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Research Article

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Location-Independent Intelligent Interface Customized to the Aid and Response of the Differently Abled

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Abstract

Today, the most feasible and easy form of Human-Computer Interaction (HCI) is the use of mobile applications. Mobile applications have become an integral part of our day-to-day lives reaching out to each corner of society and catering to the problems. The applications available are customized, but the incorporation of intelligence especially for the disabled to assist their lives is absent. This motivates the research work specified in this paper is non-commercial application development for society. Designing applications that are highly scalable and intelligent to minimize problems faced by differently abled, is explicitly covered here. The proposed system makes use of Speech-To-Text and Text-To-Speech conversion techniques for the back end and provides enhanced scalability by allowing users to regulate the functionality of the application, customized based on their preferred region, topic, and time stamps. Applications and devices meant for the differently abled do exist, however, most of them have unidirectional and singular functionality with minimum customizability. In most cases, very complicated hardware systems are associated with the proposed work which in turn makes it expensive to maintain. The proposed application aims to offer voice-based functionality automation, remote health monitoring, and pattern recognition for recommendation systems, explicitly for the visually impaired and the solitary elderly. The reading of remote health monitoring is close to the actual value with a standard deviation of 1.45% or 0.76 on the average which validates the working methodology adopted.

Keywords: Speech Recognition, Text-to-Speech, Web-Scraping, Human-Computer Interaction, Digital Assistant.

1. Introduction

With the advent of Artificial Intelligence in the early 1950s, it has since gained tremendous momentum. The technologies and complex algorithms associated with it, have evolved, been innovated, and are today, a nearly indispensable part of human lives. Our closest apprentice, when it comes to modern technology, is the plethora of mobile applications we are surrounded by. Apart from just embedded systems, it didn't take much time for Artificial Intelligence to pave its way inside Software Applications. Given, that an average internet-privileged human being spends the most time on mobile apps, out of all other technologies available, it is quintessential to create Intelligently accurate, highly scalable, and user-friendly mobile applications to ease our daily technical struggles.

The most common tech stacks for mobile app development, which have been used for quite a few years now, are Java and Kotlin for Android and C++, Swift, etc. for iOS applications. However, recent developments have portrayed a gradual shift of tech stacks from platform-dependent ones, like the ones mentioned above, to platform-independent WORA (Write once, run anywhere) technologies, which make use of single codebases. These include Flutter, Xamarin, React Native, Kivy, etc. [1,2]. The use of Neural Networks in creating Artificially Intelligent applications can empower people with limited physical sensations and mobility [2]. There has been significant development in the field of creating intelligent applications for the differently abled [3]. There is- Lookout by Google and Seeing AI by Microsoft, apps that narrate the immediate surroundings to visually impaired people, using image captioning methodologies. Then there's WeeMoGee, by Samsung, which makes voice recognition easier for people with speech disorders. The IFTTT, comes with automotive functionalities for disabled people for their daily chores, to name a few [4]. While more enhanced and better applications are being created every day, noble work culminating in better overall social and economic development, all around, is the need of the hour. Human-Computer Interaction has emerged as one of the leading domains of research in the field of Computer Science [5]. Majority of the modern research refrains a dodge from Human-Computer Interaction- in some way or the other, every major point of research work is directed towards reducing human effort by inculcating intelligent automation and simulating it in a controlled environment. However, much of it requires complex hardware, and high maintenance costs and therefore, fails to make a major impact in the real world in most households.

Due to the ever-growing shift in economic booms and its subsequent culmination into greater scopes and job opportunities, a considerable number of youths are forced to move to cities with economies and jobs better than the ones they are currently in [6]. This causes their parent(s)/guardians to remain alone in their native places all alone, mostly devoid of any proper medical attention. Not just in India, but across a good percentage of the population in the world, cardiovascular diseases remain the chief causes of mortality among elderly men and women [7]. Negligence of regular heart rate monitoring, hypertension, high lipid profiles, careless dietary measures, absence of physical exercises, smoking, alcohol, and several other reasons have proved to be contributing factors to CVDs and possible deaths caused due to it [8]. In 2014 in India, a reported 18309 people died due to heart attacks, and the number increased by a whopping 53% in 5 years, resulting in 28005 of the same, in 2019, states a report by the National Crime Report Bureau (NCRB). The LASI WAVE-1 Report, 2017-2018, which indicates the living arrangements of the elderly is mentioned below in Table 1.

	Background Characteristics				
Place of Residence	**Living Alone**	**Living with Spouse**	**Living with Spouse and Children**	**Living with Children Without a Spouse**	**Living with Others**
Rural	6.3	21.5	40.6	25.6	6
Urban	4.1	17.5	40.7	32.6	5
Total	5.7	20.3	40.6	27.6	5.7

Table 1. Living arrangements of the elderly (60 years and above) by background characteristics in India (%)

Apart from a very fraction of them, most of them are barely accustomed to modern-day technologies and forms of communication, which include operating smartphones. This paper is a noble research work based on an application of artificial intelligence with the use of NLP, Speech Recognition, and its equivalent automation to perform 5 major tasks that usually constitute the daily activities of elderly people who reside alone, the visually impaired and the ailing [9,10]. These broadly include placing calls, making grocery lists, running regular health diagnostics, providing basic multimedia entertainment, and lastly and most importantly, intelligently perceiving alarming scenarios and making emergency calls [11]. The contribution of this work is mentioned as follows:

• Digital assistant for the disabled that would enable them to place calls through voice to the contacts on the phone.
• Smart calling for the disabled customized based on location would enable them to place calls through voice to the different services available in the locality.
• Enabling the measurement of pulse rate

In section 2 of the paper, similar research works and contributions to this field have been mentioned. Section 3 consists of detailed information about the functioning of the proposed research work that has been put forward. Next in section 4, the system has been elaborated along with its complexities and dependencies. Section 5 is about the analysis of various test results obtained while testing the accuracy of the application. Sections 6 and 7 mention the conclusive contents and necessary acknowledgments, respectively.

1.1 Literature Survey

There has been a significant amount of work done in the field of automated services to aid the daily activities of people [12]. The key is intelligently perceiving scenarios and producing outputs simulated to a humanized extent.

For example, there are semi-automated vehicles with assertive voices that help distracted drivers regain their attention [13]. Alongside, on a similar scale, there exists a Context-Aware Reflective middleware System for Mobile Applications, which replicates human-like behavior and performs tasks, thus earning the deem of personal digital assistants [14, 15]. Often, incorporating Intelligence within mobile applications comes in handy, as it reduces a lot of human effort, saves time, and paves the way for further research in this field [16]. The proposed application is meant to serve as an Intelligent Voice Assistant, especially for the visually impaired and the elderly [17,18]. Some note-worthy mentions of similar developments that significantly cater to the needs of the differently-abled are as follows:

Prototype	Concept	Merits	Gaps (covered by our proposed system)
Augmented Reality Personal Digital Assistant [19] (AR-PDA)	The AR-PDA will enhance real camera images with virtual objects (animated 3D, 2D, text) and allow personalized user interaction with the augmented scene. Dedicated annotations aid the user.	● Software-based ● Easily Accessible ● Visual Assistance ● AR-authoring support and usability	● No Voice Automation ● Does not adapt to changing user-usage patterns
Siri Talks at You - Voice Activated Personal Assistant (VAPA)[20]	Offer considerable promise to individuals who are blind due to the widespread adoption of these non-visual interaction platforms along with inclusivity support	● Voice Automated ● accounting for privacy and situational factors in design ● Support for inclusivity	● No Emergency Calling Feature available. ● No Health Diagnostics measuring
Eyemate[21]	The blind person is guided through Bengali/English voice commands generated by the application according to the obstacle position. Using voice commands a blind person can establish a voice call to a predefined number without touching the phone just by pressing the headset button. The blind assistive application gets the latitude and longitude using GPS and then sends them to a server. The movement of the blind person is tracked through another Android application that points out the current position in Google Maps.	● Voice Automated ● Hands-free Call Placing ● Movement-based, guidance	● Physical Headset Required ● Offers singular functionality. ● Does not adapt to changing user-usage patterns
Smart Home Assistants [22]	Listen to their environment and react to spoken user commands to retrieve information from the internet, control appliances in the household, or notify the user of incoming messages, reminders, and the like. With their increasing ubiquity in smart homes, their application seems only limited by the imagination of developers, who connect these off-the-shelf devices to existing apps, online services, or appliances.	● Voice Operated ● High Degree of assistance offered. ● Complex and user-adaptable system ● Security Assurance ● Backed by branded VAs	● Emergency Calling not present. ● Health Vitals monitoring is not available. ● Heavy hardware requirement ● Highly expensive ● Heavy energy usage and maintenance costs

Table 2: Comparative Study of previous related works conducted.

Significant Developments in virtual and automated medical care procedures for the elderly have taken place in recent years, a few of which include voice assistants that give pharmacological reminders and ones that help in avoiding sedentarism [23,24]. On a larger scale, which requires greater infrastructure and hence greater costs, Voice Interface Applications are using Google Home and Smart Vehicle Assistants [25,26].

The lack of personal assistants and devices that can take care of and monitor health or help in emergency conditions, aggregating a lot of automotive capabilities was the key source of motivation behind this work. The fact that voice-automation of a smartphone also in turn automates the various native processes it is supposed to perform comes as a mighty relief for the people who struggle to make use of the touchscreen systems. Voice automation of applications not only saves processing time but also reduces human effort to a large extent therefore rendering systems better accessible.

An opportunity that we wanted to exploit was an already existing Speech-to-Text and Text-to-Speech third-party API, saving us the errand of building and deploying a separate system and procedure.

2. Proposed Methodology

Post installation and successful authentication, the user is prompted to grant phonebook, calling, media access, and location permissions. Once granted, internet availability checks are done. Once a successful connection to the Cloud-based Voice Script Integrator is made, the application is ready to use. Upon considering all probabilistic events, based on user queries and device-generated responses, there can be a total of 3 possible cases:

Cases and Formats	Form of User Query/ Request	Form of intended auto-generated response	Voice Script action (s)	Local App action(s)
Case 1	Static	Static	Static Voice response (Text-to-speech, non-parameterized)	Sending User Query to Voice Script
Case 2	Parameterized	Static	Static Voice response (Text to Speech, non-parameterized) ; Sending Parameterized Commands to a local app.	Sending User Query to Voice Script; Performing parameterized commands received from Voice Script.
Case 3	Parameterized	Parameterized	Sending Parameterized Commands to a local app.	User Query to Voice Script sent; Performing parameterized commands received from Voice Script. Parameterized Voice Response to User.

Table 3: Cases depending upon the form of User Queries/Requests and their respective intended Responses.

2.1 Architecture Diagram

Fig. 1 is a very generic consideration of data exchange between the User, the Mobile App, and the Cloud-Based Voice Script Integrator. Based on this blueprint, cases 1,2, and 3 of the aforementioned Table 2, are varied based on the nature of the arguments.

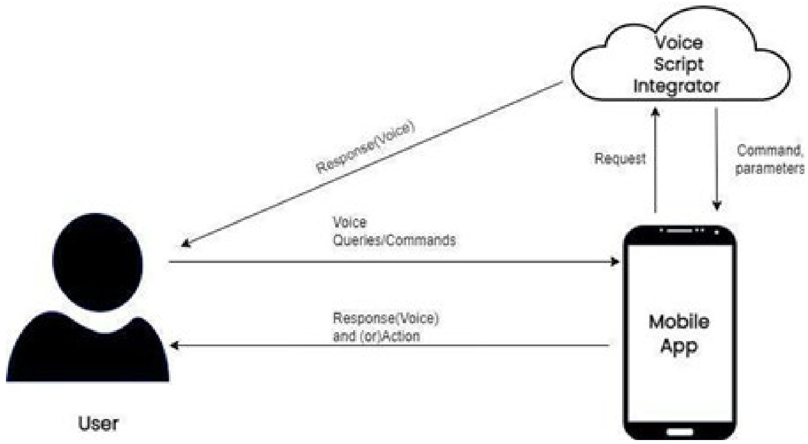


Figure 1: Architecture of the working model

Fig. 2 is based on Case 1 of Table 2, which considers non-parameterized and static commands, with the same non-parameterized and static responses from the Voice Script directly.

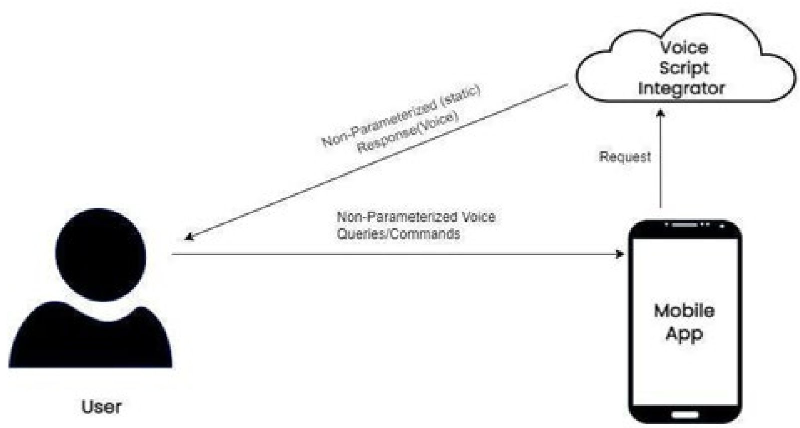


Figure 2: Architecture of the working model when the query/response is static.

Fig. 3 represents Case 2 of Table 2 where the user sends a parameterized command but the nature of the response from the Voice Script is non-parameterized and static

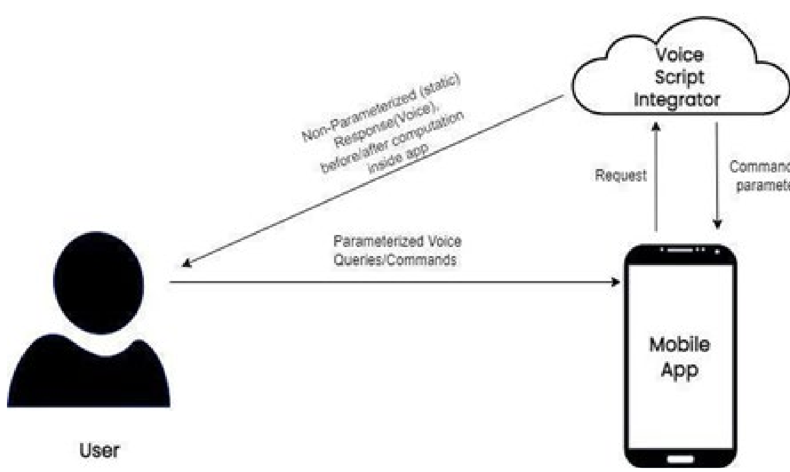


Figure. 3: Architecture of the working model when the query/response is static and parameterized.

Fig. 4 represents Case 3 of Table 2 where both the commands and responses are parameterized and variable inclusive. However, in this case, because of the nature of the response being parameterized, it is sent indirectly to the user via the Voice Script and through the Mobile App.

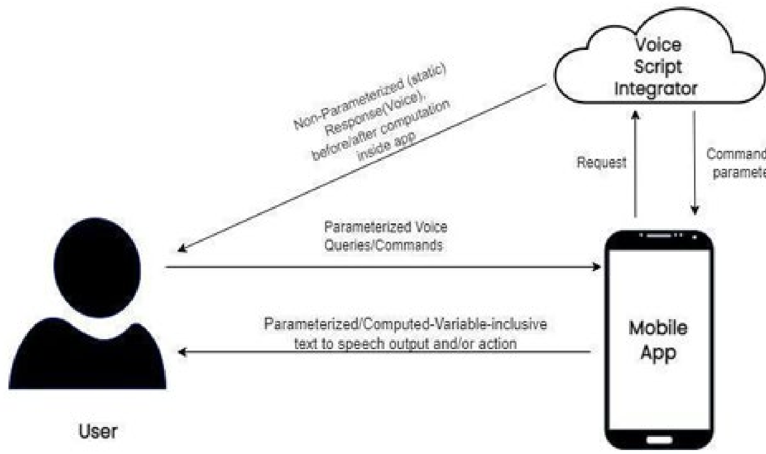


Figure 4: Architecture of the working model when the query/response are both parameterized

2.2 Data Flow Diagram

Following installation and successful login, the user is requested to authorize rights for the phonebook, calling, media access, and location. Once approved, internet availability is checked. The program is ready to use after a successful connection to the Cloud-based Voice Script Integrator is established. The data sent between entities and processes might be parameterized, non-parameterized, or just flag variables.

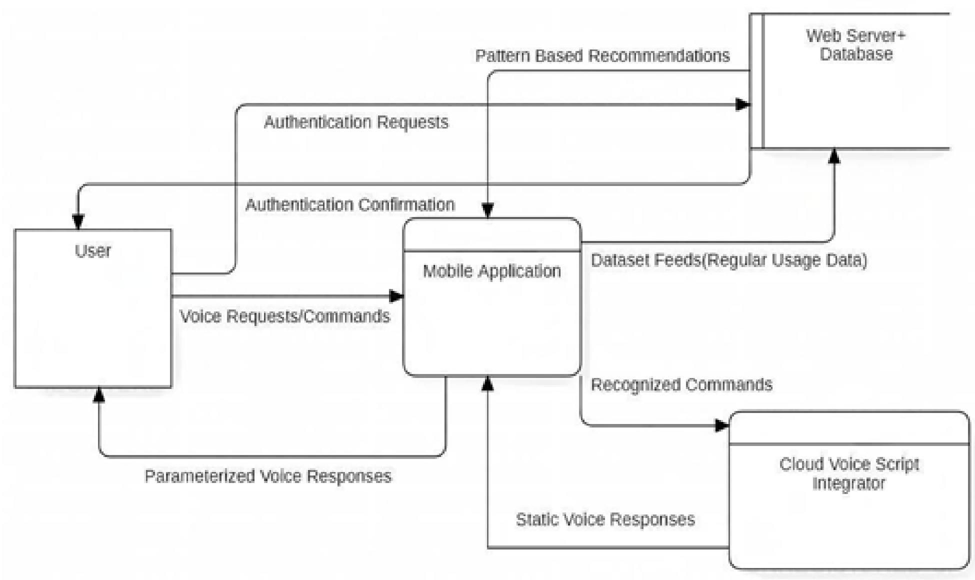


Figure 5: Data Flow Diagram. of the Application/system developed

2.3 Pseudo Code

Input- User Voice

Output- Command-infused and/or parameterized and/or static response based on the cases described in Table 2.

Algorithm Smart_Remote_Assistant_and_Interface( )

{

VoiceResponseSystem(User_Voice)

{ //User speaks out queries/commands that are recognized by matching the intents of the Voice Script

initState()

action=MobileApp(User_Voice)

}

```
initState ()
{ //local settings, internet access check, permissions-contacts, location, and camera awaited
Script = new VoiceScript () //Local Instance of Voice Script API created
Script.Listen() //Device Starts listening to the User
}
MobileApp(User_Voice)
{
send_query_to_Voice_Script(User_Voice.recognized_words)
}
Recognizer (User_Voice)
{
//matches the user's words with intents specified in the voice script and returns responses and actions based on aforementioned cases
if User_Voice=static //Case-1
action=VoiceScript.response
else
if intendedResponse=static //Case-2
action=VoiceScript.response
VoiceScript.send_command_to_mobileApp
MobileApp.compute(command)
else //Case-3
VoiceScript.send_command_to_mobileApp.
MobileApp.compute(command)
action=MobileApp.response
return(action)
}

}
```

3. Methods and Material

The proposed application has been created using a platform-independent application development framework known as Flutter, version 3.3.8, using the programming language Dart, created and maintained by Google. Average CPU usage by both the main application and the Heart Beat sub-app, in all the features used, amounts to 190.8 MB per hour. With the features currently present, it occupies 445 MB (294MB for the main app and 151 MB for the sub-app). The OS used to build the software is Windows 11 Pro, version 22H2 with a build of 22621.819. The IDE used is Visual Studio Code, version 1.71, and Android Studio version 2021.2. A noteworthy collection of third-party APIs has been put to use, to serve different purposes. All of them are mentioned below:

API/Package Name	Purpose	Alternative
Alan Voice	Text-to-speech and Speech-to-Text; Command Recognition, Cloud-Based Voice Command segregation	Local Text-to-Speech, packages for Voice Recognition.
YouTube API	Automated Music/ Video Playing	Dailymotion for Developers, Spotify API
Dark Sky Weather	Weather forecasting details for a particular location	OpenWeather API, QWeather API
Challenge	Web Scraping Purposes	Looter, Scrapy
Flutter Phone Direct Caller	Calling given numbers	Telephony

Table 4: APIs and Packages used along with their alternatives

For testing purposes, configurations of the location were set to New Town and Kolkata, and ancillary settings were done for the police station, hospital, and fire station.

4. Result Analysis

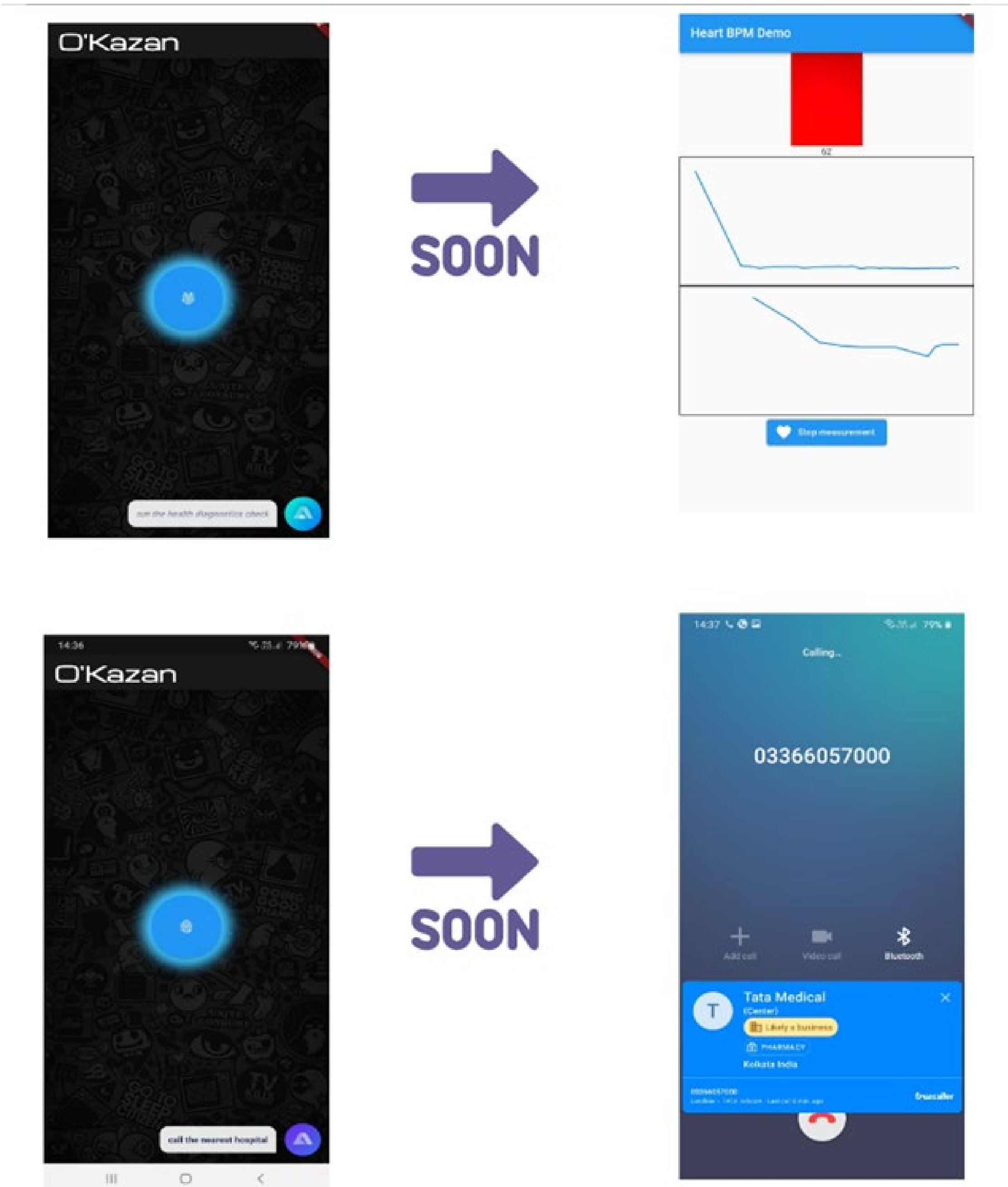
A periodic noting of pulse rates, using photoplethysmography on one thumb and a manual pulse oximeter on the other, was performed on a 69-year-old male, with diabetes, at noon for 10 days straight [27,28]. Given below are the results and the deviations from the original values. From Table 5, the average deviation between the readings of Photoplethysmography and pulse oximeter is 0.76 and the percentage of deviation is 1.45%.

Photoplethysmography	Pulse Oximeter	Tolerance	Percentage of Deviation	Mean	Standard Deviation
71	70.4	-0.6	0.852	70.7	0.424
68	66.9	1.1	1.644	67.45	0.777
76	76.7	-0.7	0.912	76.35	0.494
79	80.6	-1.6	1.985	79.8	1.131
85	86.0	-1	1.162	85	0.0
79	79.7	0.7	0.878	79.35	0.494
67	70.1	-3.1	4.422	68.55	2.192
69	69.8	-0.8	1.1461	69.4	0.5656

77	76.2	0.8	1.049	76.6	0.565
73	73.4	-0.4	0.544	73.2	0.282
Average			**1.45**		**0.76**

Table 5: Comparative Readings of Pulse Rates

4.1 Screenshot Display of Parameterized User Commands:



The user speaks to the application and the corresponding outputs are attached:
Figure 6: Screenshot of Application Functionality

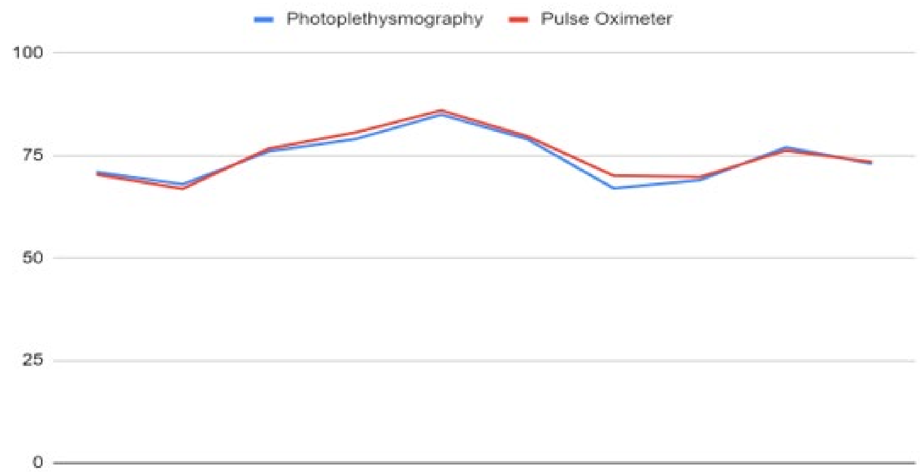


Figure 7: Chart Depicting Comparative Readings

From Figure 7 it is evident that the reading of the photoplethysmography provided by the system with that of the pulse oximeter is quite close and follows the monitored range.

5. Conclusions

The system used /prototype built as an initiative embeds many types of conversions and applications into a single uniform platform. Hence, query processing at run-time is one of the primary features of the developed system. However, the difference lies in the extent of customization the system provides based on parameters. These parameters may be based on location, choices/preferences, and historically based activities and can further be customized as per needs.

To summarize, the use of the developed system is that the system initiates connecting especially abled persons to the digital world in ordinary cases and cases of emergencies. This is just an initiative that maximizes the usage of simple devices like a smartphone. From the results taken on interpolation of 50 readings to 10 readings, the values predicted by the work are close to the actual values as shown in the result section with very little deviation by -1.56 and less than 1.46%.

There are a few system constraints and pre-assumptions which are to be considered:

● iOS doesn't allow background execution of applications that require constant audio-visual interaction. This is where the application becomes platform-specific.

● As of now, Firebase doesn't provide free phone number-based authentication, hence the app won't entirely be hands-free.

● The risk of Activity killing in the form of a back button, or RAM erasure, looms.

● Using Third-party Party Voice APIs, doesn't take into consideration the detection of non-verbal vocal patterns like coughing, sneezing, etc. which may be essential to keep a proper health track of the user

● Since the system makes continuous use of audio I/O channels, battery consumption is high.

The system can be extended to support other facilities with enhanced features. These may be related to automating tasks based on the behavior/trend captured from previous tasks in a more intelligent, purpose-driven way that may also be a generative AI-based model. There is also a parallel thought to transform the existing work into a transformer-based model that can be deployed across varying domains with the advantage of less reliance on the data and more on the model development.

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