Proceedings of the Fifth International Conference on Communication and Electronics Systems (ICCES 2020)
IEEE Conference Record # 48766; IEEE Xplore ISBN: 978-1-7281-5371-1

Medbot: Conversational Artificial Intelligence Powered Chatbot for Delivering Tele-Health after COVID-19

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***Abstract*—Telemedicine can be used by medical practitioners to connect with their patients during the recent Coronavirus outbreak, whilst attempting to reduce COVID-19 transmission among patients and clinicians. Amidst the pandemic, Telemedicine has the potential to help by permitting patients to receive supportive care without having to physically visit a hospital by using a conversational artificial intelligence-based application for their treatment. Thus, telehealth will rapidly and radically transform in-person care to remote consultation of patients. Because of this, it developed a Multilingual Conversational Bot based on Natural Language Processing (NLP) to provide free primary healthcare education, information, advice to chronic patients. The study introduces a novel computer application acting as a personal virtual doctor that has been opportunely designed and extensively trained to interact with patients like human beings. This application is based upon a serverless architecture and it aggregates the services of a doctor by providing preventive measures, home remedies, interactive counseling sessions, healthcare tips, and symptoms covering the most prevalent diseases in rural India. The paper proposes a conversational bot "Aapka Chikitsak" on Google Cloud Platform (GCP) for delivering telehealth in India to increase the patient's access to healthcare knowledge and leverage the potentials of artificial intelligence to bridge the gap of demand and supply of human healthcare providers. This conversational application has resulted in reducing the barriers for access to healthcare facilities and procures intelligent consultations remotely to allow timely care and quality treatment, thereby effectively assisting the society.**

***Keywords* —Telehealth, chatbot, natural language processing, medbot, natural language understanding, conversational technology, digital health, voice user interface, conversational user interface, conversational agent, human-computer interaction.**

I. INTRODUCTION

One of the major challenges that India as a country faces is to cater to good quality and affordable healthcare to its growing population. The World Health Report issued by WHO has ranked India's healthcare system at 112 out of 190 countries [1]. This inaccessibility of healthcare facilities especially in rural India and the intricacy in accessing means of transport further causes patients to postpone their treatment, or opt for medical facilities that may be closer but at the same time are not cost-efficient and well-matched to their medical needs. To seek more efficient ways to provide timely medical care, access and quality treatment to the patient, the role of Telemedicine comes into play which connects patients with healthcare providers and healthcare information.

Due to the recent "COVID-19" pandemic, social distancing will stay in India for a long time, especially for patients with chronic diseases, thereby imposing a hindrance for the population to access healthcare facilities.

The data released by the National Health Mission [2], amid COVID-19 shows that there has been a fall in other acute illnesses being reported during the lockdown in India. This data indicates that a reduced hospitalization case indicates a lack of access to healthcare, rather than a lack of illness. In this alarming situation, telemedicine acts as a boon for people. By using conversational artificial intelligence, healthcare providers can diagnose and treat patients without the need for a personal visit, whilst promoting social distancing and reducing the risk of COVID-19 transmission.

In the current growing age of digitization, Artificial Intelligence (AI) powered chatbots are playing a leading role by exemplifying the function of a virtual assistant that could manage a conversation via speech or textual methods. It makes use of voice queries to get answers, perform actions and recommendations according to user needs. They are adaptable to the user's individual language usages, searches, and preferences with continuing use. A conversational bot with a voice and/or chat interface can play a principal role by overcoming the current barriers towards making primary healthcare affordable, accessible, and potentially sustainable in the new digital economy. With the advent of AI, virtual assistants can be seen penetrating to the nook and corner of the world. The instant service and personalized user experience provide a significant opportunity for the utilization of conversational AI for delivering Tele-health. Voice assistants make use of a natural language interface to communicate via speech. Voice technology must be tailored to be useful in the field of healthcare [3]. The two major potential users in healthcare voice assistants are patients and physicians. Physicians use these

applications to access and record the patient's data. At the patient's end, it is a cheaper alternative; AI-enabled virtual assistants that can render 24x7 care to a wide variety of patients. People suffering from chronic diseases, disabled patients, and patients living in rural and farther areas would benefit most from such powerful virtual assistants' tools. These systems have many advantages: reduced time on the part of physicians, improved security of patient data, on-demand healthcare information, thus, making healthcare accessible and affordable for all with an intuitive interface [4].

This paper describes integrating chatbots into telemedicine. Our solution "Aapka Chikitsak" includes a Multilingual Voice Application based on Natural Language Processing to provide primary healthcare education and advice to chronic patients and women needing antenatal care. Using AI, it converts the user's speech to text which is processed and understood using natural language processing, and an output is generated which is then converted back to speech and returned to the user. Our software covers the most prevalent diseases in rural India with a special emphasis on women's healthcare. Our application imparts the services of a doctor by providing preventive measures, home remedies, healthcare tips, symptoms, and location-based diet recommendations. Prevention is always better than cure and by having a personal healthcare assistant; our software will be extremely beneficial and provide an efficient and instant solution to those in need.

II. Related Work

Certain text-based human-computer interaction systems have been developed like ELIZA [5] that imitates a psychotherapist, and then PARRY [6] which suggests the thinking of a paranoid patient. Raij et al., [7] conducted two separate experiments where they compared virtual human interactions and with a real human in a medical consultation scenario. Their result shows similarity in virtual and real interactions context. A. Fadhils et al., [8] work shows how intelligent conversational systems can be used to interact with old age populations to collect information, continuous monitoring of health conditions, especially after discharge from the hospital. Amato et al. present a medical recommendation system specifically designed to interact with the user, thereby acting as a medical physician [9]. Comendador et al., [10] introduce Pharmabot, a pediatric generic medicine consultant chatbot designed to prescribe and render useful information on generic medicines for kids.

III. Proposed Work

Tele-Health is the distribution of health-related services via electronic and telecommunication technologies [11]. It enables long-distance patients to get care, advice, reminders, education, monitoring, and remote admissions from clinicians. A chatbot is a conversational agent that communicates with users using natural language. Though there exist some applications that serve as virtual healthcare consultants, none of them provides generic healthcare information, preventive measures, home remedies, and consultation for India-specific context with multi-lingual support. India being a country with a diverse population speaking different languages, access to healthcare at present has multiple barriers including language, lack of healthcare professionals, and lack of access to facilities in rural and remote areas and costs associated with medical consultation. Therefore, an application "Aapka Chikitsak" is developed to provide users healthcare consultation, counseling and information with multi-lingual support (for now, English and Hindi) to improve the healthcare and well-being of the growing population in India and continue provision of healthcare access at ease post the lockdown as well.

IV. Conversational Tele-Health Agent

Conversational Tele-Health assists in the form of an automated conversation between the user and computer in the form of either chat or voice. Tele-Health is poised to tailor the health service to users' needs to improve their health condition by offering valuable consultations and information to patients at the comfort of their home. Application of Human-Machine interaction in the domain of healthcare is pivotal in aggregating the services of a doctor, thus, overcoming the challenges of accessibility, feasibility as well as communication for the patients. Our application bridges the gap between patients and a lack of access to healthcare facilities during pandemics by leveraging telehealth.

A. The architecture of Conversational Bots

In recent years, serverless architectures (Functions-as-a-Service) are gaining traction as an alternative way of providing backend services without requiring a dedicated infrastructure. Serverless allows its users to deploy their stateless functions into platform infrastructures. This stateless behavior makes every invocation independent of the previous runs. For our application, Firebase Cloud Functions and Google Cloud Platform as our backend infrastructure is provided [12].

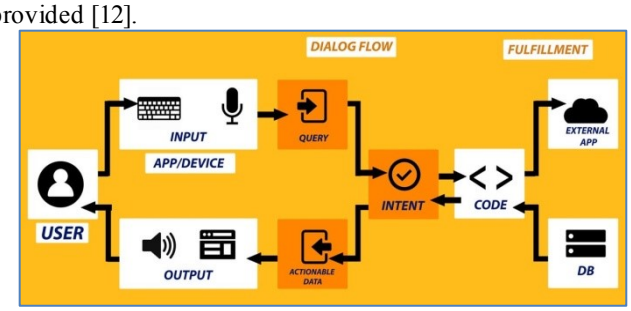

Fig 1. The Architecture of the Conversational Bot

The complete architecture of "Aapka Chikitsak" is shown in Figure 1. Our conversational bot is AI-

powered and based on a serverless architecture. It is embedded with Natural Language Processing (NLP) and Natural Language Understanding (NLU) to understand the user's query and return respective responses. NLP facilitates to read, decode, understand, and make sense of the human languages. The first level of processing in our architecture deals with audio I/O. When a user makes a query, the user query is converted from audio input into text and this is referred to as Speech-to-Text. In the second level of processing, the extracted text is used as a basis for performing Natural Language Understanding on the generated text to decode the semantic meaning of the user input and recognize morphemes. In the case of a chat interface, this is considered the first level of processing due to the absence of the need for audio-to-text conversion. Based on the semantic meaning of the user utterance, the entities are detected, which is then mapped to the respective intent on Dialogflow [13].

The intent mapping is performed by our Dialogflow agent that has been extensively trained on an annotated corpus of training phrases to allow it to find inferences. Once the intent matching is done, an HTTP POST request is sent by Dialogflow for fulfillment to the Webhook to respond to the user. For our bot, cloud functions are used for firebase [14] to create a Webhook. The webhook request consists of the information about the matched intent, the action, parameters, and the response defined for that particular intent. The Webhook request is fulfilled through the deployed cloud function on Google Cloud Platform and this service sends a webhook response message to Dialogflow. The response message consists of the response that should ultimately be sent to the user. Further, in case of a voice interface, the text response is again converted to speech (Text to Speech) and returned to the user. The technology stack used for our bot is shown in Figure 2.

Fig 2. Technology Stack used for "Aapka Chikitsak"

B. Hybrid Conversational Technology

For conversational application, Hybrid model is used to employ a partially Rule-Based and Machine Learning approach. To recognize user expressions and classify the text into one of the intents [15], Dialogflow agent uses machine learning algorithms to map them to intents and extract structured data. The two algorithms used by Dialogflow for intent matching are Rule-based grammar matching and ML matching [16]. By default, Dialogflow attempts both of these algorithms and chooses the best result out of the two. The language models built into Dialogflow as well as the annotated training phrases corpus are used to train the agent [17]. Firstly, the hybrid model attempts to match according to rule-based grammar. If a match is not made, it switches to ML matching. This mode is considered to be the best and an optimized solution for most use cases considering that it works accurately with a sufficient number of training phrase examples, thereby allowing quick updation of the models. To search for a matching intent, Dialogflow provides scores to the potential matches by assigning an intent detection confidence, also known as the confidence score, whose values range from 0.0 to 1.0. The 0.0 score represents that the match is completely uncertain and 1.0 signifies that the match has been completely certain. For filtering out false-positive results and getting variety in matched natural language inputs that set the machine learning classification threshold value to 0.3. A fallback intent [18] is triggered if the confidence value is smaller than the classification threshold. If no fallback intent has been defined, then none of the intents will be triggered.

V. CONVERSATIONAL DESIGN

The conversation of our bot has been framed and designed in a way to mimic human behavior to develop a user-friendly chat system that allows them to feel at ease, overcoming the bias of machine interaction. While designing the conversational flows, multitudinous utterances that can be used by the users while interacting with the chat system is considered. Our application uses the Dialogflow Conversation API [13] for creating an automated conversational chat system to hold a conversation with the user by understanding the natural language. Dialogflow employs Google's ML expertise, its products like Google Cloud Speech-to-Text and runs on GCP (Google Cloud Platform) that allows scaling of applications to hundreds of millions of users. When a user chats with our application, there can be a broad variety of utterances that they can utilize aiming at the same purpose. In particular, Dialogflow provides a high-level dialogue flow to identify user queries by mapping them to intents that have been trained with an extensive amount of training phrases pool [19]. Training phrases are certain model phrases that users would use, referred to as end-user expressions [20]. An Intent is a collection or a category of such related end-user expressions during one conversation turn. In our conversational design, it created 255 intents and each of them has been trained with multiple user utterances that were collected during user-testing. By recognizing

the intent of the query, Dialogflow chooses the specific actions to fulfill the intent. Entities in Dialogflow are meaningful sequences of characters or lexemes. It is used to extract specific keywords in a user's query [21]. Entities allow us to map the synonyms to its reference value. To create a contextual flow of conversation it used the input and output contexts in our design, which allows the bot to keep track of what was asked earlier, what user is asking next, and respectively reply to the user [22]. Using contexts, one can easily organize the flow of conversation by defining specific states and lifespan that a conversation must be in, for the intent to match. The chatbot uses the intents and entities, recognized in the user input, along with the context of the conversation, to interact with the user and finally generate a helpful response. A database of responses are created by using information from the National Health Portal [23] to ensure quality responses. For our use-case, our conversational system flow of dialogue has been intended to handle the following use-cases (as shown in figure 3):

1) Providing information about the majority of prevalent diseases in India along with their possible symptoms and applicable preventive measures.
2) Home remedies and quick remedies for common illnesses.
3) Interactive counseling sessions for emotional support and expectant mothers.
4) Local food recommendations and recommended diet depending upon the geographic location of the user.
5) Vaccine administration information.

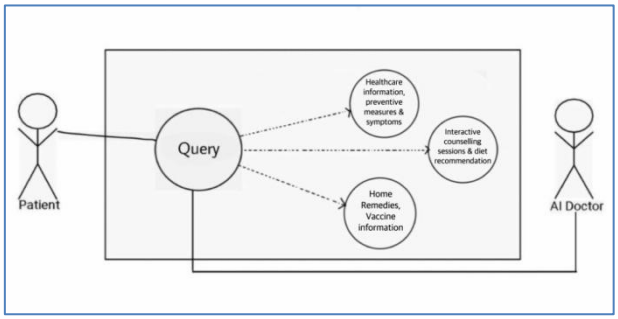

Fig 3. UML diagram showing the use cases of the Bot

A. Voice-based Tele-Health Bots

The interaction process designed behind the voice bot makes it extremely simple and easy to communicate with the user. Voice is the most powerful medium as well as a natural form of communication. Voice bots use Natural User Interface and are Artificial Intelligence-powered which enables it to understand and have human-like conversations.

B. Design of Voice User Interface (VUI)

A typical voice-user interface (VUI) makes possible spoken human chat with computers via speech recognition to understand spoken words and answer questions, and specifically uses text to speech to create a reply. Speech Synthesis Markup Language (SSML) [14] is used to make the voice experience more interactive and robust. Several points are kept while designing the voice user interface of our conversational system. Our bot has its personality so that it sounds more human-like, convincing, and user-friendly.

The flow of the conversation consists of short and concise replies in layman language that aids in saving time and makes the interaction more human-like. It includes various health tips and suggestions to increase interactivity and encourage greater engagement. Our bot is devised with multilingual support which has aided us to target both rural and urban areas in India. It structures the VUI of our conversational bot in such a way, to give responses with the focus on having a doctor-patient-like conversation. Our bot has its naturalness as it duly greets users and is trained to give suggestions, health tips, location-based food recommendations according to the patient's concerns and queries. Figure 4 shows the working of the Voice User Interface of our bot.

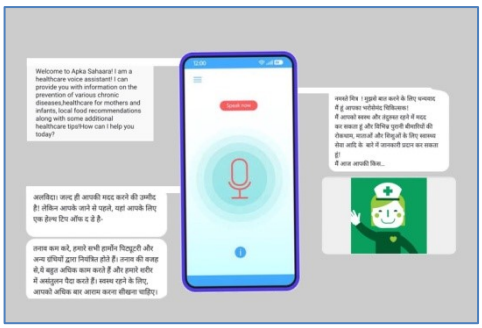

Fig 4. Working of the Voice User Interface

C. Chat-based Tele-Health Bot

Conversational User Interfaces of the messaging apps allow us to invoke a text chat by just a simple button click. A Fadhil et al., [8] conducted a survey that proves that applications that also support conversational interfaces are extensively used and users feel more relaxed using them daily. Text-based messaging services are relatively cheaper, faster, and democratic as well as popular [24], and for millennials and young people especially, it is considered as the preferred way of communication [25]. The efficacy and efficiency of text-based healthcare chatbots have already been shown in [26].

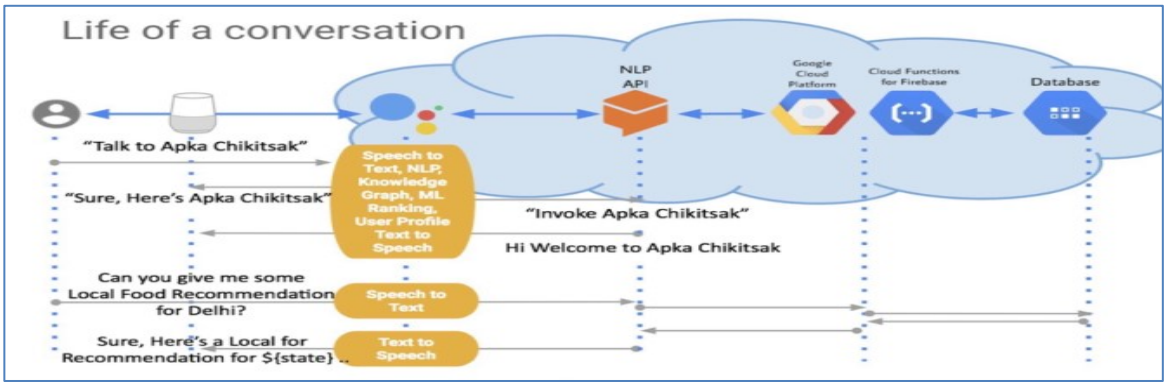

Fig 5. Sequence Diagram for Conversational Bot

Albeit, it is open how to design a Conversational User Interface supporting patients as well as healthcare professionals within a therapeutic setting, beyond the

D. Design of Conversational User Interface (CUI)

Conversational interfaces are platforms that mimic a conversation with a real human. The models has been designed with a Conversational User Interface (CUI) that focuses on linguistic cues along with a set of visual cues like gifs to make the conversation interactive, user-friendly, and more intuitive. Designing techniques applied in the conversational user interface are not similar to the conventional GUI patterns.

These are some vital elements that are considered while dealing with designing the CUI for our conversational agent, like look and feel of the chatbot, notifications to engage its users, ease in getting responses, good NLP support, keeping conversation brief, and reduced users monotony.

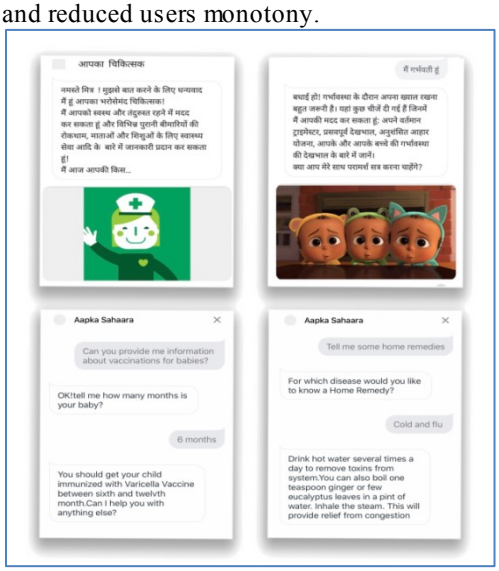

Fig 6. Conversational User Interface Screens

VI. CONCLUSION

Keeping in mind the after-effects of a pandemic and the imbalance between the demand and healthcare services currently provided, especially in rural India have tried to bridge the gap by creating a Multilingual Conversational Application with Natural Language Processing (NLP). This is a one of a kind personalized healthcare bot which is sensitive to the needs and understanding of the Indian rural population provides generic healthcare information along with preventive measures for prevalent diseases and ailments indigenous to our country in a user simplified language; with special emphasis on interactive antenatal and postpartum healthcare. It has additional features including home remedies, location-based diet recommendations, age, and gender-specific health check-up advice, emergency helpline numbers, and can be linked with a real-time messaging application like WhatsApp. The aim of this application is not just to prevent malicious infectious diseases in the grappling population but to help achieve overall wellness. Our application is quite reliable in detecting various common diseases, suggesting home remedies and local food diets as long as problems and symptoms faced are well communicated by the user to the chatbot, and leading questions from the chatbot are appropriately answered.

VII. FUTURE WORK

Even post the lockdown, our application will facilitate in reducing the burden on doctors, without threatening the safety of the patients and health workers, whilst allowing the patients to get consultations and information at the comfort of their homes. In the future, it has been looking forward in making the voice assistant more talented by adding an anti-depression support system that will provide music therapy, mental health tests, and self-assessments. This will also create a supporting website for conversational application for people who would like to read more information. The authors are working on bringing professional healthcare closer to the users by providing live connectivity with doctors and including features like appointments by a tap.

ACKNOWLEDGMENT

This novel work stems from the participation of our research team under Harman International, a Samsung Company, at the Smart India Hackathon Software Edition 2019, which is India's biggest and most coveted National Hackathon organized by the Ministry of Human Resource Development (MHRD), Government of India. Our team emerged as a National Finalist. The statements made here are solely the responsibility of the authors.

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