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DESIGN AND IMPLEMENTATION OF A RASPBERRY PI-BASED VOICE ASSISTIVE SYSTEM FOR HEALTHCARE AND SAFETY APPLICATIONS

G. Rishika Reddy, A. Manaswini, CH. Prem Kumar
UG Students, Electronics and Communication Engineering,
MGIT Engineering College, Hyderabad, Telangana, India
V. Saidulu
Assistant Professor, Electronics and Communication Engineering,
MGIT Engineering College, Hyderabad, Telangana, India
CH. Raja
Associate Professor, Electronics and Communication Engineering,
MGIT Engineering College, Hyderabad, Telangana, India

ABSTRACT
Voice-based assistive systems enhance communication, safety, and healthcare monitoring. This paper presents a smart system using a Raspberry Pi 4 Model B that enables voice interaction even in noisy environments through advanced noise reduction. Audio signals are processed and converted to text using cloud-based speech recognition, allowing commands to be executed and responses delivered as speech. The system also monitors vital signs like heart rate, detects falls, and track's location using GPS. All data is stored in a cloud database for real-time monitoring and emergency response. This low-cost, scalable solution integrates IoT, voice recognition, and embedded systems, making it especially useful for elderly and physically challenged individuals.

INTRODUCTION
Hearing loss is a widespread condition affecting millions of individuals globally, leading to communication difficulties and reduced participation in daily activities. Conventional hearing aids typically amplify all incoming sounds without discrimination, which often results in poor speech understanding, particularly in noisy environments such as markets, classrooms, and public transport.

Recent advancements in digital signal processing (DSP) and embedded technologies have opened new possibilities for intelligent hearing systems. These systems can analyze sound signals and adapt their behavior dynamically based on environmental conditions. This project aims to design a smart assistive hearing device capable of real-time sound analysis and adaptive amplification. By focusing on speech enhancement and noise suppression, the system seeks to provide a more natural and efficient hearing experience.

LITERATURE REVIEW
Over the years, hearing assistive technology has undergone significant improvements, evolving from simple sound amplification devices to more advanced systems focused on enhancing speech quality. Early hearing aids increased the volume of all incoming sounds, which often resulted in poor listening experiences in noisy environments. To address these challenges, modern systems utilize digital signal processing techniques that help in isolating speech signals and reducing background noise. Methods such as adaptive filtering, dynamic gain adjustment, and directional audio processing have improved performance considerably. More recent advancements include the use of intelligent algorithms that can automatically adjust system parameters based on the surrounding environment. Additionally, the integration of wireless communication and mobile applications has made these devices more user-friendly and customizable. There is also a growing trend of combining hearing assistance with additional features like health monitoring and fall detection, leading to more comprehensive assistive solutions.

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BLOCK DIAGRAM

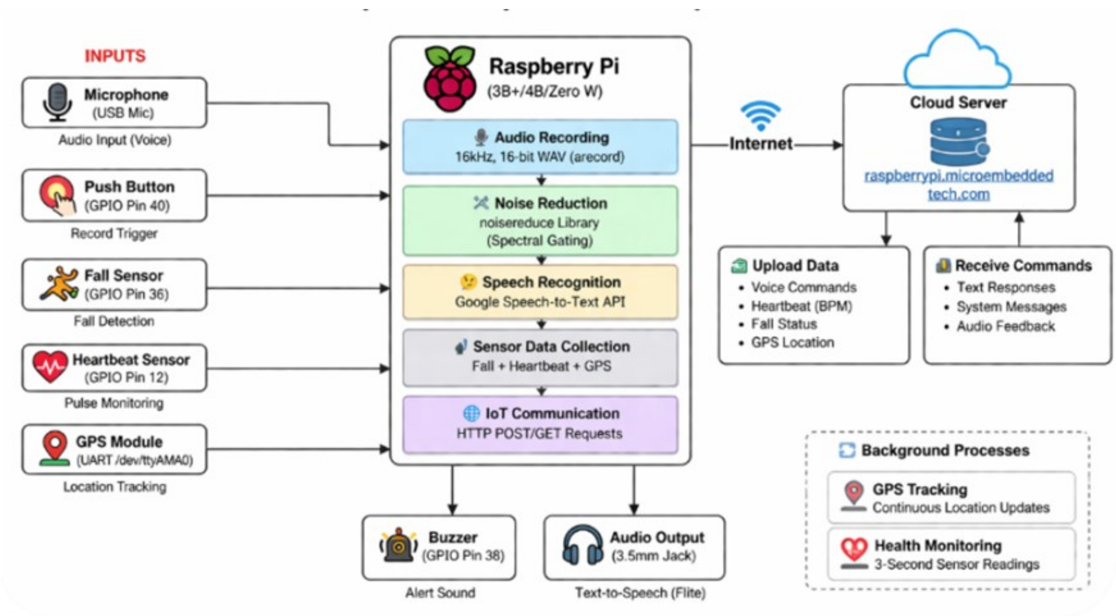

Figure.1, Block diagram of Smart Hearing Device

Figure.1 shows the block diagram of the proposed voice-based assistive system, where inputs from the microphone and sensors are processed by the Raspberry Pi 4 Model B for noise reduction and speech recognition. The processed data is sent to the cloud for analysis, and responses are returned as audio output, with continuous health monitoring and GPS tracking.

METHODOLOGY

The proposed system is built around the Raspberry Pi, which acts as the central controller for both audio processing and sensor integration. The process begins with capturing audio signals through an external microphone. These signals are then processed using noise reduction techniques to minimize background disturbances and enhance speech clarity. After preprocessing, the improved audio is passed to a speech recognition module, which converts spoken words into text. This text is then transmitted to a mobile application, allowing the user to easily understand the conversation in real time. The communication between the system and the mobile application is achieved through wireless connectivity. In parallel, the system continuously monitors the user's safety and health using integrated sensors. A fall detection sensor identifies sudden movements or impacts, while a heart rate sensor tracks pulse levels. The GPS module provides real-time location data. If any abnormal condition is detected, the system automatically sends an alert message along with location details to predefined contacts, ensuring quick response in emergency situations.

RESULTS AND DISCUSSION

The implemented system demonstrates effective performance in real-time audio processing and communication support. The noise reduction techniques help in minimizing background disturbances, allowing clearer speech recognition and accurate text conversion. The mobile application successfully displays the converted text, making it easier for users to follow conversations. The safety features also perform reliably. The fall detection sensor accurately identifies sudden movements, while the heart rate sensor provides consistent monitoring of pulse levels. The GPS module ensures accurate location tracking, which is useful during emergencies. Alerts are generated promptly when abnormal conditions are detected. Overall, the system shows stable operation and meets the intended objectives of improving communication and ensuring user safety. Minor delays may occur due to network dependency in speech processing, which can be improved in future versions.

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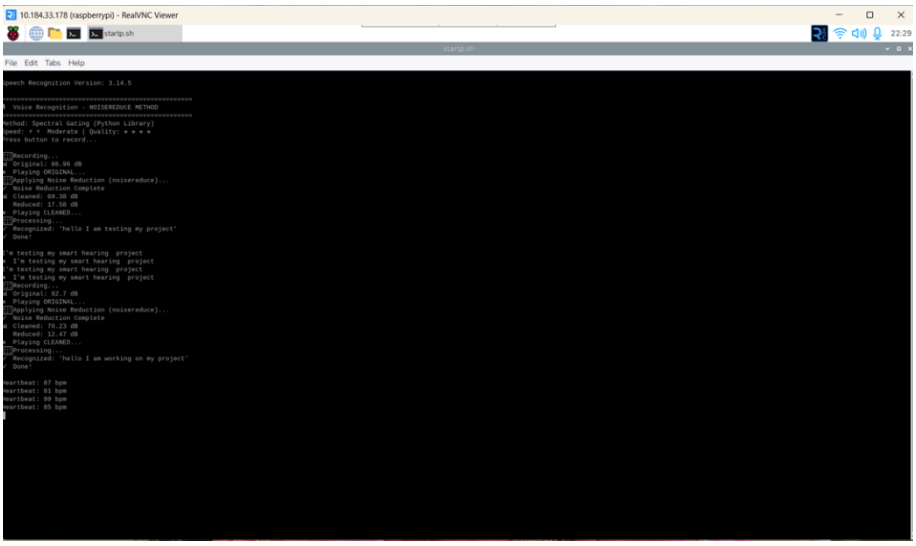

Figure.2, Software Execution Output of the Smart Voice-Based Assistive System

Figure. 2 shows the real-time output of the system running on the Raspberry Pi 4 Model B. It captures voice input, applies noise reduction, and converts speech into text. The display includes sound levels before and after filtering, recognized voice commands, and heart rate readings (bpm), demonstrating simultaneous voice processing and health monitoring

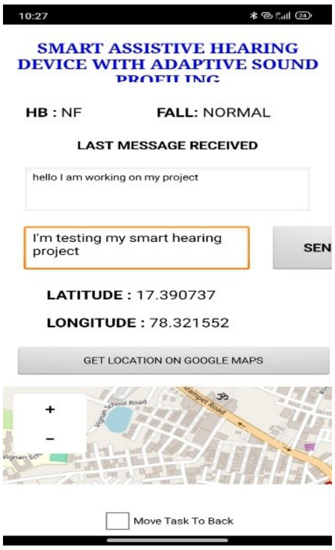

Figure.3, Mobile Application Interface of the Smart Assistive System

Figure. 3 shows the mobile application interface of the system. It displays health status (heart rate and fall detection), the last received voice message, and user input. It also provides real-time location coordinates with a map view, enabling tracking and quick access to location services.

CONCLUSION

This project presents a smart assistive hearing device that combines speech enhancement, text conversion, and safety monitoring into a single system. By using the Raspberry Pi, the system achieves efficient processing while maintaining low cost and flexibility. The device not only improves communication for users with hearing difficulties but also enhances their safety through features like fall detection and location tracking. The integration of multiple functionalities makes the system more practical and useful in real-life situations. The results confirm

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that such assistive solutions can be effectively implemented using modern embedded technologies.

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