databases and other huge storage systems we intend to use Cloud Storage technology that proves to provide both privacy and security to the users. To

provide advanced digitalization of health data, a summarized/consolidated system is being implemented to help the patients understand their medical reports at ease. As doctor's oral advice is often forgetful during consultation, we also propose a system that is capable of recording doctors voice and presenting key-points from the discussion. Not only we aim to digitalize aforementioned aspects but also, we would like to propose a card system that completely modernizes the existing system by providing efficient authorization through QR scanning system. Finally, to make it feasible for the patients to view their health reports, we focus to build a mobile application that retrieves the health data about specific patient through the cloud system.

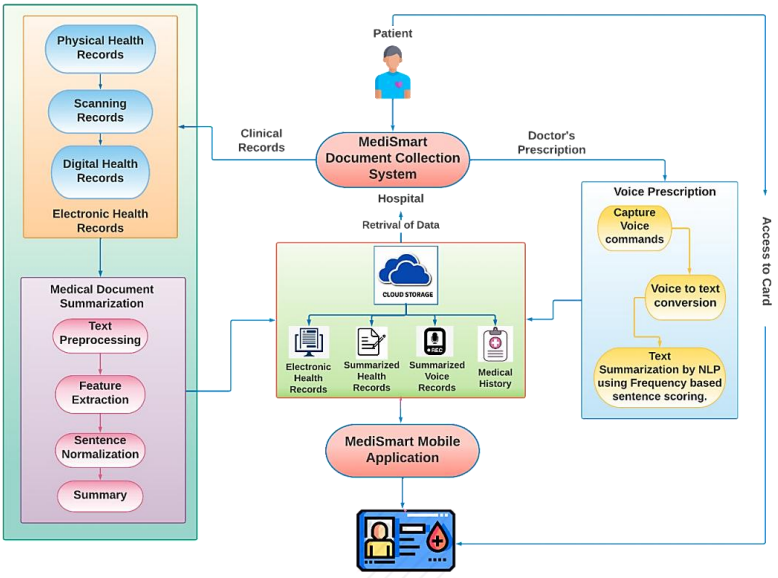

Figure 1. Architecture diagram of MediSmart

The primary principle of this system is to establish a patient centric design that can help the patients to view their health data efficiently without hustle. Beginning with scheduling of an appointment with the doctor until discharge from a hospital, patient must be continuously monitored in every aspect of medical care. Thus, the architecture diagram focuses on the same.

Document collection using flask web application

The design of this system can be elaborated by starting with the patient scheduling an appointment at a hospital. The onset of this step is carried forward by filling an online application form by the hospital administrators which is mentioned as MediSmart Document Collection System in the current scenario. This application form includes predominant information about the patient like name, contact information, blood group, symptoms, and treatment information. Both the electronic health records as well as the voice prescription advised by the doctor are directly uploaded along with the patient specific information. The above-mentioned data is collected using a web-based HTML(HTML 5) and Bootstrap(v5.1) form in the front-end and stored at the back end using

python(Python 3.10.4) language which is coded on Flask Application(Flask 0.10.1). After successful registration of patient data for current appointment and noting the problems occurred by carrying huge medical records, we propose to build a system that can digitalize all the medical records and convert them to EHR(Electronic Health Records). During the time of appointment, since it is very difficult for the doctor to read all the patient's medical records as well as his past medical history, we aim to summarize all the health records using Natural Language Processing techniques in this system. Text Summarization technique in NLP is the process of summarizing large texts and presenting in a consolidated manner. Various approaches like extractive and abstractive analysis or Latent Semantic Analysis are some of the NLP techniques used for Text Summarization.

Voice Prescription using frequency-based sentence scoring

Voice Prescription is another notable objective that we aim to build for this system. The term voice prescription is elaborated as a voice recording of discussion happening between doctor and a patient. We also intend to incorporate summarized voice prescriptions for the patients which can provide key points from the discussion as well as notify the patient with respective medical remainders noted form the voice prescription. Voice summarization is also done using the concepts of natural language processing. Sentence extraction along with feature extraction of rank-based sentence selection is performed. Later, sentence compression and consolidation are performed to present a precise report to the patient.

Data in the cloud

After successful summarization of both health records and voice prescriptions they are pushed into the cloud storage. Cloud storage mechanism in this system is proposed to be used as it has efficient storage and retrieval operations and provides high privacy and security services. There are many cloud storage options to store data like Amazon AWS, Google Cloud Platform (GCP) or Microsoft Azure etc. Yet, we intend to use Firebase as a cloud storage framework in this system as it provides efficient yet feasible features like cloud firestore (to store and retrieve data as dictionaries), firebase storage (to store and retrieve files/documents) and firebase push notifications (to notify the patients about their pills/upcoming appointments). The firebase cloud storage for this system comprises of various grouped data like Patient's Electronic Health Records(EHR), Summarized Electronic Reports, Voice Prescriptions and past medical history of a particular patient. Since firebase is open source and an efficient way to build backend side of mobile applications, it helps in feasible connection establishment with the application using dictionaries presented in key value pairs.

Application access through card using QR code system

As our main aim for this project is to reduce the burden of carrying huge documents, we intend to propose a Card System that can function by presenting the patient's information when scanned. To maintain proper authorization, we incorporated a QR code scanning technique that will only retrieve patient specific data in a specified manner. This QR code contains a unique patient ID that is

being mapped to the patient's health data which can be easily retrieved from the firebase cloud storage system.

Android mobile application using flutter framework

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Experimental Analysis

Before diving into the implementation, it is necessary to understand the workflow of the system. The below mentioned MediSmart Document Collection System provides an interface that has fields to be filled only by the hospital administrators. Later, the patients can view this information with the help of the MediSmart Card that is provided with a unique QR code. Simultaneously, the important information stored in the card is available to the patients at MediSmart Application.

MediSmart document collection system

In this paper, we focused on collecting patient's personal information prior to performing any required analysis on medical documents. An interactive HTML form is built in the front-end using HTML 5 which contains fields to enter patient's specific information. Bootstrap-5 is used to enhance the interactivity of the system as well as JavaScript is used to validate fields in the form. The information being collected has 2 parts: the first part contains personal information fields which require patient's name, contact details, blood group and address while the second contains hospital specific information like hospital name, patient's symptoms, treatment information, electronic health records (EHR) and voice record of doctor's prescription. The form can be successfully submitted after confirming the details of the patient.

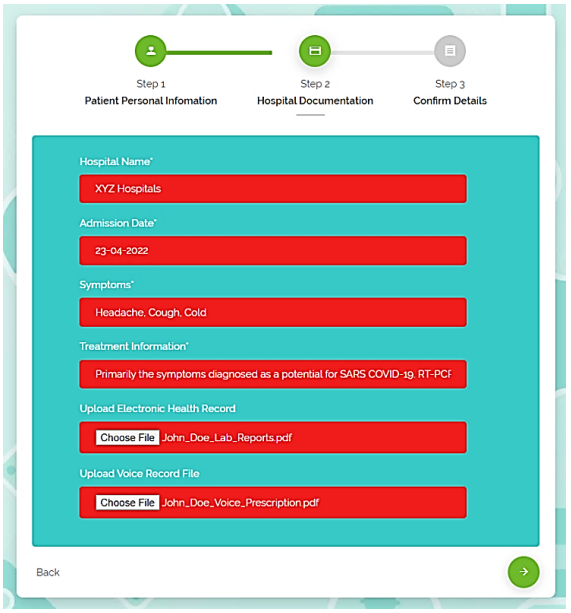

Figure 2. MediSmart flask application

This form has its backend built in Python (Python 3.10.0) with Flask framework as it supports light weight web applications. The details submitted from the form are collected and the Electronic Health Records along with voice records are selected to perform algorithmic analysis for summarization and voice prescriptions respectively.

Medical record summarization

The Electronic Health Records (EHR) obtained through the form are summarized using a Natural Language Processing Techniques. We intend to use extractive summarization method by generating the output for the given input medical document. Frequency based text scoring used in this paper is presented in the following manner. After giving input as an EHR document, the algorithm uses SpaCy (an NLP pipeline) to split the document into words and sentences. Spacy returns a DocObject which contains tokenized text from the document. Later, a dictionary is created without any stop words and punctuation along with relative scoring. Each sentence gets a score after summing the relative frequencies of a sentence. Then, the final summary generated with k-sentences with highest score is returned and is stored in the cloud storage system.

Voice Prescription

After doctor's voice is recorded during the time of patient consultation, the uncompressed .wav file is successfully sent for algorithmic analysis through the MediSmart Document Collection form. This audio is converted to text using SpeechRecognition which is a subfield of Natural Language Processing. Later, the obtained text is analysed using the MED7 model introduced in SpaCy and utilized across pipelines. This MED7 transformer is utilised for EHRs where it indicates 7 medication attributes like *dosage, drug names, duration, form, frequency, route* of

administration and *strength.* This process of information extraction from text is performed and the result is obtained as Named Entity Recognition(NER) used for extracting the above 7 attributes from the audio file. These attributes are securely stored in the Cloud Storage System which are retrieved using the mobile application.

Cloud Storage – Firebase

Firebase is an open-source cloud storage platform to push backend data to both mobile and web applications. In this system a single firebase project is used and is connected to both web application and Android Application separately. Since we require to retrieve data into the application, both cloud firestore and firebase storage features are used. After successfully creating a project in the firebase and connecting it to the web application (i.e., Flask application) data is pushed into the respective cloud service systems mentioned below.

Cloud Firestore

After patient specific information is submitted through the form, data is pushed into the cloud firestore option in firebase. Since the system is aimed to be patient-centric, “Patient Id” is mapped to the main collection. As the patients consult doctors from different hospitals, the “Hospital Name” is mapped under documents section of the main collection. The patient specific information collected from the form is stored as key-value pairs of a particular patient. In the fig:4.2, Another notable point is that patient Id remains same throughout the system for a specific patient.

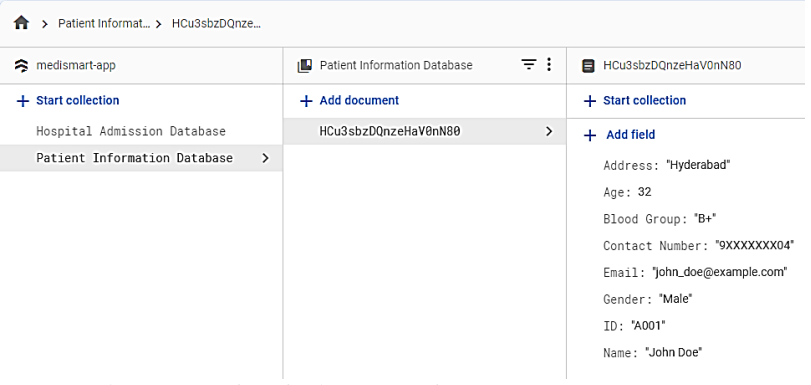

Figure 3. Cloud Firestore data storage structure

Firebase Storage

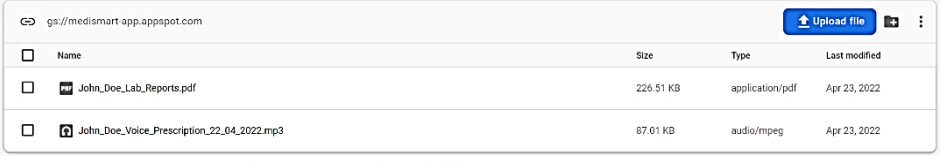

Figure 4. Cloud file storage structure

Since cloud firestore is only limited to mapping data as primitive datatypes, it is constrained not to push any file uploads into the system. This is where the storage option plays a key role in pushing the medical documents. Whenever the algorithm summarizes the EHRs along with the Voice prescriptions the files are directly uploaded into the firebase storage. They are in turn mapped again with the patient Id to ensure accurate retrieval of summarized records from patient's end.

MediSmart Card

Figure 5. MediSmart Card

The design of MediSmart Card is done by ensuring authentication of right patient access into the system. We use the concept of QR code to make authorization unique to a specific card holder. For only the first time when patient is registered, a card with a unique QR code is imprinted on it. The card contains basic information like patient's name, age, contact details and QR code. This QR code contains only the patient Id which helps us to map a particular patient's details both at the firebase side as well as application side.

MediSmart Mobile Application

In-order to help the patients access their reports and other medical details, a specific mobile application for Android is built by using Flutter Framework. This application contains primary features like displaying EHR, viewing summarized medical documents, keynotes generated from voice prescriptions and a virtual view of patient's health card. And secondary features like remainder generation and alert notifications, ordering medicines and ambulance services are provided.

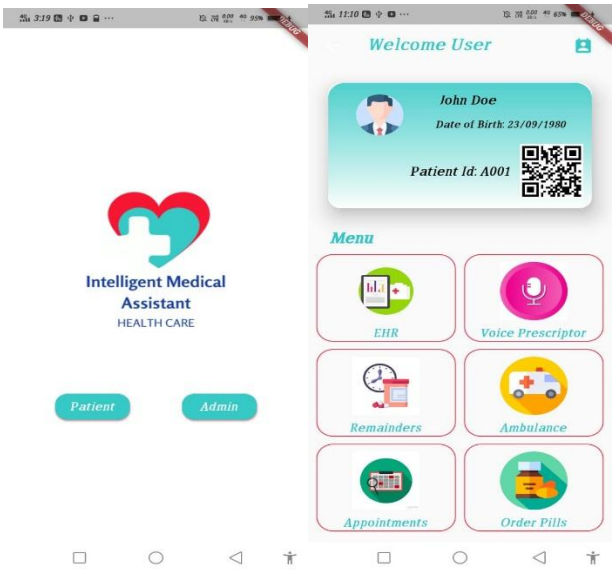

Figure 6. Splash screen and home page of the application

Patient can enter into the application by scanning the QR code present on the physical smart health card. Only after successful authentication the patient is allowed to access information on the card. Here the patients can only get view access to their medical data in the application and cannot tamper them. At the same time, the hospital administrators can append, update, or delete data for a specific patient using the unique patient Id, where this patient id is only accessible after successful QR code scanning.

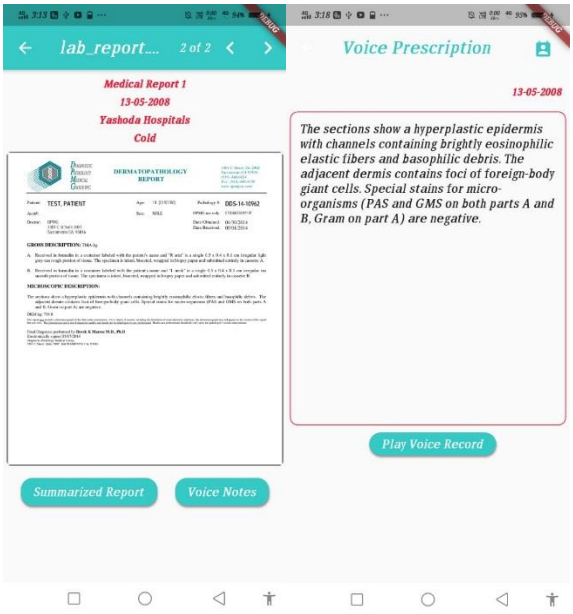

Figure 7. EHR page and voice prescription screen of application

The backend service for this application is also obtained through Firebase. As mentioned above in 4.2the firebase project is connected to both web and mobile applications respectively. As web application pushes the data into firebase, the mobile application is used to retrieve data from the firebase simultaneously.

Conclusion & Future Scope

Though there is huge advancement of technology in the healthcare sector, still there is a lot of hassle in the context of maintaining and monitoring patient's health information. Our system intends to propose a solution that can both digitalize and modernize the current situation of carrying huge medical records every time for consultation and at the same time modernize the system by introducing a card functionality with an interactive card design. To maintain accurate records, the patients are provided with valid reports every time they visit a new hospital by providing the MediSmart Document Collection System to the hospital administrators. This system also focuses on utilizing efficient storage systems based on Cloud which prove to provide both privacy and security to the health data. In the context of EHR, the summarization techniques foster the system by providing accurate information to the patients about their health through the MediSmart Document Summarization System and the MediSmart Voice Prescription. On the other hand, since interactive card design is built, it is very feasible for the patients to access the health card anywhere as it is pocket friendly and uses simple authentication with high privacy. As the patients require a medium to view their health reports and at the same time to avail all the functionalities of our system the MediSmart Mobile Application comes in handy. It provides necessary features like viewing summarized documents, EHRs, Voice Prescriptions, etc. Since this system is implemented on a small scale it is difficult to project a notable amount of awareness to the people in the society, but if implemented at a larger level or with the support of Government authorities, it bolsters modernization of the healthcare sector in the society.

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