Journal of Trends in Computer Science and Smart Technology (ISSN: 2582-4104)
www.irojournals.com/tcsst/

Sound Metric Proximity Hearing App

S.P. Revathy.[1], M. Harini.[2], J. Pooja[3]

[1]Assistant Professor, [2,3]Students, Department of Information Technology, Velammal Engineering College, India

Email: [1]revathy.sp@velammal.edu.in, [2]harinimuthulingam7272@gmail.com, [3]poojajaishankar3@gmail.com

Abstract

Globally, hearing impairment affects over 466 million people, creating barriers to accessing audiometric testing and timely diagnosis. Conventional methods often prove challenging to access, especially for people with limited resources or any other disadvantages. The proposed innovative "Sound Metric Proximity Hearing App" aims to revolutionize auditory health through mobile technology. Utilizing advanced techniques such as frequency-specific sound generation, individual ear sound production, and obstacle detection, the app provides comprehensive hearing tests through a user-friendly platform. The application is developed using React Native for the frontend and Django for the backend. It integrates seamlessly with mobile devices and databases, ensuring efficient and reliable performance. With simple result export and tools for early detection, the application enhances the accessibility and efficiency in hearing assessments. It bridges gaps in traditional testing methods, empowering users to proactively manage their auditory health. The "Sound Metric Proximity Hearing App" addresses the essential need for accessible, efficient hearing tests, making a positive impact on global auditory health. Through its innovative approach, the app aims to reduce the stigma associated with hearing loss and promote early intervention. By providing a convenient tool for educators, the app supports classroom management and improves learning environments. With its potential to reach unprivileged people and enhance awareness, the proposed sound metric application is devised to contribute significantly to global auditory health.

Keywords: Digital Audiometer, Mobile Application, Hearing Assessment, Proximity Testing, Classroom Management.

DOI: https://doi.org/10.36548/jtcsst.2024.3.006
Received: 08.07.2024, received in revised form: 05.08.2024, accepted: 22.08.2024, published: 31.08.2024

1. Introduction

Introducing the "Sound Metric Proximity Hearing App," an innovative mobile application at the forefront of transforming auditory health management. This app is designed to enable users by providing a comprehensive set of features designed to assess and monitor their hearing health conveniently and effectively.

1.1 Key Features and Scope

The "Sound Metric Proximity Hearing App" boasts an intuitive and user-friendly interface, ensuring accessibility for users of all ages [1]. One of its key features is the ability for users to conduct personalized hearing tests directly from their smartphones. This functionality allows individuals to track changes in their hearing over time, with the app providing detailed results and customized recommendations based on the test outcomes [2].

In addition to its assessment capabilities, the app serves as a valuable educational resource hub on various aspects of hearing loss, including its causes and available management options. Users can access a various articles, videos, and infographics to gain deeper insights into maintaining optimal auditory health [3]. For those considering hearing aids, the app offers a dedicated section where users can explore different hearing aid options, compare features, and find local providers [4].

Recognizing the importance of telehealth in modern healthcare, the app seamlessly integrates tele audiology services. This feature enables users to schedule virtual consultations with audiologists for remote assessments and personalized recommendations, enhancing accessibility to hearing care [5]. Moreover, the app provides customizable settings for both hearing tests and user profiles, ensuring that users receive accurate and customized results based on their specific hearing profiles and preferences [6].

1.2 Benefits

The "Sound Metric Proximity Hearing App" brings a host of benefits to its users. It improves access to auditory health assessments, particularly benefiting individuals in remote areas or those with limited resource availability [7]. By enabling users to conveniently monitor their hearing health and conduct tests from anywhere, the app promotes proactive management

of auditory well-being. The inclusion of extensive educational resources further enhances users' understanding of hearing loss and available treatment options [8].

2. Related Work

A thorough examination of existing literature provides valuable insights into the landscape of auditory health assessment and management. Sharma et al. (2020) investigated the prevalence and severity of hearing loss among the older old population, highlighting its significant impact within this demographic [1]. Potgieter et al. (2015) focused on the development and validation of a smartphone-based digits-in-noise hearing test in South African English, showcasing advancements in mobile technology for hearing assessments [2]. Goman and Lin (2016) discussed the prevalence of hearing loss in the United States, categorizing it by severity and focusing on the scale of the issue [3]. The association between hearing loss and cognitive decline in older adults was explored by Lin et al. (2013), emphasizing the need to address auditory health for overall cognitive function [4]. Mohr et al. (2000) investigated the societal costs of severe to profound hearing loss in the United States, revealing the economic burden it poses [5]. Gates and Mills (2005) provided insights into presbycusis, the age-related hearing loss affecting many older individuals [6]. Deal et al. (2017) conducted the Health ABC Study, examining the link between hearing impairment and incident dementia and cognitive decline in older adults, offering valuable longitudinal data [7]. Golub (2017) explored brain changes associated with age-related hearing loss, focusing on the physiological aspects [8]. Gopinath et al. (2009) looked into depressive symptoms in older adults with hearing impairments, pointing to the mental health implications [9]. Lee et al. (2010) investigated the relationship between hearing impairment and depressive symptoms in an older Chinese population, contributing to the understanding of cultural factors [10]. Mener et al. (2013) highlighted the association between hearing loss and depression in older adults, emphasizing the necessity for comprehensive care [11]. Golub et al. (2019) associated audiometric age-related hearing loss with depressive symptoms among Hispanic individuals, further underlining the mental health aspects [12]. In the field of hearing aids, Ferguson et al. (2017) conducted a comprehensive review on hearing aids for mild to moderate hearing loss in adults, providing insights into treatment options [13]. Chien and Lin (2012) studied the prevalence of hearing aid use among older adults in the United States, indicating adoption rates [14]. Simpson et al. (2019) conducted a longitudinal cohort study on the time from hearing aid candidacy to adoption, revealing factors influencing adoption rates [15]. Patel and McKinnon (2018) offered

an overview of hearing loss in the elderly, emphasizing the necessity for comprehensive care [16]. Tao et al. (2018) focused on tele audiology services for rehabilitation with hearing aids in adults, showcasing the potential of telehealth [17]. The role of human factors in telehealth was discussed by Demiris et al. (2010), highlighting the importance of user-centred design [18]. Heinz et al. (2013) explored perceptions of technology among older adults, providing insights into user preferences [19]. Sarkar et al. (2016) assessed the usability of commercially available mobile applications for diverse patients, emphasizing the importance of accessibility [20]. Wildenbos et al. (2015) proposed a framework for evaluating mHealth tools for older patients on usability, offering a structured approach [21]. Czaja et al. (2019) discussed principles and creative human factors approaches for designing for older adults, emphasizing customized design [22]. Mitzner et al. (2019) provided findings from the PRISM trial on technology adoption by older adults, showcasing factors influencing adoption [23]. Czaja et al. (2014) explored the use of a telehealth system by older adults with hypertension, indicating the potential for remote healthcare management [24]. Portz et al. (2019) utilized the technology acceptance model to explore user experience with a patient portal among older adults with multiple chronic conditions, providing insights into user behaviour [25]. Through an exhaustive review of existing literature, a comprehensive understanding of the challenges and advancements in audiology was obtained. The "Sound Metric Proximity Hearing App" represents the culmination of these insights, integrating advanced technologies, user-centric design principles, and legal compliance. It aims to provide a comprehensive and accessible platform for auditory health assessment and management, ultimately enhancing the quality of life for individuals with hearing impairments.

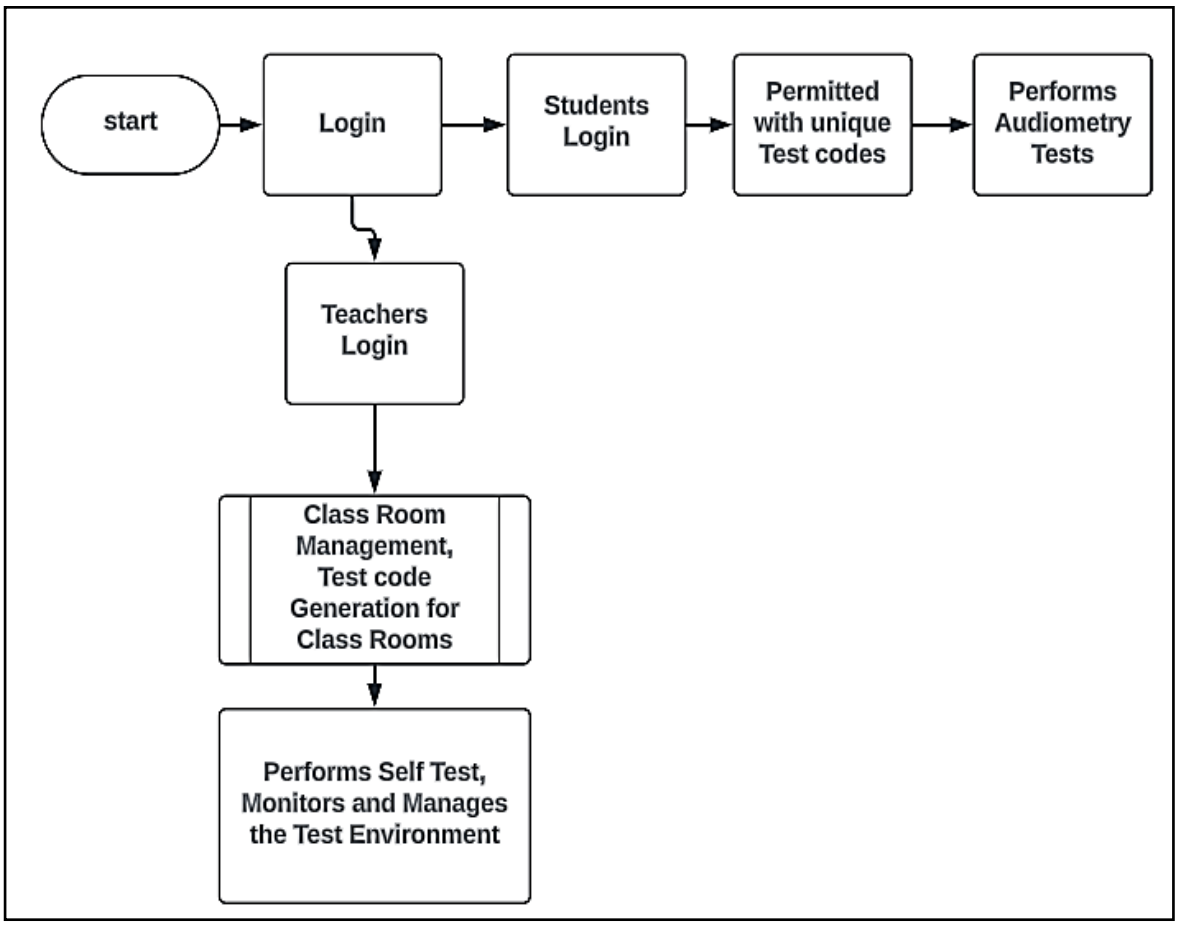
3. Proposed Work

3.1 Overview

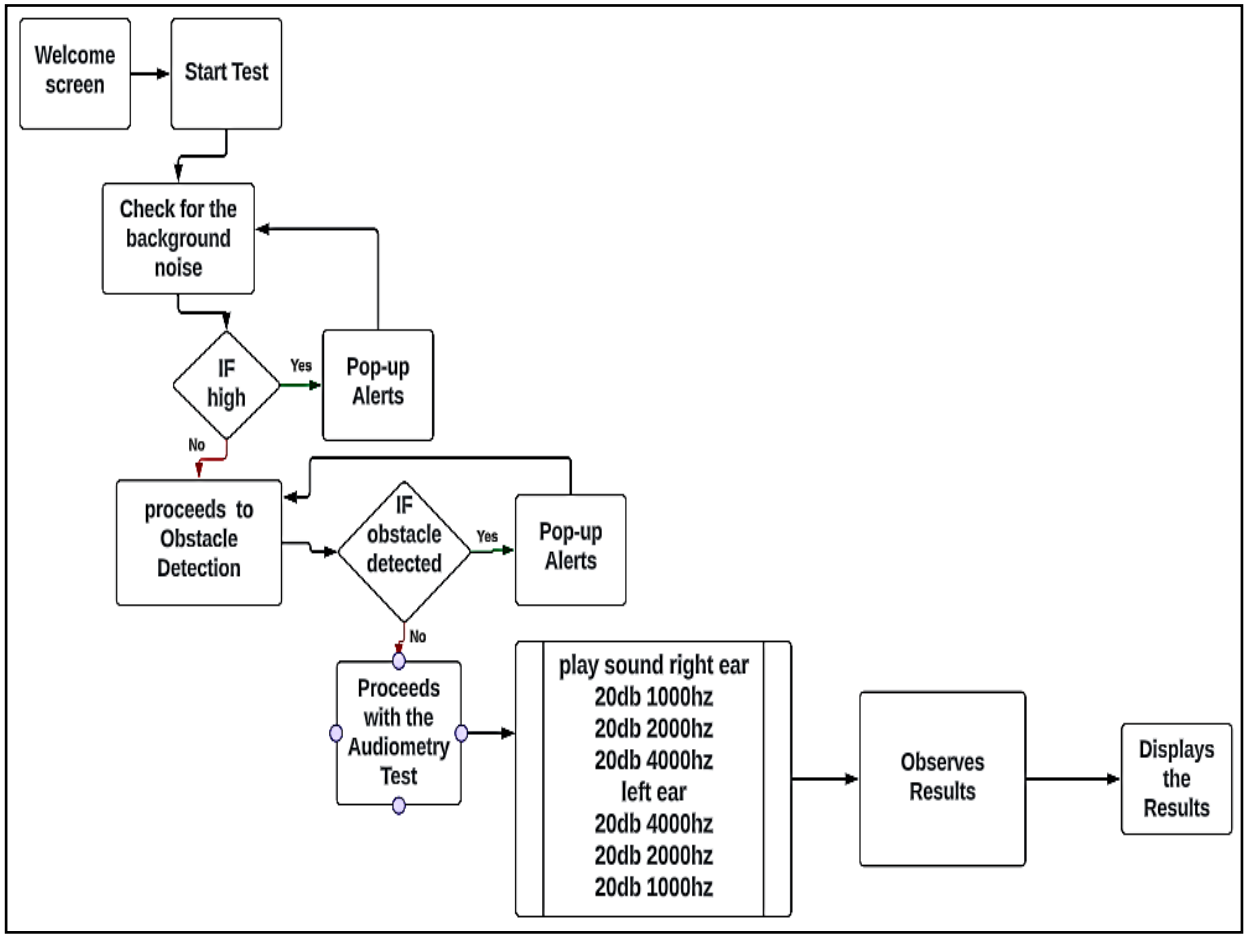
The "Sound Metric Proximity Hearing App" represents a cutting-edge approach to auditory health assessment and care. Leveraging advanced technologies like React Native and Django, the app delivers a seamless user experience. Its features include personalized assessments, obstacle detection, and secure data handling, empowering educators and healthcare professionals alike. By facilitating accurate evaluations and timely interventions, the app seeks to significantly improve the quality of life for those with hearing impairments.

3.2 Methodology

The evaluation methodology for the "Sound Metric Proximity Hearing App" adopts a mixed-methods approach, combining qualitative interviews and quantitative surveys to collect extensive data on auditory health assessment. The workflow begins with users logging in and receiving unique test codes, which are automatically recorded for teachers' review. This aids in identifying students with hearing impairments, who can then opt for retesting or professional referral. The workflow emphasizes efficiency with automated recording and clear paths for follow-up actions. Privacy is maintained through secure data handling, and teachers have centralized monitoring capabilities. Collaboration with healthcare professionals ensures holistic care, and clear instructions enables users to manage their auditory health. The process begins with a noise check, prompting users to optimize their testing environment for accurate results. Users then select ears for evaluation, detect sound frequencies, and record responses, with a detailed assessment display. This streamlined process, combined with visual prompts, enhances user engagement and accessibility, ensuring precise and reliable hearing assessments.



(a)



(b)

Figure 1. (a), (b) Workflow

Figure 1 (a) and (b). Illustrates the Workflow of Sound Metric Proximity Hearing App The application integrates the cutting-edge algorithms and methodologies to perform noise checks and accurately predict noise levels during audiometric testing. These advanced techniques are essential for ensuring the reliability and accuracy of the testing process, ultimately leading to improved quality of hearing healthcare services provided to users. The proposed system utilizes adaptive filtering, the Fast Fourier Transform (FFT) for frequency analysis, and a Hidden Markov Model (HMM) to detect patterns in background noise. A pop-up notification advises users to move to a quieter location if noise levels exceed a set threshold. For obstacle detection, the app employs a Convolutional Neural Network (CNN) along with edge and contour detection, with alerts triggered by a rule-based system. The phone's microphone captures the background noise. These methodologies significantly improve the accuracy of audiometric testing and the overall quality of hearing healthcare services.

3.3 Design Procedure

The mobile application is developed on Expo, an open-source platform that supports user-friendly mobile app development and testing. The Figure.2 shows the flow of data from the user interface to the backend and database.

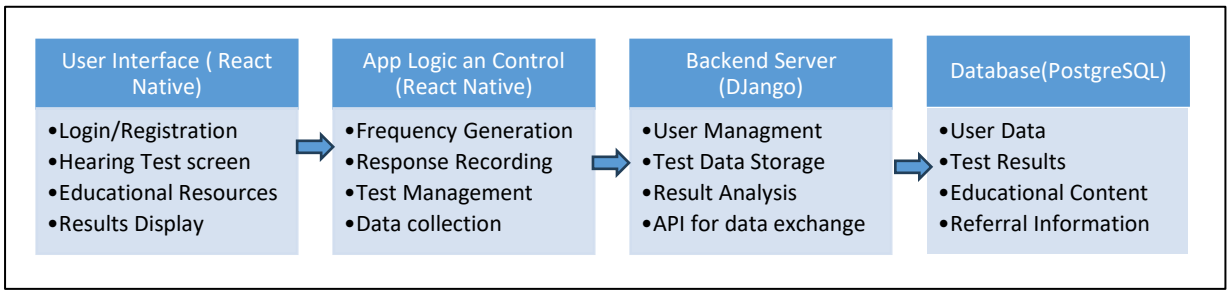


Figure 2. Data Flow Diagram

The user interface is designed to conduct the hearing tests and display the results of testing.

Frontend: The react native libraries are utilized to generate and play back sounds at different frequencies for basic hearing test. This is done by using pre-recorded sound files that are obtained at different frequencies. These files are generated through the online tone generators and placed in the React Native project assets folder. These audio files are played and managed using the react_native_sound library. The routing and the navigation are managed using the @react-navigation/native package.

Backend: The Django REST framework creates a RESTful API to manage the hearing test, user data and handle all the requests received from the frontend.

4. Results and Discussion

The proposed mobile app developed for audiometry testing has six major modules.

First Module, is the user authentication module which includes two distinct interfaces for users(students) and teachers enabling account creation, login, and access to audiometric tests. It ensures a streamlined experience with user friendly design elements, enabling an easy registration and a secure login by implementing a token-based authentication with JWTs (JSON web tokens) ensuring a sensitive data is transmitted over HTTPs and stored securely. Additionally strong passwords and robust access controls are employed on the backend to prevent unauthorized access. The student's login is permitted with a unique test code managed

by the teachers. The teacher login, consists tools for patient profile management, test customization and data analysis, to have the details of the students with hearing impairment. The Figure 3 shows the user authentication pages of proposed audiometry testing app.

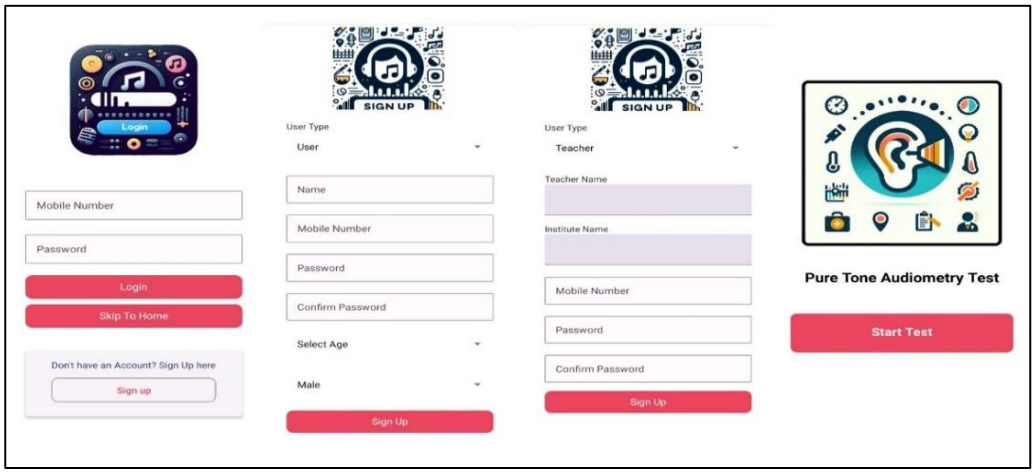


Figure 3. User Authentication

In Figure 3 , authentication page involves users entering their credentials (username, password), which are then securely checked by the server for access.

The Second Module, is the class room management module. It enables the teachers to create and manage the classrooms for the audiometric testing. The teachers log in, inputs the details of the classroom, and generates unique code for the classroom for the students use. The app allows teachers also to have self-tests. This enables the teachers to monitor the progress and manage the testing environment effectively.

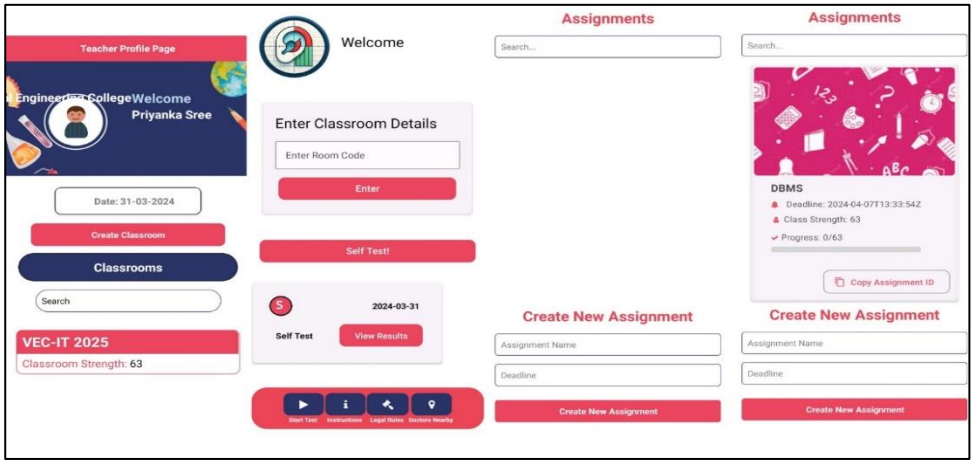


Figure 4. Classroom Management

Figure 4 illustrates the workflow of the classroom management module in the Sound Metric Proximity Hearing App, showcasing how teachers create classrooms, generate room codes for student access, and conduct self-tests for audiometric testing.

The Third Module, is the preliminary checks module, within the Sound Metric Proximity Hearing App. This serves as an essential preparatory step to ensure optimal conditions for accurate audiometric testing. It guides users to wear headphones, turn off notifications, and remain silent during testing to minimize distractions and enhance test validity. This step ensures quiet environments with minimal distractions to enhance the validity of audiometric results. The app uses the react-native-microphone-stream to access the phone's microphone, capturing background noise. The Fast Fourier Transform (FFT) is implemented using fft.js in conjunction with Python libraries like numpy and scipy for frequency analysis. Abnormalities or excessive noise are detected using a Hidden Markov Model (hmmlearn library), while adaptive filtering enhances signal quality, categorizing ambient noise from moderate to severe. The module also performs obstacle detection using OpenCV and TensorFlow for image processing with a CNN model, edge, and contour detection. A rule-based system triggers pop-up alerts when obstacles, such as earrings, are detected.

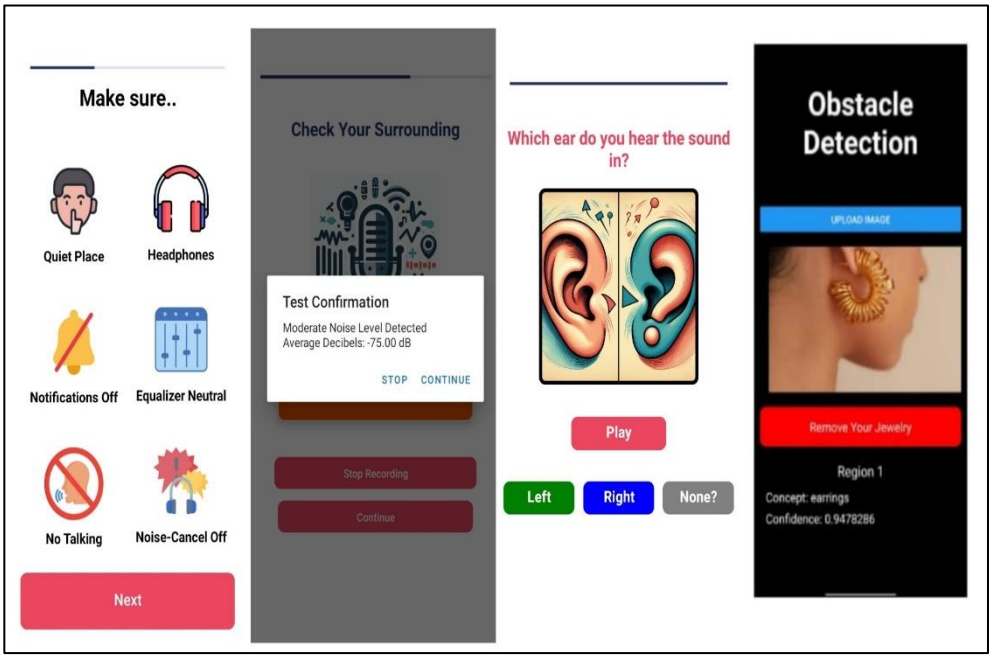


Figure 5. Preliminary Checks

Figure 5 illustrates the preliminary Checks module in the audiometry app ensures accurate testing conditions by confirming a quiet environment, headphone use, no speaking, and assessing noise levels.

The fourth module, is the user interface, within the Sound Metric Proximity Hearing App. It is a pivotal component that facilitates user interaction and navigation through various functionalities. Upon accessing this module, users are presented with the "Echo Rhythms" page, which serves as the central hub for accessing different subtopics and features. One prominent feature is the "Start Full Test" option, which initiates comprehensive audiometric testing for users seeking to assess their hearing capabilities thoroughly. Additionally, the module provides clear instructions for new users, ensuring they understand how to navigate the app and perform audiometric tests effectively. Legal compliance information is also accessible, providing users with important regulatory and privacy disclosures to ensure transparency and adherence to relevant laws. Another valuable feature is the "Doctors Near Me" function, which leverages location services to identify nearby Ear, Nose, and Throat (ENT) doctors, facilitating easy access to healthcare professionals for consultation or treatment this is facilitated by giving the longitude and the latitude co-ordinates of the doctors nearby. This feature is still in the development stage. Currently, it is designed to focus on doctors available in specific areas.

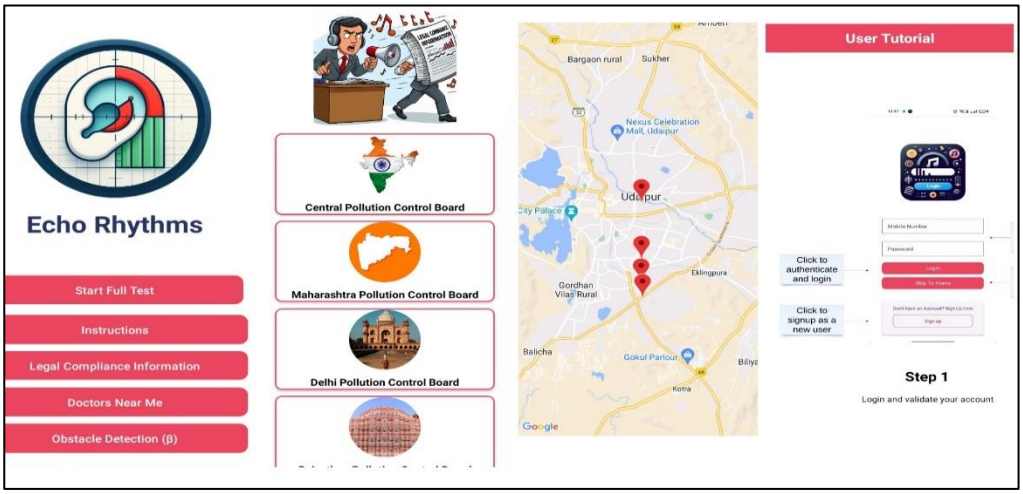


Figure 6. Test Progress

Figure 6 illustrates the test progress module systematically assesses users' hearing with clear instructions and Bluetooth-enabled sound detection across five threshold levels for comprehensive evaluation.

The final module, is the Test Result module, it is an important stage in the Sound Metric Proximity Hearing App, here the data collected from the previous modules is analysed to provide users with comprehensive hearing assessment outcomes. Upon completion of the audiometric tests in the fifth module, the average hearing threshold for each ear is calculated. This average is then compared against predefined ranges to determine the severity of the user's hearing impairment. The module categorizes hearing loss into six levels: normal, mild, moderate, moderately severe, severe, and profound, each with distinct threshold ranges representing varying degrees of impairment. After the calculations for both the left and right ears are completed, the module displays the results, indicating the respective level from the six categories for each ear. Additionally, the module generates audiogram graphs, visually representing the user's hearing thresholds across different frequencies. These graphs provide a clear visualization of the user's hearing profile, aiding in understanding and interpretation of the results. Furthermore, the module offers functionality to export the results into a PDF format, facilitating easy sharing through messaging apps like WhatsApp or other social media platforms. This enables users to conveniently share their audiometric test results with healthcare professionals, family members, or other relevant parties for further consultation or treatment planning. By providing detailed and visually informative results, the Test Result module empowers users to make decisions regarding their hearing health and facilitates seamless communication with healthcare providers, ultimately contributing to improved accessibility and quality of care in the field of hearing healthcare.

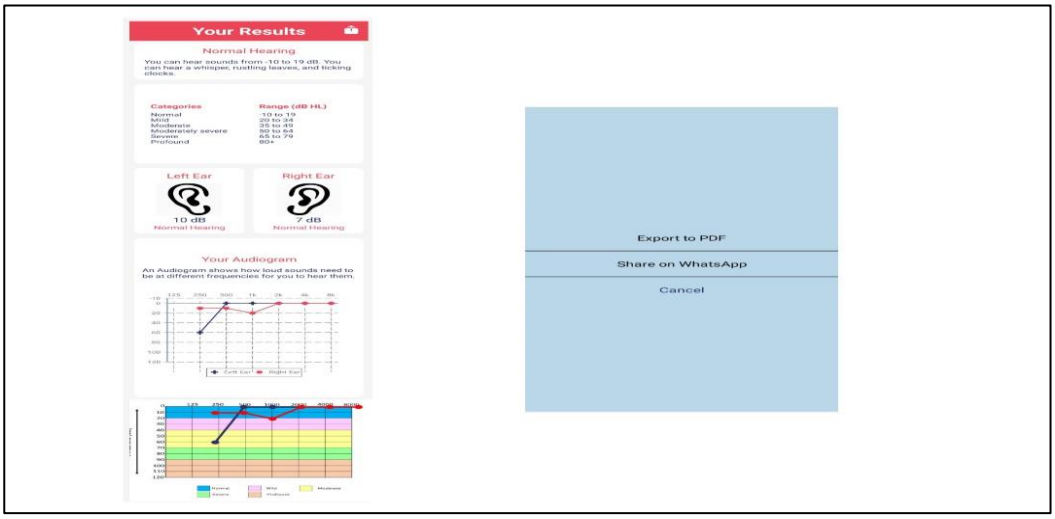


Figure 7. Test Results

Figure 7 illustrates the test result module categorizes hearing loss, generates audiogram graphs, and facilitates result sharing for enhanced user understanding and communication with healthcare providers.

The app is deployed on Google Cloud Platform (GCP), to ensure seamless access for users while maintaining high levels of performance and availability.

5. Conclusion and Future Work

The "Sound Metric Proximity Hearing App" is a significant advancement in auditory health assessment, addressing challenges in traditional audiometric testing. Developed using React Native for the frontend and Django for the backend, the app offers a user-friendly experience through innovative features, like frequency-specific sound generation. By integrating advanced algorithms, the app enhances accuracy and provides valuable auditory health insights. Future collaborations with educational institutions and healthcare facilities, along with efforts to support multiple languages and improve accessibility, will drive widespread adoption. The app's potential to improve lives, particularly for those with hearing impairments, will be realized through continuous development and strategic partnerships of education institutions and healthcare providers.

References

[1] Sharma, Rahul K., Alexander Chern, Olivia Begasse de Dhaem, Justin S. Golub, and Anil K. Lalwani. "Chronic obstructive pulmonary disease is a risk factor for sensorineural hearing loss: a US population study." Otology & Neurotology 42, no. 10 (2021): 1467-1475.

[2] Potgieter, Jenni-Marí, De Wet Swanepoel, Hermanus Carel Myburgh, Thomas Christopher Hopper, and Cas Smits. "Development and validation of a smartphone-based digits-in-noise hearing test in South African English." International journal of audiology 55, no. 7 (2016): 405-411.

[3] Goman, Adele M., and Frank R. Lin. "Prevalence of hearing loss by severity in the United States." American journal of public health 106, no. 10 (2016): 1820-1822.

[4] Lin, Frank R., Kristine Yaffe, Jin Xia, Qian-Li Xue, Tamara B. Harris, Elizabeth Purchase-Helzner, Suzanne Satterfield et al. "Hearing loss and cognitive decline in older adults." JAMA internal medicine 173, no. 4 (2013): 293-299.

[5] Mohr, Penny E., Jacob J. Feldman, Jennifer L. Dunbar, Amy McConkey-Robbins, John K. Niparko, Robert K. Rittenhouse, and Margaret W. Skinner. "The societal costs of severe to profound hearing loss in the United States." International journal of technology assessment in health care 16, no. 04 (2000): 1120-1135.

[6] Gates GA, Mills JH. Presbycusis. Lancet 2005;366(9491):1111–1120.

[7] Deal, Jennifer A., Josh Betz, Kristine Yaffe, Tamara Harris, Elizabeth Purchase-Helzner, Suzanne Satterfield, Sheila Pratt et al. "Hearing impairment and incident dementia and cognitive decline in older adults: the health ABC study." Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences 72, no. 5 (2017): 703-709.

[8] Golub JS. Brain changes associated with age-related hearing loss. Current Opinion in Otolaryngology & Head and Neck Surgery 2017;25(5):347–352.

[9] Gopinath, Bamini, Jie Jin Wang, Julie Schneider, George Burlutsky, John Snowdon, Catherine M. McMahon, Stephen R. Leeder, and Paul Mitchell. "Depressive symptoms in older adults with hearing impairments: the Blue Mountains Study." Journal of the American Geriatrics Society 57, no. 7 (2009): 1306-1308.

[10] Lee AT, Tong MC, Yuen KC, Tang PS, Vanhasselt CA. Hearing impairment and depressive symptoms in an older Chinese population. Journal of Otolaryngol Head Neck Surgery 2010;39(5):498–503.

[11] Mener DJ, Betz J, Genther DJ, Chen D, Lin FR. Hearing loss and depression in older adults. Journal of the American Geriatrics Society.2013;61(9):1627–1629.

[12] Golub JS, Brewster KK, Brickman AM, et al. Association of audiometric age-related hearing loss with depressive symptoms among Hispanic individuals. JAMA Otolaryngol Head Neck Surgery 2019;145(2):132–139.

[13] Ferguson, Melanie A., Pádraig T. Kitterick, Lee Yee Chong, Mark Edmondson-Jones, Fiona Barker, and Derek J. Hoare. "Hearing aids for mild to moderate hearing loss in adults." Cochrane Database of Systematic Reviews 9 (2017).

[14] Chien, Wade, and Frank R. Lin. "Prevalence of hearing aid use among older adults in the United States." Archives of internal medicine 172, no. 3 (2012): 292-293.

[15] Simpson, Annie N., Lois J. Matthews, Christy Cassarly, and Judy R. Dubno. "Time from hearing aid candidacy to hearing aid adoption: A longitudinal cohort study." Ear and hearing 40, no. 3 (2019): 468-476.

[16] Patel, Rohan, and Brian J. McKinnon. "Hearing loss in the elderly." Clinics in geriatric medicine 34, no. 2 (2018): 163-174.

[17] Tao, Karina FM, Christopher G. Brennan-Jones, Dirce M. Capobianco-Fava, Dona MP Jayakody, Peter L. Friedland, De Wet Swanepoel, and Robert H. Eikelboom. "Teleaudiology services for rehabilitation with hearing aids in adults: A systematic review." Journal of Speech, Language, and Hearing Research 61, no. 7 (2018): 1831-1849.

[18] Demiris, George, Neil Charness, Elizabeth Krupinski, David Ben-Arieh, Karla Washington, John Wu, and Bonne Farberow. "The role of human factors in telehealth." Telemedicine and e-Health 16, no. 4 (2010): 446-453.

[19] Heinz, Melinda, Peter Martin, Jennifer A. Margrett, Mary Yearns, Warren Franke, Hen-I. Yang, Johnny Wong, and Carl K. Chang. "Perceptions of technology among older adults." Journal of gerontological nursing 39, no. 1 (2013): 42-51.

[20] Sarkar, Urmimala, Gato I. Gourley, Courtney R. Lyles, Lina Tieu, Cassidy Clarity, Lisa Newmark, Karandeep Singh, and David W. Bates. "Usability of commercially available mobile applications for diverse patients." Journal of general internal medicine 31 (2016): 1417-1426.

[21] Wildenbos, Gaby Anne, L. W. Peute, and Monique WM Jaspers. "A framework for evaluating mHealth tools for older patients on usability." In Digital healthcare empowering Europeans, IOS Press, 2015. 783-787.

[22] Czaja, Sara J., Walter R. Boot, Neil Charness, and Wendy A. Rogers. Designing for older adults: Principles and creative human factors approaches. CRC press, 2019. https://doi.org/10.1201/b22189.

[23] Mitzner, Tracy L., Jyoti Savla, Walter R. Boot, Joseph Sharit, Neil Charness, Sara J. Czaja, and Wendy A. Rogers. "Technology adoption by older adults: findings from the PRISM trial." The Gerontologist 59, no. 1 (2019): 34-44.

[24] Czaja, Sara J., Chin Chin Lee, Neysari Arana, Sankaran N. Nair, and Joseph Sharit. "Use of a telehealth system by older adults with hypertension." Journal of telemedicine and telecare 20, no. 4 (2014): 184-191.

[25] Portz, Jennifer Dickman, Elizabeth A. Bayliss, Sheana Bull, Rebecca S. Boxer, David B. Bekelman, Kathy Gleason, and Sara Czaja. "Using the technology acceptance model to explore user experience, intent to use, and use behavior of a patient portal among older adults with multiple chronic conditions: descriptive qualitative study." Journal of medical Internet research 21, no. 4 (2019): e11604.