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Original Article

Voice-Based Patient Registration and Information Retrieval System

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Abstract - *Hospital patient registration and consultation processes in Nigeria are laden with long queues of sick patients due to misplaced or loss of patients' folders managed manually or with a partial-automated system. There is a high waiting time which slows down promptness to receiving good health care. To proffer a solution to these problems, the research study developed a voice-based patient information retrieval system as a means of reducing the patients' waiting time. The system was developed using; MATLAB R2021a 64-bit installed on Windows 10 platform, WAMP server 64-bit software as a background application to manage the patients' database, MFCC algorithm was used to extract the voice features of captured patient's voice, and K-Nearest Neighbour algorithm used as a classifier for voice recognition and matching of returning patients input voice data, at the login platform. A total of 100 questionnaires obtained through ethical approval were randomly distributed among patients to comparatively obtain various times utilized at each section of the hospital using the conventional and the developed systems. During the implementation, the system was integrated into the database of the University of Ilorin Teaching Hospital and utilized for patient registration and voice capture. Consequently, the system allowed the patient to log in after the discovery of a match voice data, and results obtained showed that 57% of the respondents' patients who commenced consultation with the developed system utilized between 5 - 10 minutes and 43% utilized between 11 - 40 minutes, while 85% that used the conventional system utilized between 1 - 3 hours; as total waiting time. The adoption of this research output will reduce patient waiting time at the hospital.*

Keywords *- K-Nearest neighbour, MATLAB, Mel Frequency Cepstral Coefficient, Patient, Waiting time.*

1. Introduction

The quality of the waiting experience in a Hospital has a strong correlation with patient's satisfaction with the health care they receive. An important indicator of the quality of hospital services is the length of time patients spend waiting to receive care[1]. The Institute of Medicine (IOM) recommended that at least 90% of patients should get appropriate care within 30 minutes of their scheduled appointment time[1]. A long waiting time in the clinic is a known source of dissatisfaction, as reported by patients, and primary healthcare studies also found a link between increased waiting time and patient satisfaction[2].

In most Nigerian Teaching hospitals, Doctors generally see more patients than necessary, and this increases the number of times patients have to wait to access health care services because of the manual registration of a large number of new patients and retrieval of records or files for the returning patients is very cumbersome. The patient registration process and information retrieval are directly affected, leading to patient dissatisfaction.

The use of Speech Recognition technology now has a significant effect on healthcare information systems, especially on the lives of people with special needs[3]. Medical practitioners can update and retrieve patient records instantly using mobile voice technologies from anywhere where network coverage exists. Hence, the medical records of the patients are always up to date[3]. The fundamental components of speech-recognition software are the amplifier, sound card, vocabulary, speaker profile, language model, and recognition engine [4]. Speech or voice recognition systems must be fast and have a high degree of accuracy, so there is a need to extract distinct features during processing to identify the speaker; a common and typical speech recognition system begins with a feature analysis step using the Mel Frequency Cepstral Coefficient (MFCC), which does the following processes:- Framing, Windowing, and Fourier transform.[5]. The MFCC algorithm saves the distinct extracted features in a codebook. Voice identification and the matching process require the utilization of very fast and accurate algorithms as classifiers in other to aid the retrieval process, especially during logins. One such is the K-Nearest Neighbour (KNN)

classifer[6]. K-Nearest Neighbour (KNN) is a supervised learning technique where a new instance is classified based on the closest training samples present in the feature space[6].

2. Statement of Research Problem

Hospital patient registration, consultation, and information retrieval processes in Nigeria are laden with excessive long queues for critically sick patients as well as returning patients. This is due to the current manual or partially automated registration systems being utilized. Patients' records are sometimes misplaced or lost. Thus, multiple openings of folders are constantly done due to the inability to trace or retrieve previous patients' data, especially for returning patients.

All the aforementioned problems increase the patients' waiting time and promptness to receive good health care leading to frustration and increasing the desire to go for self-medication. Hence, the need for a technological-based registration and retrieval system via voice-dependent algorithms in view of curbing these problems is desired.

3. Literature Review

A lot of research has been done in the area of voice recognition by different researchers in the area of using voice-based applications in patient care management. Some of the publications are discussed in this journal. Few among recent publications on this subject are discussed based on their adopted methodology and limitations in

Author	Method	Contribution	Limitation
[7]	Design and Development of a Voice Actuated Hospital Bed for Patient Care	C language compatible with Arduino was used to develop a prototype bed that responds to basic commands and assists the user in reclining, inclining, and commanding for a food table	The required angles were predetermined in this project.
[10]	Extracting optimal performance from dynamic time warping.	The authors clarify misconceptions and outline research efforts aimed at increasing the efficiency and efficacy of both the fundamental DTW algorithm and the higher-level algorithms that leverage DTW, such as similarity search, clustering, and classification. They examined many DTW variations, including restricted DTW, multidimensional DTW, and asynchronous DTW, as well as optimization strategies such as lower bounds, early abandonment, run-length encoding, bounded approximation, and hardware optimization.	The approach may be optimized and applied to different domains for a variety of data kinds and problems, most notably in the healthcare industry.
[13]	Real-time speaker recognition system using MFCC and vector quantization technique	MATLAB is used to create the real-time speaker recognition system. They developed a database of the speaker and saved it as a reference throughout the registration process. (e=0.003). The threshold for VQ distortion is set to 7e, which indicates that if the testing speech has a VQ distortion less than 7e, only the user is confirmed; otherwise, the speech is rejected.	The work can be extended to a greater number of users and can also be used with other matching techniques (HMM) and biometrics (face recognition).

[19]	Natural language processing–enabled and conventional data capture methods for input to electronic health records.	There was a total of 118 notes throughout the three topic categories. The NLP-NLP protocol required a median of 5.2 minutes for a cardiology note, 7.3 minutes for a nephrology note, and 8.5 minutes for a neurology note, compared to 16.9, 20.7, and 21.2 minutes for the Standard-Standard protocol and 13.8, 21.3, and 18.7 minutes for the Standard-NLP protocol, respectively (1 of 2 hybrid methods). The NLP-NLP protocol received a median quality score sum of 24.5 for 8 of the 9 characteristics measured by the PDQI-9 instrument, the Standard-Standard protocol.	Other algorithms or models may be employed to achieve a higher level of accuracy and precision.
[28]	Voice and speech recognition in the Tamil language	Hidden Markov Model (HMM) to obtain the greatest possible word recognition accuracy for this system. It was 100 percent accurate throughout the training phase and roughly 98 percent accurate during the testing phase.	Other Algorithms or models can be used, which may produce better accuracy and result.

Limitations observed from the reviews in comparison with the proposed voice-based patient registration and retrieval system are that they all do not have a direct impact on patient waiting time, and some of the algorithms used do not present a high degree of accuracy regarding voice recognition and matching. Some also had issues where the expected results were already predetermined, which may not be ideal for very sick patients who need urgent attention.

4. Methodology

This section discusses the methodology adopted for the generation and utilization of a voice-based patient registration and information retrieval system; aimed at reducing patient waiting time in the hospital. Factors affecting patient waiting time were looked at with a view of generating a mathematical expression for calculating average patient waiting time. Also, a patient speech capturing and recognition software was be developed using MATLAB R2021a; language comprehension and generation modules will also be developed for the speech recognition software to aid patient voice processing, and Mel Frequency Cepstral Coefficients Algorithm (MFCC) will be used for the voice feature extraction which will be saved in a code table, and the K-Nearest Neighbor Algorithm will be used as the classifier for the patient new voice feature matching and recognition with the already existing voice feature in the code table so as to allow user have continued access to the patient voice recognition software.

The output was integrated into a hospital database for the utilization of patients. Also, a comparative analysis of the output data from the improved system and existing conventional system (manual or partially computerized system) was executed, and the results were obtained.

5. Assumptions Made

- That all respective clinical sections of the hospital must have a high-end desktop, laptop, or mobile device that can be used for the implementation.
- That the hospital must have a server installed to house the voice-based application in a network environment.
- That the hospital or user clinic has a noise-reduced cubicle to capture patient voice during registration or visitation.
- That the hospital or user clinic have a voice-capturing device like a microphone or computer speaker attached to their computers.

6. Architecture of the Systemdesign

The proposed Voice-Based Patient Registration and Information Retrieval System will be made up of the following major modules, namely:- the voice capturing module, the voice processing module, and the voice pass login module.

- The Patient Voice Capturing Module: This is an easy-to-use module where all patient information like the biodata (age, blood group, genotype, sex, next of kin, phone number, and the patient image is captured.) Most importantly, the patient's voice is also captured through a microphone in this module and saved in the database.
- The processing Module: This is more of a backend module; the saved captured voice is taken through some processing using the MFCC algorithm to carry out feature extraction. The extracted features are saved in the code table to be used by returning patients for login.
- The patient voice passes login: In this module, the returning patient is required to speak into the microphone, and voice recognition and matching are carried out. This module has a K-Nearest Neighbour Algorithm, which is used as a classifier to compare the new voice features with the existing voice data sets and use the nearest neighbor as a match and give voice pass access to the user.

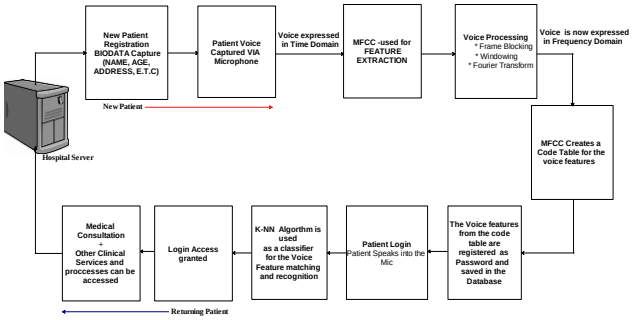

Fig. 1 Architecture of the Voice-Based patient registration and information retrieval system

7. Result

Presented below are screenshots of the internal workings of the developed voice-based Patient Registration and Information Retrieval System after the implementation stage. The start-up home page for the application is shown in Figure 2.

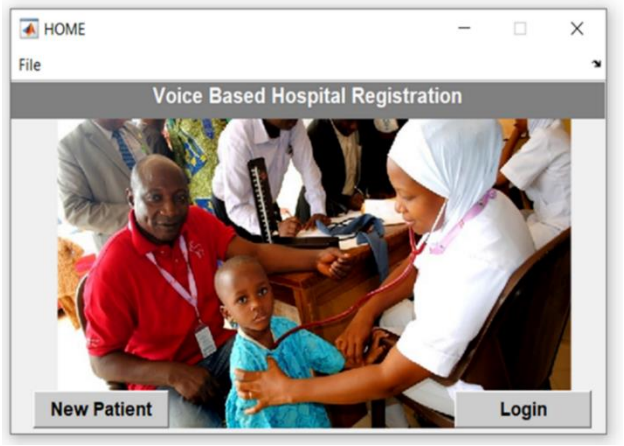

Fig. 2 Snapshot of the home page of the developed system

This page has two command buttons, namely:- "The "New Patient," which is for new unregistered patients, and the "Login," which is for returning duely registered patients. A click on the "New Patient" command button will display the patient registration and voice capture page; the patient's biodata, picture, and voice are captured on this page, as shown in Figure 3.

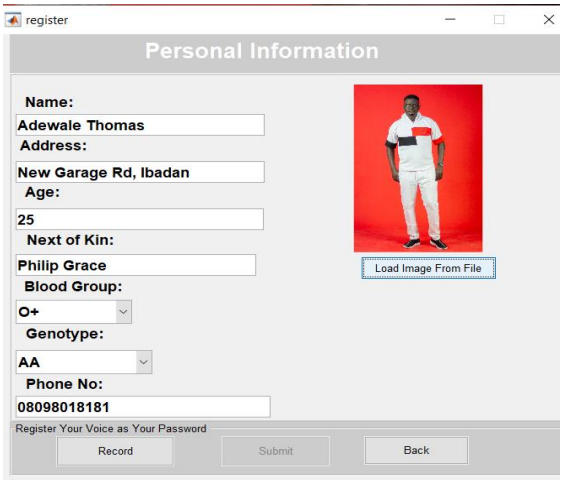

Fig. 3 Snapshot of the registration page on the developed system

After the capture of the patient biodata and the loading of the picture, a click on the record command button captures the voice note of the patient, as displayed in Figure 4., and a display of the patient voice wave is subsequently shown, as illustrated in Figure 5. The user can record another session if the captured wave displayed is not presented properly; the captured wave will only be saved when the user clicks the "Submit" command button.

Fig. 4 Screenshot of the patient voice capture of the developed system using a computer mic

After the patients' voice is captured and submitted, a successful registration message box is displayed, as illustrated in Figure 5.

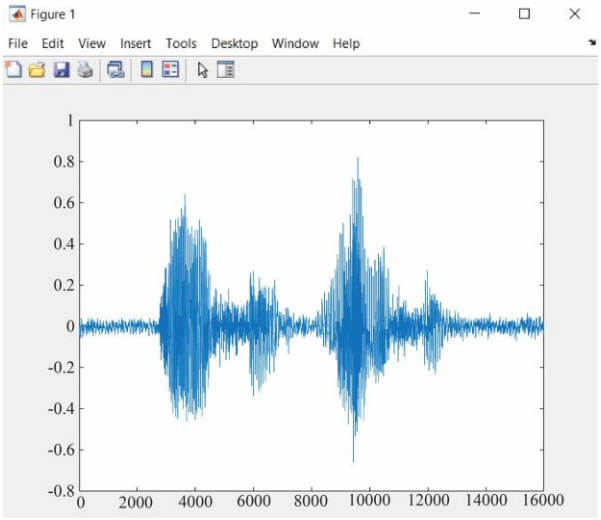

Fig. 5 Screenshot of the patient voice wave captured on the developed system

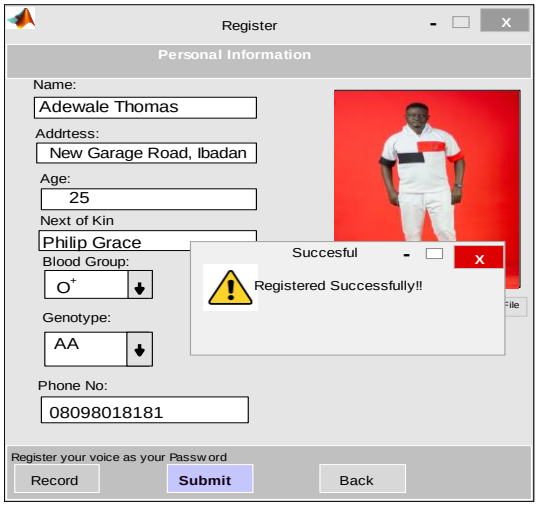

Fig. 6 Snapshot of a successfully captured patient

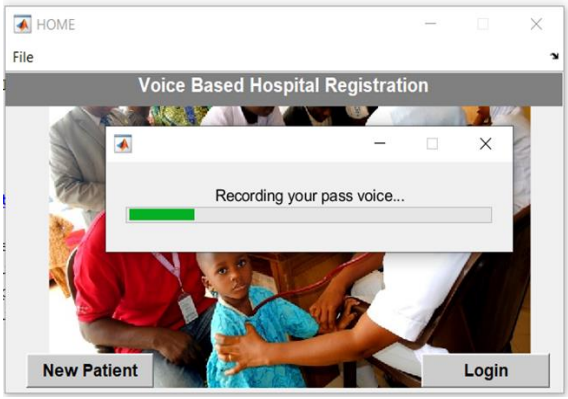

Fig. 7 Screenshot result of patient voice password login module

It is important to note that the saved voice note will be attached to the patient's biodata and captured picture to be used for login processes when the patient reports subsequently for another visitation. However, at the backend, the MFCC algorithm does patient voice feature extraction taking it through some processing, and these specific peculiar features are stored in a code table to be used for voice recognition and matching at the next visitation, during patient voice pass login, as illustrated in figure 7.

This page shows a login process that involves clicking the "Login" command button, after which the patient is expected to speak into the system's microphone for the process of voice recognition and to match to begin. At the back end, the K-Nearest Neighbour Algorithm (K-NN) is used as a classifier for voice recognition and matching to compare the voice with the already saved voice note data in the feature code table, and if the nearest neighbor is detected and a match found, access will be granted to the user, a pre-recorded welcoming audio message is heard, and a medical card page will be displayed as illustrated in Figure 8.

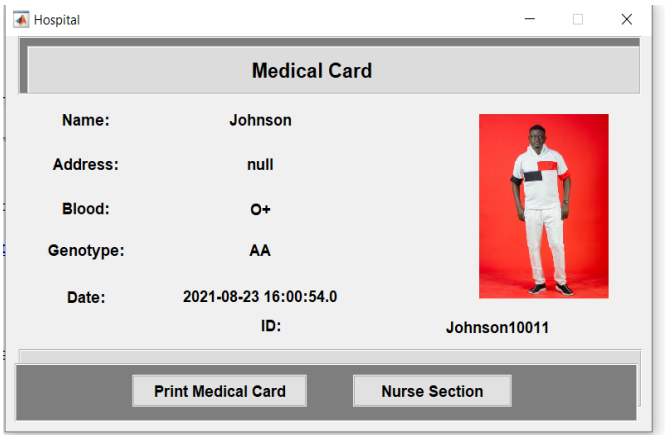

Fig. 8 Screenshot of a successful voice login page

This page will display already captured patient information and have two command buttons, namely "Print Medical Card" to send a printout patient card request to the printer and a "Nurses Section" that will allow nurses to enter vital statistics of the patient, as illustrated in Figure 9.

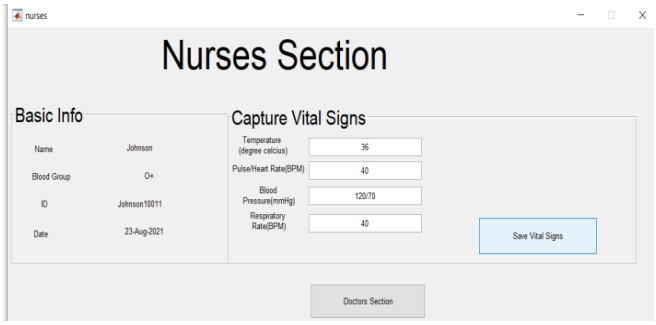

Fig. 9 Screenshot result of a nurses page

Nurses use this page to capture all necessary patient vital statistics like Genotype, Blood Group, Heart rate, Pulse rate, etc. These vital statistics are saved. Moreover, a click on the "Doctors Section" command button will proceed to the Doctors Module, as illustrated in Figure 10.

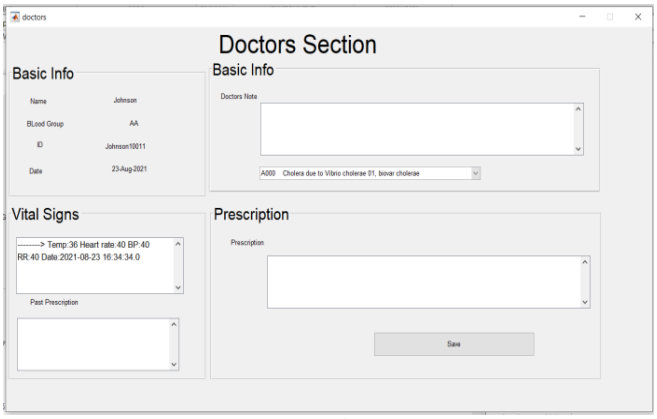

Fig. 10 Screenshot of the doctor's page

This Doctors page shows all previous inputs by the records unit as well as the nurse's captured vital signs from past and previous visits. The doctor can capture investigations and select diagnoses from the embedded ICD-10 classification of all diseases in the world instead of typing them in.

8. Evaluation of the Voice Based on Patient Registration and Retrieval System

Implementation of the newly developed system involved its integration into the database of the University of Ilorin Teaching Hospital, Ilorin, kwara State, Nigeria its utilization of 100 randomly selected patient registration and information retrieval processes. A questionnaire was distributed to these selected patients containing questions answered on time spent by patients in 5 selected sections of the hospital (Records, Nurses, Waiting in consulting clinic, During Consultation and Pharmacy). The questionnaire also evaluated Patients' satisfaction rate with waiting times at these clinics for the conventional system and the newly developed system.

SPSS was used in the analysis of the data obtained from the use of the conventional system and the newly developed voice-based registration and information retrieval system.

Table 1. Time Spent at Various Clinics – Conventional System

S/N	Statement	<10 Minutes (%)	20-40 Minutes(%)	>40 Minutes(%)	M	SD
1	Registration with Records Department	0	15 (15)	85 (85)	2.85	0.37
2	Waiting Time Before Nurses Services	0	35 (35)	65 (65)	2.65	0.49
3	Waiting Time Before Doctors Consultation	0	25 (25)	75 (75)	2.75	0.44
4	Consulting With the Doctor	30 (30)	55 (55)	15 (15)	1.85	0.67
5	Time Spent at the Pharmacy	0	25 (25)	75 (75)	2.75	0.44

Table 2. Time Spent at Various Clinics – Improved System

S/N	Statement	<10 Minutes(%)	20-40 Minutes(%)	>40 Minutes(%)	M	SD
1	Registration with Records Department	70 (70)	30 (30)	0	1.3	0.47
2	Waiting Time Before Nurses Services	60 (60)	40 (40)	0	1.4	0.40
3	Waiting Time Before Doctors Consultation	45 (45)	55 (55)	0	1.6	0.51
4	Consulting With the Doctor	35 (35)	65 (65)	0	1.65	0.48
5	Time Spent at the Pharmacy	75 (75)	25 (25)	0	1.25	0.44

Interpretation of Results: Table 1 and Table 2 reveals that 85% of the patients spent more than 40 minutes at the records department, where registration and retrieval of patient information take place with the old system, while only 30% spent between 20-40 minutes at the records unit with the new system. As a matter of fact, 70% of the patients spent less than 10 minutes at the records unit for the improved system, as shown in Table 2 for the newly developed improved system. Using the existing system, it was found that 85% of patients spent far more than 1 hr as their effective waiting time in the hospital, while nobody spent up to 1 hr waiting in the hospital for the improved system; as a matter of fact, 70% spent between 30-40 minutes as their effective waiting time.

Table 3. Patient Satisfaction with time spent hospitals' sections using existing system

S/N	Statement	S(%)	D(%)	U(%)	M	SD
1	Registration with Records Department	15 (15)	65 (65)	20 (20)	2.05	0.60
2	Waiting Time Before Nurses Services	10 (10)	70 (70)	20 (20)	2.10	0.55
3	Waiting Time Before Doctors Consultation	10 (10)	80 (80)	10 (10)	2.00	0.46
4	Consulting With the Doctor	15 (15)	70 (70)	15 (15)	2.00	0.56
5	Time Spent at the Pharmacy	15 (15)	70 (70)	15 (15)	2.00	0.56

Table 4. Patient Satisfaction with Time Spent Hospitals' Sections Using Developed System

S/N	Statement	S(%)	D(%)	U(%)	M	SD
1	Registration with Records Department	70 (70)	5 (5)	25 (25)	1.55	0.87
2	Waiting Time Before Nurses Services	85 (85)	0	15 (15)	1.3	0.72
3	Waiting Time Before Doctors Consultation	75 (75)	10 (10)	15 (15)	1.4	0.74
4	Consulting With the Doctor	75 (75)	5 (5)	20 (20)	1.5	0.81
5	Time Spent at the Pharmacy	75 (75)	10 (10)	15 (15)	1.4	0.74

Table 3 and Table 4 show results obtained from patients' satisfaction while using the existing conventional system and the newly developed voice-based system; it was observed that a cumulative sum revealed that 71% were not satisfied with the existing system, and only 13% were. However, for new, improved system, 76% cumulative sum of respondents said they were satisfied with the improved system of voice-based registration and information retrieval.

9. Conclusion

The adoption of a voice-based patient information retrieval system dramatically reduced patient waiting time and significantly decreased excessive time spent at various hospital departments, clinics, and other sections where medical services are discharged. Once registration, Information retrieval consultations are conducted by speech or voice, the fundamental tasks and operations of hospital administration become easier. Voice-activated registration and consultation enable many users to have timely and concurrent access to patient data stored in medical records. Additionally, it aids in the reduction of hospital physical dwelling space, which is a costly component in all sorts of locations.

Not only will the system successfully gather, store, and manage data, but it will also provide simultaneous access by all authorized workers, ensuring that everyone benefits from the system to the fullest extent possible. The developed system's full potential will be realized by seamless integration into the healthcare system, which will lead to increased efficiency for health practitioners as well as increased response from patients needing health care.

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