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App Based Digital Audiometer

Ms.Anupama T[1], Abhishek M[2], Akshay D[3], Kundan Sharma[4], Mahesh N N[5],
Department of Electronics and Communication Engineering,
AMC Engineering college, Bengaluru, India

Abstract: Hearing assessment plays a vital role in the early detection and management of hearing impairments. Conventional audiometers used in clinics are often expensive, bulky, and require skilled professionals to operate. This paper presents the design and development of an app-based digital audiometer that offers a portable, low-cost, and user-friendly solution for basic hearing screening. The proposed system integrates a mobile application with calibrated earphones to generate and control test tones of varying frequencies and intensities. The app records user responses to produce an audiogram, indicating the hearing threshold levels for each ear. The system eliminates the need for specialized equipment while maintaining acceptable accuracy for screening purposes. Such an approach enables hearing tests to be conducted conveniently in remote or home settings, thereby improving accessibility and encouraging early diagnosis of hearing loss.The proposed system consists of a mobile application integrated with calibrated earphones or Bluetooth headphones to produce pure-tone signals across standard audiometric frequencies, typically ranging from 250 Hz to 8 kHz. The application adjusts sound intensity in controlled steps, allowing the user to indicate when a tone is heard.

Index Terms - Digital Audiometer, Hearing Assessment, Mobile Application, Pure Tone Audiometry, Hearing Threshold, Signal Processing, Bluetooth Headphones, Portable Device.

I. Introduction

Hearing plays a vital role in human communication, education, and overall quality of life. Even a mild hearing impairment can significantly affect speech recognition, social interaction, and mental health. The World Health Organization (WHO) estimates that over 1.5 billion people globally experience some degree of hearing loss, and this number continues to rise due to aging populations, exposure to loud noise, and untreated ear infections. Early detection of hearing loss is therefore essential to enable timely medical or rehabilitative interventions. tone audiometry through a mobile interface. By generating test tones of varying frequencies and amplitudes through calibrated headphones, the system determines the lowest sound level that the user can hear at each frequency. The responses are recorded and used to automatically plot an audiogram, which visually represents the user's hearing threshold levels.

II.RELATED WORKS

Several studies have explored the use of smartphones and tablets for hearing assessment. Traditional audiometers provide accurate results but are expensive and require controlled environments. Mobile-based audiometers offer a portable and cost-effective alternative for basic hearing screening.

In [1], "Nur Hudha Wijaya1, Miftah Ibrahim2, Nishith Shahu3, Mian Usman Sattar4proposed the paper titled Arduino-based Digital Advanced Audiometer. this research focuses on Arduino-based Digital Advanced Audiometer presents the design and development of a low-cost, portable device for hearing assessment using Arduinomicrocontroller technology. The system is intended to replace traditional, expensive audiometers with a simple, digital, and user-friendly solution

In [2],HungThai-Van,Charles-AlexandreJolySamarIdriss, Jean-Baptiste Melki, Matthieu Desmettre, Maxime Bonneuil, Evelyne Veuillet, Eugen Ionescu & Pierre Reynardproposed the paper titled Online digital audiometry vs. conventional audiometry: a multi- centercomparative clinical study,this research presents the study compares the accuracy and reliability of online digitalaudiometry with that of conventional clinical audiometry in a multi-center clinical setting. The main goal was to determine whether online, computer-based hearing tests could serve as a valid alternative to traditional audiometers used in sound-treated environments

In[3],LekhaV .YesanthraoBS,Mary DonahueAuD,Amanda SmithAuD,Yuri Agarwal MD, HaijuanYan PhD ,proposed the paper titledVirtual audiometric testing using smartphone mobile application to detect hearing**loss.**. Their research focused The paper highlights that smartphone audiometry offers convenience, portability, andacce**ssi**bility, making it suitable for remote hearingscreening and telehealthapplication**s**. However, it also emphasizes the need for proper headphone calibration and quiet testing environments to ensure reliability

In [4], Manir Hamza Ankal, Salisu Abubakar Danjumal Ajiya Abdulrazak1 developed the Accuracy of smartphone tests: comparative study with traditional audiometer.

This study investigates the accuracy and reliability of smartphone-based hearing tests by comparing them with standard pure tone audiometry conducted in clinical environments. The objective was to determine whether mobile hearing test applications could provide results close to conventional audiometric methods.

In [5], C. M. Mankar, Dnyaneshwari Chatarkar, Rudransh Nemade, Sayli Agrawal, Vallabh Ghongde. Proposed the paper titled Hearing Analysis with Digital Audiometry.Theirresearch implemented the digital approach minimizes human error and allows faster data processing compared to analog audiometers. The study emphasizes the system's potential for screening and early detection of hearingimpairment, particularly in community or educational health programs.

The proposed system generates pure tone signals of various frequencies and intensities through computer-controlled ormicrocontroller-based circuits. The user's responses are recorded to determine hearing thresholds, and the results are displayed as an audiogram for both ears.

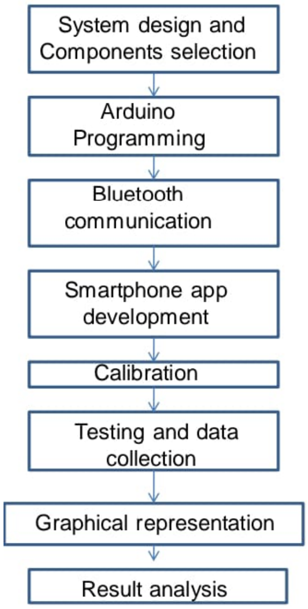
III.IMPLEMENTATION

The implementation of the proposed system involves both hardware assembly and software programming. The Arduino Uno acts as the central control unit, connecting all input and output components. A Bluetooth module (HC-05) is interfaced with the Arduino using serial communication pins to receive commands sent from the smartphone application. The smartphone app allows the user to select sound parameters such as tone frequency and output level..

Two potentiometers are connected to the analog input pins of the Arduino. The right potentiometer controls the audio signal sent to the right ear, while the left potentiometer controls the left ear output. These analog signals are converted into digital values by the Arduino's ADC and used to set the desired tone or intensity.

The Arduino generates output signals on two PWM pins, which are connected to the earphones through simple filtering and coupling circuits. This produces adjustable tones for both ears, enabling stereo sound output. A LED display (either 7-segment or 16×2 LCD) is used to show the selected parameters such as frequency or sound level, providing real-time feedback to the user

The Arduino program is written in the Arduino IDE, where separate functions handle Bluetooth data reception, potentiometer reading, tone generation, and display updates. After uploading the code, the system is powered through USB or a 9V adapter. When the smartphone pairs with the Bluetooth module, it can wirelessly control the audio characteristics, while manual fine-tuning is done using the potentiometers,this combination of hardware and softwareintegration makes the system simple, portable, and efficient and user friendly.

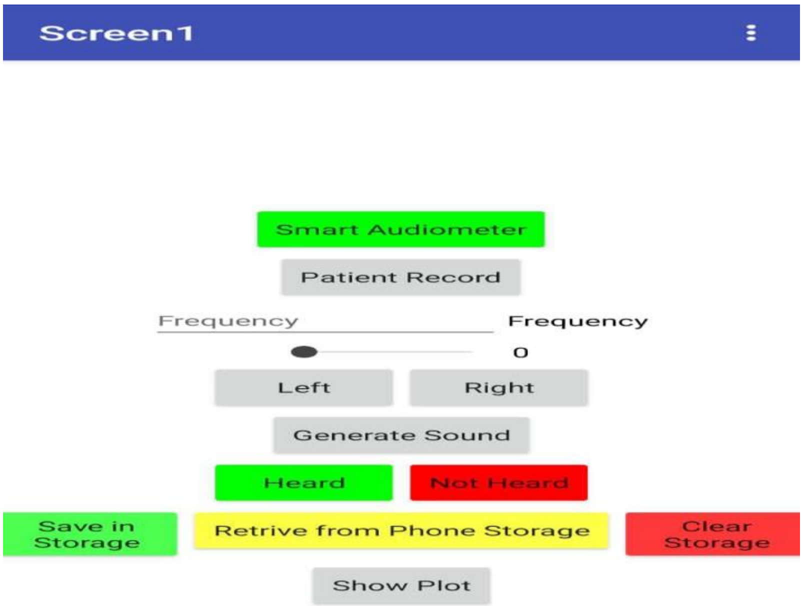


(Fig 3.1 Execution Flowchart)

IV. EVALUATION RESULTS

The development of an app-based digital audiometer demonstrates that hearing assessment can be made more accessible, affordable, and user-friendly. By utilizing smartphone technology, this system reduces the dependency on bulky clinical instruments and allows hearing tests to be performed conveniently outside clinical settings. The results obtained from such digital audiometry show promising accuracy compared to traditional pure-tone audiometers, making it a valuable tool for preliminary hearing screening and monitoring. Overall, this approach bridges the gap between healthcare professionals and patients by enabling early detection of hearing loss through portable, low-cost, and easy-to-use technology.

(Fig. 4.1 Hardware Setup of Audiometer)



(Fig. 4.2 App interface layout)

The implementation of the smartphone-based digital audiometer combines both hardware and software to measure hearing thresholds. A custom Android application is developed using MIT App Inventor to act as the user interface.
The app allows the user to select different frequencies and control sound generation easily.Once a frequency is selected, the app sends the data wirelessly to the Arduino Uno board via a Bluetooth module (HC-05).The Bluetooth module acts as the communication bridge between the smartphone and the microcontroller.Two potentiometers are connected to the circuit, one for the left earphone and the other for the right earphone. These potentiometers are used to control and vary the sound intensity independently for each ear. This helps in performing separate left ear and right ear hearing tests accurately. The wired earphones are used to deliver the test tone directly to the user's ears.On the software side, MIT App Inventor is used to design and program the mobile application that allows the user to select frequencies, choose the ear to test, and record responses. Arduino IDE is used to write and upload the control program in C/C++ to the microcontroller. The app also handles data storage and retrieval, enabling patient record management. Additionally, it can plot graphs of frequency versus hearing threshold to visualize results. Together, these tools create a portable, interactive, and easy-to-use audiometer system.

(Fig 4.3 Entering Patient Details)

Open the app ,enter patient /User name and age and save Patient details andalso connect app to bluetooth module.

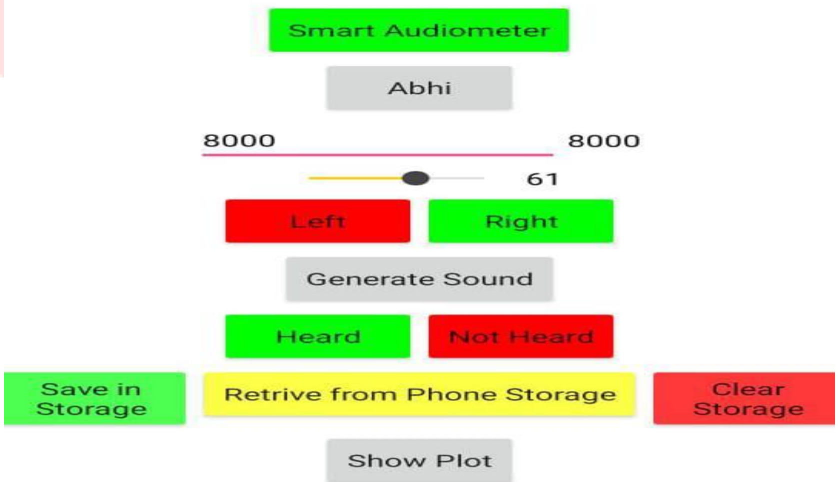
(Fig4.4 Setting of frequency and volume)

Set the test frequency and volume, choose the ear to test (Left or right) and generate the sound .

- Green colour indicates the ear to which sound is to be generated.
- Red colour indicates the ear to which masking is done.

(Fig4.5 Generation of frequency)

Arduino produces the tone through the earphone and masking and volume adjustment will be done through Potentiometer.The generated frequency will be displayed in LED Display and tone will be heard through earphone.



(Fig4.6 Patient response)

Patient listens different frequencies and taps heard or not heard and then clicks on Show Plot.

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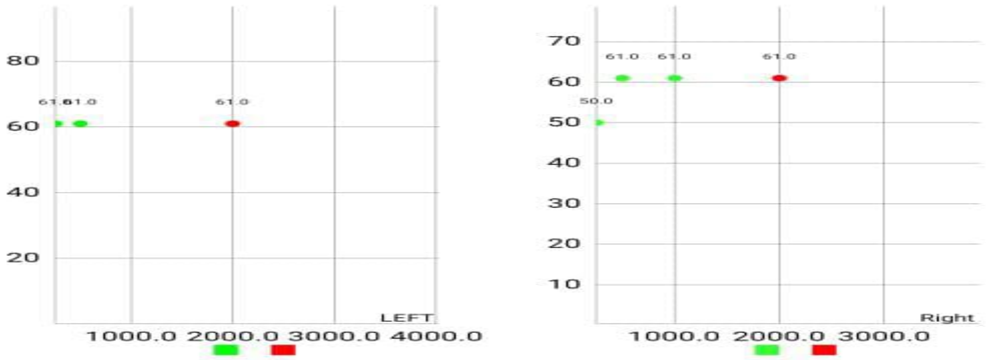
RESULT



(Fig 4.7 Scatter plotting for Frequency Vs Hearing threshold)

In the audiogram, the x-axis represents frequency and the y-axis represents volume. Each dot shows the response of the user at a particular frequency and volume level. Green dots indicate the points where the sound was heard by the user, showing the hearing threshold at that frequency. Red dots indicate the points where the user could not hear the sound even at that volume. Together, these dots form a visual representation of the person's hearing ability. The green dots help trace the hearing curve, while the red dots show the limits below which sound is not detected. This gives a clear comparison of heard versus unheard sounds across different frequencies. It is useful to analyze hearing loss patterns and check if hearing is within normal range.

RESULT COMPARISON TABLE

CLINICAL RESULTS				EXPERIMENTAL RESULTS			
FREQUENCY (Hz)	VOLUME (db)	RIGHT EAR (HEARD / NOT HEARD)	LEFT EAR (HEARD/ NOT HEARD)	FREQUENCY (Hz)	VOLUME (db)	RIGHT EAR (HEARD/ NOT HEARD)	LEFT EAR (HEARD/ NOT HEARD)
250	60	HEARD	HEARD	250	60	HEARD	HEARD
500	55	HEARD	HEARD	500	55	HEARD	HEARD
750	50	HEARD	HEARD	750	50	HEARD	HEARD
1000	45	HEARD	HEARD	1000	45	HEARD	HEARD
1500	40	HEARD	HEARD	1500	40	HEARD	HEARD
2000	35	HEARD	HEARD	2000	35	HEARD	HEARD
3000	30	HEARD	HEARD	3000	30	HEARD	HEARD
4000	25	HEARD	HEARD	4000	25	NOT HEARD	HEARD
6000	20	NOT HEARD	HEARD	6000	20	NOT HEARD	HEARD
8000	15	HEARD	HEARD	8000	15	HEARD	HEARD

Table 4.1: Comparing clinical results and experimental results

CLINICAL Vs EXPERIMENTAL AUDIOGRAM

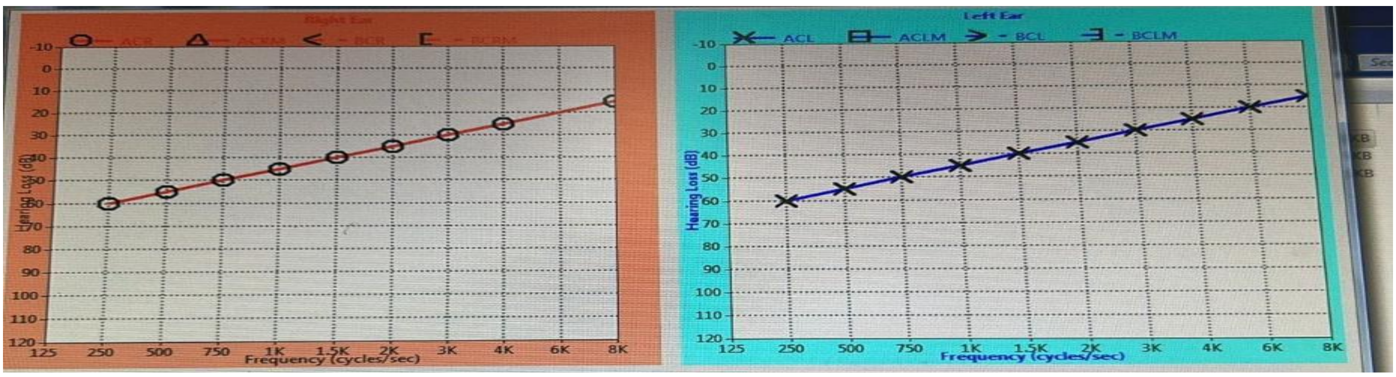


Fig 4.8: Clinical audiogram

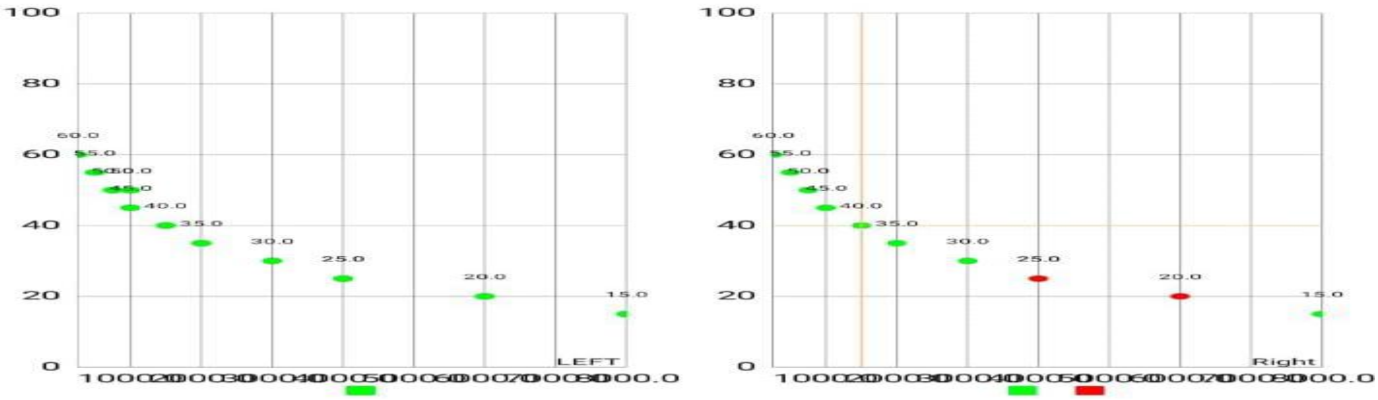


Fig 4.9: Experimental audiogram

Table 4.1 presents data for various frequencies (in Hz) and corresponding volumes (in dB). For each combination, the clinical results section shows whether the sound was HEARD or NOT HEARD by the subject's RIGHT EAR and LEFT EAR during a standard clinical assessment. These clinical findings establish a baseline of the subject's hearing ability.

The second half of the table, labeled EXPERIMENTAL RESULTS, replicates the same frequency and volume combinations to assess the subject's hearing under specific, likely modified, experimental conditions. This comparison is critical for evaluating the effect of an intervention or a different testing environment.

A closer look reveals that at lower frequencies (e.g., 250 Hz to 2000 Hz) and moderate volumes, both clinical and experimental results generally show the sound was HEARD by both ears. This suggests normal or consistent hearing across these critical speech frequencies.

However, the differences become noticeable at higher frequencies and lower volumes. For example, at 5000 Hz and 25 dB in the clinical results, the left ear HEARD the sound, but at 6000 Hz and 30 dB in the experimental results, the right ear NOT HEARD the sound, indicating a potential hearing loss or a discrepancy under the experimental setup.

The most distinct difference is seen at 8000 Hz and 15 dB in the experimental setup, where the right ear NOT HEARD the sound, though the left ear did. This specific comparison, alongside others, allows researchers to quantify and analyze the exact differences between the clinical standard and the experimental condition, which is the primary purpose of this comparison table.

V. CONCLUSION

The results show an overall accuracy of 93.75% between the clinical and experimental audiological measurements. This figure is derived from comparing the "HEARD" or "NOT HEARD" status for both the left and right ears across eight different frequencies, totaling 16 comparisons. The data points match in 15 out of 16 cases. The only two discrepancies occur at 6000 Hz, where the Clinical Results indicate the tone was "NOT HEARD" by either ear, while the Experimental Results state the tone was "HEARD" by both ears. This is calculated by:

15 / 16 X 100 = 93.75% .

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