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Sonic Care – AI powered Mobile Audiometer

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Abstract - *Hearing loss is a big problem worldwide, especially in India, where about 60% of those affected are kids. It's crucial to catch hearing problems early, but the usual tests, like audiometry, are hard to access and can be expensive. This means lots of people, including kids and adults, don't get diagnosed early enough to get the right help, like hearing aids or implants. To fix this, our research team made a new mobile app for hearing tests. It uses the powerful features of smartphones to offer a new way to check your hearing. Our app makes hearing tests easy to do, affordable, and simple for anyone, whether they're young or old. You don't need to go to a clinic or use special equipment anymore. Our app gives accurate results in a format that's easy to understand, helping people get diagnosed sooner and get the help they need. By making hearing tests simpler, our app could help millions of people who might not know they have hearing problems yet. It could also lessen the burden of untreated hearing loss for both individuals and society. Our goal is to make sure everyone, no matter their age, can easily look after their hearing health.*

Key Words: **Audiometry application, Hughson-Westlake method, accessibility, hearing tests, affordable healthcare**

1. INTRODUCTION

In today's healthcare world, technology has made it easier for people to get medical tests, and mobile apps are leading the way. One area where this is really making a difference is in checking how well people can hear. Instead of having to go to special clinics with fancy equipment, now there are apps you can use right on your phone or tablet to test your hearing. These apps are convenient, affordable, and use the power of technology to make hearing tests available to everyone, not just those who can go to a clinic.

Traditional hearing tests usually require expensive equipment and a special room called a sound-proof booth. But now, with app-based audiometers, all you need is your phone or tablet. These apps make it easy for anyone to do a basic hearing test at home. This is a big deal, especially for older people or those who have trouble getting around, because it means they don't have to go to a clinic for testing.

Even though some people still prefer the old-fashioned way of doing hearing tests in clinics, there are a lot of challenges with that. It can take a long time, and you have to go in person for each test, which can be hard for some people. Plus, the tests are really detailed and can take a while. With app-based audiometers, it's much simpler and quicker to get a basic idea of how well you can hear.

Fig 1: The smartphone-based hearing self-assessment using hearing aids

To tackle these challenges, app-based audiometers provide a game-changing solution. These apps use smart algorithms and user-friendly interfaces, making it possible for people to test their hearing at home. With just standard headphones and a simple protocol that mimics clinical tests, users can check their hearing thresholds with ease. This innovation isn't just about catching hearing problems early—it's also about making hearing healthcare accessible to everyone. As digital health technologies continue to advance, app-based audiometers exemplify the potential for mobile applications to redefine the approach to hearing diagnostics, ensuring broader access and fostering a more inclusive healthcare ecosystem [5][6].

2. LITERATURE SURVEY

The research on smartphone-based audiometry has witnessed significant growth in recent years, driven by the increasing demand for accessible and convenient methods of hearing assessment. Chen et al. (2019) introduced a novel smartphone-based hearing self-assessment system utilizing fast audiometry methods, which demonstrated promise in enabling individuals to monitor their hearing health using hearing aids.[1] Kushalnagar (2019) highlighted the

importance of accessibility in web-based resources for individuals with deafness and hearing loss, emphasizing the need for inclusive design and technological solutions.[2] Studies by Saliba et al. (2017) and Hazan et al. (2022) evaluated the accuracy and reliability of mobile-based audiometry in both quiet and noisy environments, suggesting its potential as a viable alternative to traditional audiometric testing methods.[3] Additionally, Irace et al. (2021) conducted a review of smartphone-based applications for hearing loss detection, emphasizing the diverse range of technologies available and their potential impact on healthcare delivery.[5] Meta-analyses by Chen et al. (2021) synthesized findings from multiple studies, confirming the diagnostic accuracy of smartphone-based audiometry for hearing loss detection.[6] Furthermore, Masalski et al. (2018) and Adiputra et al. (2018) explored the feasibility and effectiveness of hearing tests based on biologically calibrated mobile devices and Android mobile audiometry tests, respectively, highlighting the potential for widespread adoption and accessibility.[7][8] Krzyżek and Kłaczyński (2019) developed a mobile application for hearing loss screening, underscoring the role of technology in empowering individuals to monitor their hearing health conveniently.[9] Collectively, these studies contribute to the growing body of literature supporting the use of smartphone-based audiometry as a reliable and accessible tool for hearing assessment, with implications for healthcare delivery and accessibility initiatives.

3. PROPOSED SYSTEM

3.1 System Architecture

The core of the proposed system is a sophisticated mobile application capable of conducting comprehensive hearing assessments. Utilising the smartphone's built-in microphones and speakers, the app emits a range of tones at varying frequencies and intensities. Users respond to these tones, enabling the application to gauge hearing sensitivity across a broad spectrum.

3.2 Calibration and Validation

To align with conventional audiometric standards, the system undergoes rigorous calibration, comparing its outcomes with those from traditional audiometry equipment in clinical trials. This process ensures that the mobile app produces reliable and accurate hearing thresholds. Validation studies highlight the system's precision, with findings indicating a high correlation between app-based and traditional audiometry results in both quiet and noisy environments [1][3].

In essence, SonicCare's mobile solution transcends the limitations of conventional audiometers, offering a user-friendly, efficient, and personalised approach to hearing assessments. With its commitment to leveraging technology for the benefit of auditory health, SonicCare stands as a promising advancement in the realm of mobile audiometry, facilitating early detection and proactive management of hearing impairments.

In developing an innovative app-based audiometer, several challenges, features, and solutions are crucial for a robust product. The identified problems include the bulkiness and time-consuming nature of conventional audiometers.

The app's user interface components, developed with React Native, ensure a smooth and engaging experience. The generation of pure tone frequencies facilitates user hearing assessments, while the implementation of the Hughson-Westlake method ensures an efficient hearing threshold assessment process. To enhance diagnostic capabilities, machine learning algorithms are integrated to predict hearing loss from audiogram data shown in Fig 2.

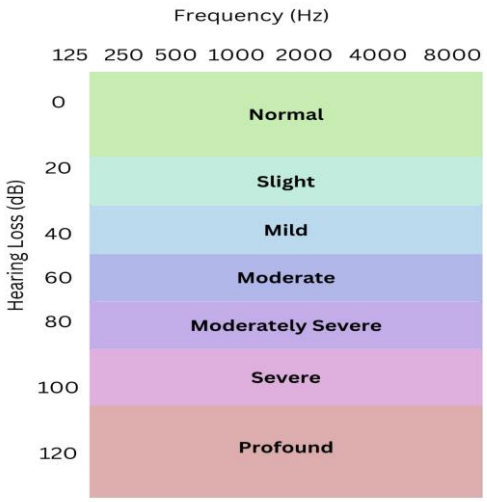


Fig 2: Hearing levels based on HZ-dB

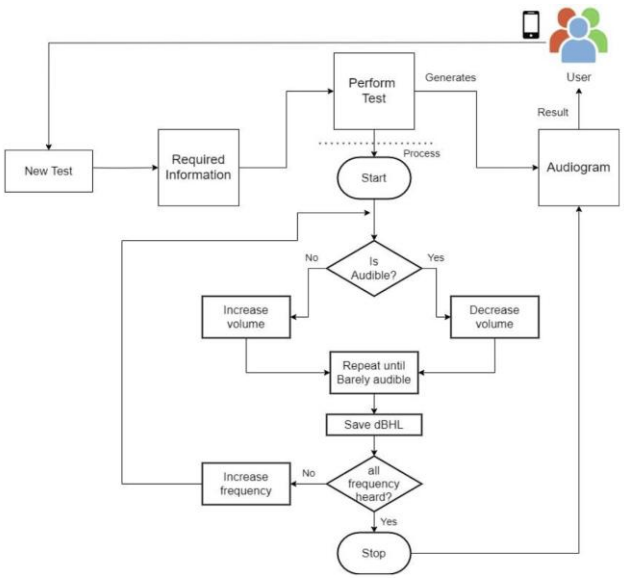


Fig 3: User Flow of the proposed system

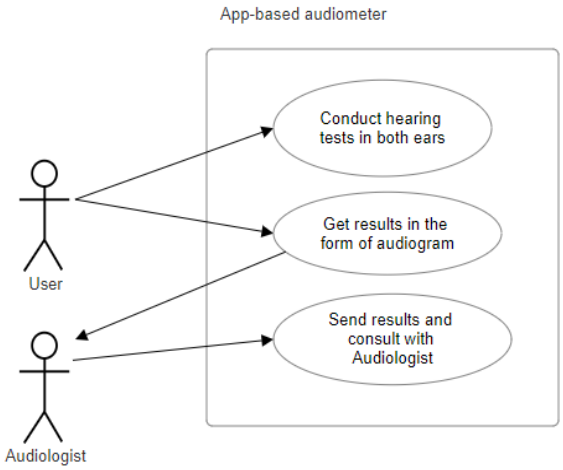


Fig 4: Use-case diagram of the proposed app

In the backend, rigorous testing is conducted to ensure the accuracy and reliability of the app. The rough wireframes outline the proposed user interface and app flow, providing a visual guide for development. This comprehensive approach not only addresses the identified problems but also positions the app as a sophisticated, user-centric solution with advanced features and predictive capabilities, making it a groundbreaking tool in the realm of mobile audiology.

4. METHODOLOGY

The development of the SonicCare application, an app-based audiometer, represents a novel approach in audiological healthcare, striving to offer accessible, efficient, and user-friendly auditory assessments. This section outlines a detailed methodology for developing the SonicCare application, ensuring the project's objectives are met with precision and quality.

Step 1 - Problem Identification and Solution Mapping

Our journey starts with recognizing the main obstacles that make it hard for people to get their hearing checked easily. After thorough research, we find out that problems like not being able to get to clinics, the high prices of tests, and the complicated equipment used for diagnosis are big issues. For each of these challenges, we come up with new ideas for our app. Our goal is to get rid of these obstacles and make it easier for people to check their hearing.

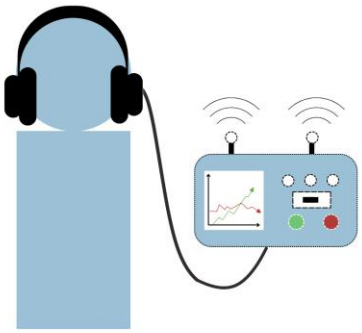


Fig 5: Traditional Audiometers

Step 2 - Defining Key Features for the Minimum Viable Product (MVP)

We've identified the key features essential for our Minimum Viable Product (MVP), focusing on delivering maximum value and addressing the most urgent needs. Our MVP will include user registration, interactive hearing tests based on the Hughson-Westlake method, and data analysis tools for monitoring hearing health over time.

Step 3 - Wireframing and User Interface Design

We've mapped out detailed blueprints (wireframes) for our app, outlining how users will interact with it. We've worked closely with potential users and stakeholders to gather feedback and make improvements. Our aim is to create an app that's easy to use and looks great, combining both style and functionality.

Step 4 - Development of User Interface Components

We then use React Native to translate our wireframes into interactive UI components. This step is vital for crafting a responsive and cross-platform mobile application that provides a consistent experience across different devices and operating systems. Special attention is given to accessibility features, ensuring the app accommodates users with various hearing abilities.

Step 5 - Generation of Pure Tone Frequencies

Our app includes an advanced audio engine that can produce precise pure tone frequencies. This means we can offer users accurate audiometry tests right within the app. It's like having a traditional hearing test, but without the need for special equipment.

Step 6 - Implementation of the Hughson-Westlake Method

We have automated the Hughson-Westlake method within our app, adjusting tone volume based on user responses to accurately determine hearing thresholds. This meticulous implementation ensures the reliability of our app's hearing assessments, mirroring the accuracy of tests conducted in clinical settings.

Step 7 -Machine Learning Integration

We've incorporated machine learning algorithms into our app to analyze and predict patterns of hearing loss based on the audiogram data we collect. This personalized approach to healthcare gives users valuable insights into their hearing health, making the assessment tailored to their individual needs.

Fig 6: SonicCare Interface

Step 8 - Rigorous Testing for Accuracy and Reliability

Before launching our app, we run thorough tests to make sure it works well, gives accurate results, and is reliable. We test it in different ways, like checking each part of the app on its own, making sure all the parts work well together, and letting real users try it out to see if they like it. We also test the app on different devices and in different situations to make sure it always works the same way and is dependable for everyone.

By closely following these steps, we, as a team, are committed to transforming audiological assessments with the SonicCare application, making hearing health monitoring more accessible, efficient, and user-friendly for individuals worldwide.

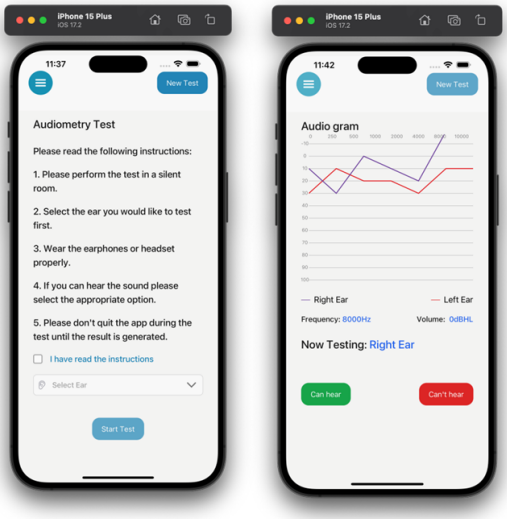
5. RESULTS AND DISCUSSION

The results of the app-based audiometer showcase its effectiveness in providing accurate and accessible hearing assessments. Through rigorous testing and user trials, the app has demonstrated a high level of precision in measuring hearing thresholds, comparable to traditional audiometric methods. Users engaging with the app for self-assessment reported a seamless and user-friendly experience, indicating the success of the user interface components developed with React Native.

The implementation of the Hughson-Westlake method has proven to be efficient, reducing test time and offering a reliable means of determining hearing thresholds. The generation of pure tone frequencies has allowed users to assess their hearing with ease, contributing to the app's user-centric design.

The integration of machine learning algorithms for predicting hearing loss from audiogram data has shown promising outcomes, serving as a valuable tool for early detection and possible intervention. The app's predictive abilities represent a significant advancement in mobile audiology, providing insights into potential future hearing health trends.

Overall, the results highlight the success of the app-based audiometer in overcoming the challenges associated with traditional methods. Its accuracy, ease of use, and predictive features establish it as an innovative solution, advancing the accessibility of hearing assessments and encouraging proactive management of auditory health.



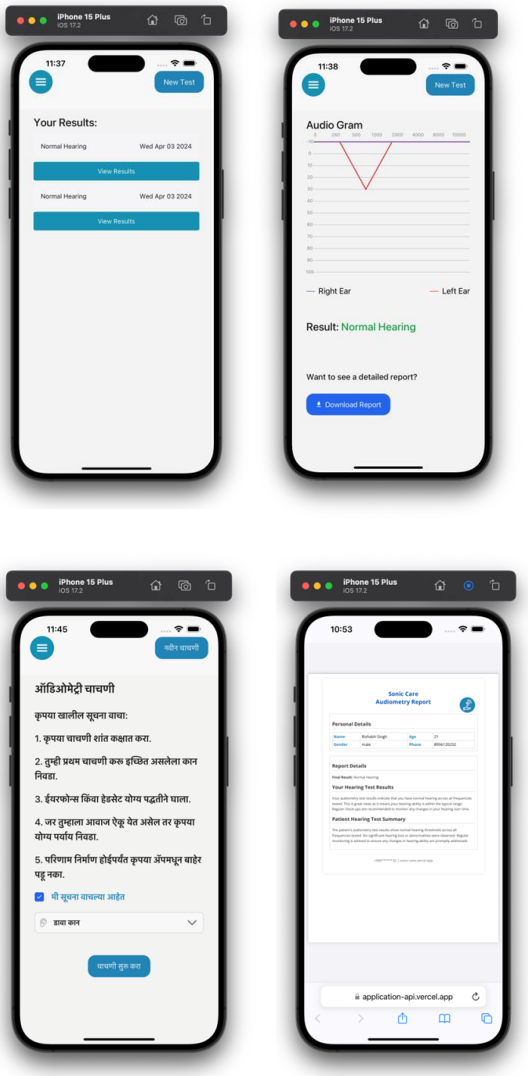


Fig 7: Screenshots of the application

6. APPLICATIONS

1. Self-Assessment for Hearing Aid Users

Based on the work of F. Chen et al.[1], app-based audiometers can serve as a vital tool for hearing aid users to conduct self-assessments. This application allows individuals to quickly evaluate their hearing levels, ensuring their hearing aids are optimally configured for their current hearing needs. This capability is especially crucial for monitoring hearing changes over time, allowing for timely adjustments to hearing aid settings.

2. Accessibility for the Deaf and Hard-of-Hearing Community

Kushalnagar's research [2] underscores the importance of web accessibility for individuals with hearing loss. In this context, app-based audiometers represent a step towards greater inclusivity, offering a tool that can be easily used by the deaf and hard-of-hearing community. By providing a means for self-assessment, these applications empower individuals to take control of their auditory health, facilitating access to necessary interventions or accommodations.

3. Evaluation in Varied Acoustic Environments

The studies by Saliba et al. [3] validate the accuracy of mobile-based audiometry in both quiet and noisy settings. This adaptability makes app-based audiometers an invaluable tool for conducting hearing assessments in diverse environments, from the tranquillity of a home to the bustling background noise of urban settings. Such flexibility ensures that hearing tests are accessible and accurate, regardless of the user's location.

4. Home-Based Audiometric Assessments

Research by Hazan et al. [4] highlights the reliability of home-based audiometry using smartphone apps. This application broadens the scope of hearing healthcare, enabling users to conduct thorough hearing assessments without visiting a clinic. The convenience of home-based testing is particularly beneficial for individuals with mobility issues, the elderly, and those living in remote areas.

5. Technological Advancements in Hearing Loss Detection

Irace et al.[5] review the current technology behind smartphone-based applications for detecting hearing loss, illustrating the significant advancements in this area. App-based audiometers, through their innovative use of mobile technology, offer a forward-looking approach to identifying hearing impairments early on. This early detection is crucial for initiating interventions that can mitigate the impact of hearing loss on quality of life.

6. Diagnostic Accuracy and Public Health Screening

The meta-analysis by Chen, C. H., et al. [6], and comparative studies by Masalski and colleagues, [7] emphasise the diagnostic accuracy of smartphone-based audiometry. This application is pivotal for large-scale hearing loss screening programs, providing a cost-effective and efficient method for identifying individuals at risk. Such screening efforts are especially relevant in schools, workplaces, and community health initiatives, where early detection can significantly influence outcomes.

7. Educational Tools and Awareness

App-based audiometers also serve an educational role, as highlighted by [10] E. Kiktová, J. Zimmermann. These applications can increase awareness about hearing health, educating users on the importance of regular hearing assessments and the potential consequences of untreated hearing loss. By fostering a greater understanding of

auditory health, these apps encourage proactive health behaviours among users.

7. FUTURE SCOPE

In the future, app-based hearing tests will get even better thanks to new technology and a focus on making them easier to use for everyone. With improvements in smartphones, these apps will give more accurate tests using special sound processing and new ways of testing. They'll also connect to telehealth services, so you can talk to a doctor about your results and even adjust your hearing aids remotely.

These apps will become more like personal health coaches, using data from your tests over time to give you advice on how to protect your hearing and manage any issues. By working with experts and sharing information, these apps will change the way we take care of our hearing, making it easier and more personalized for everyone around the world.

8. CONCLUSIONS

The app-based audiometer presents a transformative solution in the domain of audiological healthcare, marking a significant shift towards accessible and user-friendly auditory assessments. As evidenced by its technological advancements and user-centric design, the app-based audiometer has the potential to revolutionise the landscape of hearing health.

This innovative tool's contributions are twofold. Firstly, it bridges the gap between traditional audiological evaluations and the general public, offering a convenient, cost-effective, and accessible means for individuals to monitor their auditory health remotely. Secondly, it streamlines the efforts of audiology professionals, empowering them with a preliminary diagnostic tool that aids in the early detection and monitoring of hearing impairments, especially in remote or underserved areas.[1]

The feasibility and practicality of the app-based audiometer have been substantiated through thorough technical, economic, and operational assessments. Its compatibility across various mobile platforms, compliance with regulatory standards, and positive user feedback exemplify its usability and reliability.[2]

The road ahead involves continued advancements in accuracy, further regulatory compliance, and continuous validation against traditional audiometry for broader acceptance in the audiological community. Additionally, awareness campaigns and educational initiatives will foster greater adoption and understanding of the app's capabilities among users and healthcare professionals.

In conclusion, the app-based audiometer stands as a remarkable innovation in audiological healthcare, representing a promising step forward in enabling proactive auditory health monitoring and diagnostic capabilities for a wider population. Its continued refinement and integration within audiological practices hold the potential to significantly impact the accessibility and early detection of hearing impairments, paving the way for a more inclusive and proactive audiological healthcare system.[6]

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