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ailment that is endemic in Nigeria and Sub-Saharan Africa where language of doctor to patient interaction is a huge challenge. This is the gap that this research aims to fill by designing and implementing an Android-Based mobile Text-To-Speech enabled malaria diagnosis system with multi language select option (Hausa, Yoruba and Ibo) as this will go a long way in breaking the jinx of language barrier between the Doctors and Patients during clinical and diagnosis interaction.

II LITERATURE REVIEW

2.1 Android

Android is mobile operating system developed by consortium of developers known as the Open Handset Alliance, with google being the main contributor and commercial marketer. The operating system is written in Java, C, C++ and among others. The market targets are smartphones, smart TVs, tablets, computers, wearable devices and automobiles [6].

2.2 Text-To-Speech

Text-to-speech is a technology that makes it possible for text to be converted to a human speech using a synthesizer which is normally United Kingdom or United States of America accent [6]. Text-To-Speech Synthesis is a technology that offers a way to convert written text from a descriptive form to a spoken language that the end user can readily understand Nwakanma [8]. Text-To-Speech is mainly the capability of a device to speak text of different language, it serve as an interface of communication between two parties [8]. Basically Text-To-Speech also known as TTS is the conversion of raw text to human language speech.

2.2.1 Google Text-to-Speech API

Google cloud text-to-speech API converts text input into audio data of human-like speech in more than one hundred (100) voices across more than Twenty (20) languages. With the API, developers can create interactions with users that are aimed to feel more lifelike [9].

2.3 Medical Expert System

A medical expert system consists of programs and a medical knowledge base. The data acquired from the medical expert system is similar to the data provided by the expert in that specific area. Medical expertise of the specialized doctor is essential and very important when developing a medical expert system [10].

2.4 Related Concepts

[11] Developed an Android based voice assistant for blind people, it has Speech-To-Text and Text-To-Speech feature to help visually impaired people to be able to operate a smartphone, such that they will be able to access library `resource on their smartphones. The application was designed such that it runs in the background as long as the phone is switched on, it can read out email, incoming phone caller name or number, text, notifications and battery percentage all in Indonesian. The strength of this research and application is to help visually impaired people to be able to make use of smartphones all by themselves and the weakness is that it is not targeted at solving problems in the health and medical domain and it only tgranslate text-to-speech in English only.

[12] Implemented a mobile based expert system for disease diagnosis and medical advice provisioning for diseases that are common in Nigeria. It was implemented with a rule based mobile medical system which stored knowledge base. It was designed to be used for offline diagnosis. Though their system can diagnose disease as its strength, the weakness in the system is that it cannot report diagnosis using speech synthesis (Text-To-Speech).

[13] Developed an expert system for diagnosing malaria and typhoid, Visual Basic.Net was used to develop the system. Top-down approach was used for the system design and Microsoft SQL 2005 sever was used as the database. Their system is a desktop application and designed to only diagnose malaria. The weakness in their system is that it can only diagnose malaria and it is not capable of reading the diagnosis to the user, it is not text to speech enabled but it has the strength of diagnosing malaria.

[14] Implemented a text-to-speech conversion using raspberry pi, it combines Optical Character Recognition (OCR) with Text-To-Speech synthesizer (TTS) in raspberry pi to help visually impaired people interact with computer and that is the strength of this system while the weakness in this system is that it is not useful in health domain and it only translate in English.

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[15] With the aid of open-source tools created an Android application that allows handicapped students to play educational computer games such as chess without typing but speech and the computer-generated moves when the computer takes its turn to play are spoken to the player via Text-To-Speech synthesizer. Google voice recognition is used to collect the voice of the player and is a free and open source android tool. The main purpose of their research was help handicapped students play computer games with the use of Text-To-Speech synthesizer and Google voice recognition and that is the strength of their research while the weakness in their research is that it is not in any way related to using Text -To-Speech in medical diagnosis.

[16] Implemented a Voice-Based Medical Alert System for Medical Adherence, it is called "The Voice MedAlert System". It can send voice call to patients about drug to be taken at a particular time and it can also send calls to patient about appointments some hours before the scheduled appointment. The system was implemented using HTML (Hypertext Markup Language), hypertext pre-processor (PHP), MYSQL and TWILIO REST API. This system is only capable of speech synthesis only and used to remind patients to take their medication and the is strength while the weakness in the system is that the words to be spoken has been predefined and it is not converting Text-To-Speech.

From the above literature reviewed, there is no research or work that uses android-based mobile text-to-speech enabled technology to diagnose and report the diagnosis results to the user/patient from English text in to Hausa, Yoruba and Ibo text/speeches respectively. This is the gap that this research intends to fill.

III RESEARCH METHODOLOGY

3.1 Functional Requirement

Figure 3.1 below shows the Use Case diagram that illustrate the text-to-speech enabled malaria diagnosis system. The system consists of two actors which are the user and the system chatbot. The user have to register if he/she is a first-time user while an existing user can just login, once a user is granted access after authentication, the user can enable or disable the text to speech feature, select most preferred language, input symptoms to begin diagnosis, respond to the chabot suggested symptoms that a user may be experiencing, be able to see or hear diagnosis report. The chatbot on the other hand makes symptoms suggestion and read the diagnosis report.

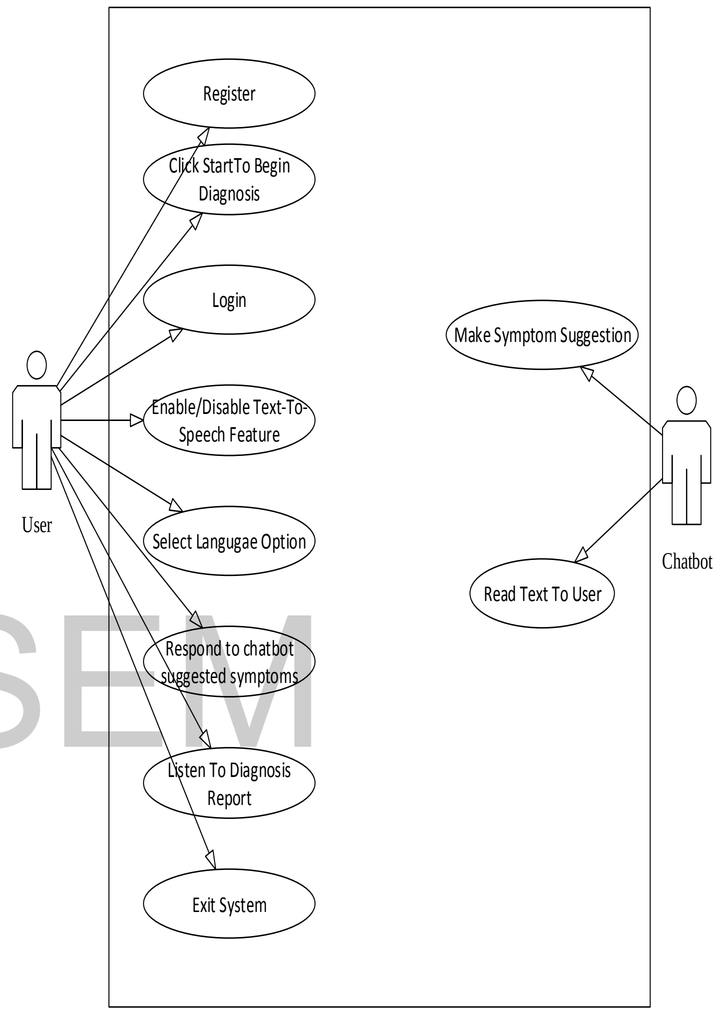

Figure 3.3: Use Case Diagram of the Proposed System

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3.2 System Architecture

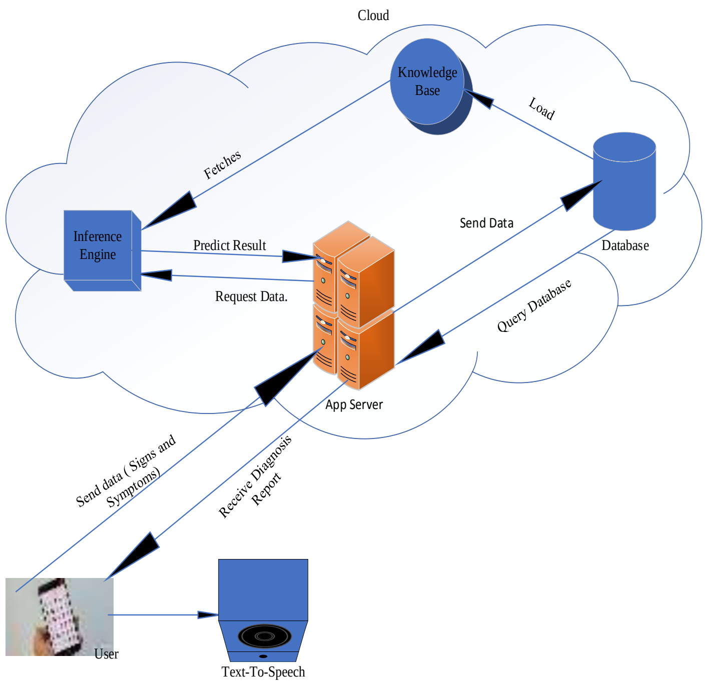

Figure 3.2: System Architecture

System architecture is the conceptual representation of the component and subcomponents that shows the behaviour of the system, it shows how the component and subcomponents functions together to implement the overall system. Figure 3.2 shows the system architecture.

From the system architecture shown in Figure 3.2;

1. User: User input signs or symptomd he/she is experiencing, into the system.
2. App Sever: It connects the system which is a client server to the cloud that host the database, thereby taking user input and stores in the database, it also requests the predicted result from the inference engine and send it to the user.
3. Database: If signs or symptoms is found in the database, the database loads it into the knowledge base.
4. Knowledge base: The knowledge base which contain expert opinion for each symptom is fetched into the inference engine
5. Inference Engine: The inference engine considering the expert opinion for each symptom predicts the result.
6. Text-To-Speech: Text-to-speech which is a component in the system read out the result to the user with the help of text-to-speech synthesis.

3.3 System Flow Chart

A flow chart is a graphical representation of the sequence of steps and decision needed to perform a process and each steps and process or action is represented by certain shapes and an arrow showing the work flow. Figure 3.3 below shows the work flow of the system. Once a user starts the system it prompts the user to login, if a user does not exist previously then the user will be prompted to register and then login again and once a user is logged in, he/she can select language preference as well as enable or disable text-to-speech feature in the option setting but they are by default activated, then a user can click on start menu to input symptoms for the system to begin diagnosis, then the chatbot will process the symptoms against the diseases in its knowledge base, the Chatbot suggest more symptoms that is related to a known disease in the database and is similar to symptoms entered by the user, the user react to the suggested symptom by clicking “Yes” or “No” buttons attached to the suggested symptoms and that will serve as more input data that will be processed against the disease in the knowledge base. The chatbot automatically stop suggesting symptoms to a user once it has taken enough symptoms input that is attributed to a particular disease, for as long as there is no enough symptoms with a disease match in the knowledge base it keeps prompting for more input by suggesting symptoms but as soon as a match is found it will generate the diagnosis report and read it out to the user but if it takes as much input as possible and there is no match it will display a message telling the user that disease not found then the diagnosis process stop.

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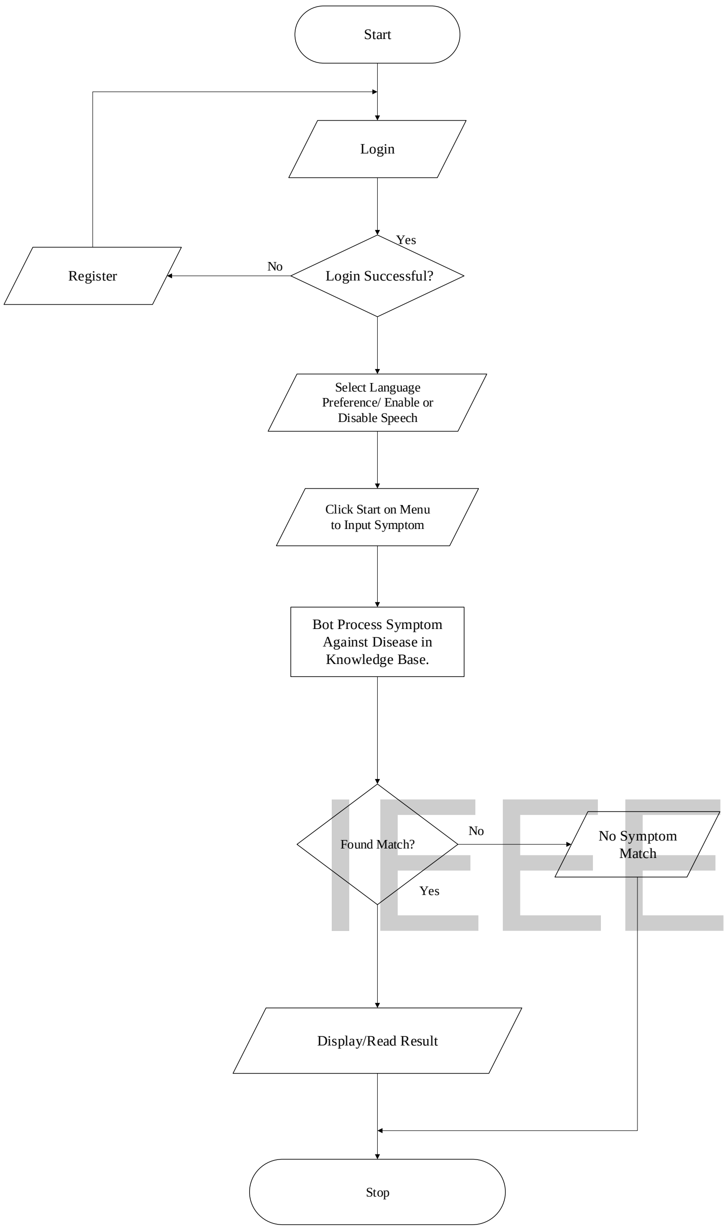

Figure 3.3: Flow Chart of the Proposed System

IV SYSTEM IMPLEMENTATION

4.1 System Menu Implementation

4.1.1 Registration Interface

This interface is developed to help users to be able to get registered and recognised by the system. Information such as First Name, Last Name, Email, Gender and Password with password confirmation. Figure 4.1 below shows the user registration interface.

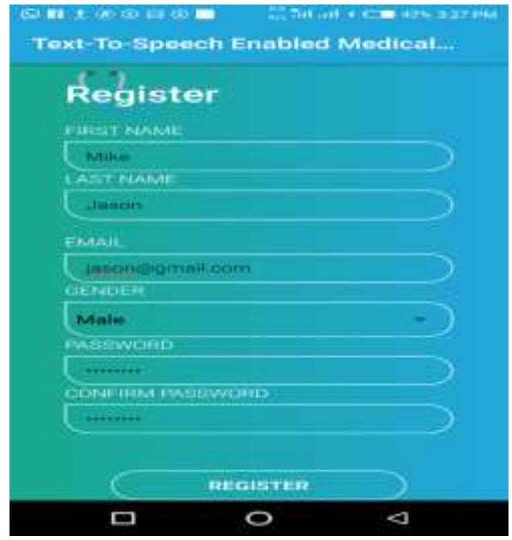

Figure 4.1: User Registration

4.1.2 User Login Interface

The user interface takes the user email and password as input for authenticating and validating that a user is genuily registered to the system before granting him/her access to the system as shown in Figure 4.2 below.

Figure 4.2: User Login

4.1.3 Chat Interface

This is the interface where the user will land once granted access upon login, user's name will be displayed in a chat bubble with another chat bubble giving instruction on how to begin diagnosis. This is the interface where most of the user interactivity will take place because the system was designed to work as a chatbot. User begins diagnosis by inputting symptoms in the search bar after

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clicking the search button and the user also interact with the chatbot by using the “Yes” or “No” buttons. The final result after the chatbot has finished taking symptoms inputs will be displayed on this interface. The Figures below shows different activities that takes place on this interface.

Figure 4.3 is the welcoming note for a successfully logged in user.

Figure 4.3: Interface after User Logged in

Figure 4.4 shows the diagnosis process for malaria with the inputted symptoms and it also shows the interaction between the user and the chat bot. The screenshot in Figure 4.4 shows the complete diagnosis process and the final result as the last interaction or chat made by the chatbot with the user and the final diagnosis for the symptoms and interaction of the bot with the user is acute malaria.

Figure 4.5: Diagnosis Result Interface in English

The screenshot in Figure 4.5 shows the text toggle on and off switch in the setting where a user can choose to enable or disable the Text-To-Speech function and in this interface Text-To-Speech feature is enabled.

Figure 4.5: Speech Enabled Interface

Figure 4.6 is showing the language selection interface where user can select a language (English, Hausa, Ibo and Yoruba) user wants to interact with the system. The default language is English Language.

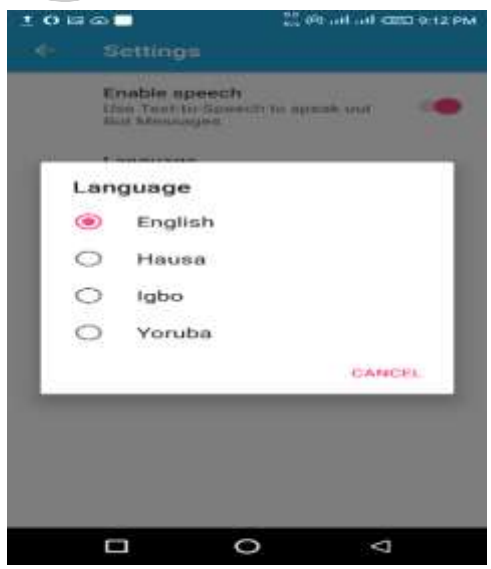

Figure 4.6: English Language Option Interface

4.1.4 Text Translation of Different Local Languages

This section is showing the diagnosis and the result of the symptoms of malaria from English text/speech and translate them to Hausa, Ibo and Yoruba speeches respectively.

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Figure 4.7 is showing the diagnosis process in Hausa language, whereby the text is being translated to Hausa from English with the aid of language text-to-speech translate API and the text is also read out to the user in Hausa speech.

Figure 4.7: Diagnosis in Hausa

Figure 4.8 is showing the diagnosis process in Igbo language, whereby the text is being translated to Igbo from English with the aid of language text-to-speech translate API and the text is also read out to the user in Igbo speech.

Figure 4.8: Diagnosis in Igbo

Figure 4.9 is showing the diagnosis process in Yoruba language, whereby the text is being translated to Yoruba from English with the aid of language text-to-speech translate API and the text is also read out to the user in Yoruba speech.

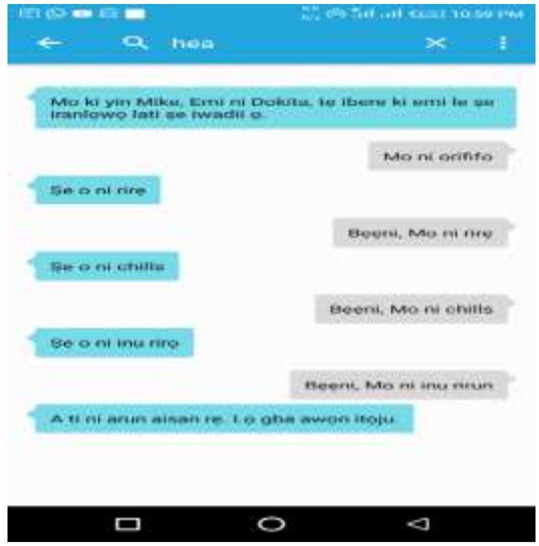

Figure 4.9: Diagnosis in Yoruba

V CONCLUSION

An Android-Based Mobile Text-to-Speech enabled Medical Diagnosis system for Malaria was implemented. The implemented system enables the interaction between Doctor who diagnose by asking the Patient some questions regarding the symptoms and the result of the diagnosis from English text and translate them into Hausa, Ibo and Yoruba text/speeches based on the language option selected by the user. The implementation of this text-to-speech medical diagnostic system will help to fill communication barrier for patients who do not have good understanding of the English language experience when they go to the hospital to get diagnosed and thereby reduce malaria scourge in the Nigeria society.

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