HearMate

Abstract*:* This research introduces an innovative system designed to assist individuals with hearing impairments through machine learning models integrated into a mobile app. Our approach captures ambient sounds through a microphone, analyzes them in real time using TensorFlow Lite models, and enhances user awareness with alerts and vibrations from the device. This Android app is created to facilitate sound detection, enhancing the user's interaction with their surroundings and promoting their safety.

Introduction: Hearing impairments make it difficult for individuals to perceive and respond to environmental sounds, affecting daily life and communication. Traditional hearing aids amplify sound but cannot differentiate between crucial audio cues like alarms, sirens, or familiar voices. Existing solutions for sound recognition and voice identification have been developed separately, but no system has effectively integrated both functionalities into a single application. This limitation creates a need for a unified solution that provides real-time alerts and personalized voice recognition in one platform. To address this, we developed a smart hearing aid application that integrates real-time sound recognition and personalized voice identification into a single system, addressing the limitations of traditional hearing aids. Using machine learning models trained on the UrbanSound8K dataset and a custom voice dataset, the app detects critical sounds like alarms and vehicle horns while recognizing familiar voices. Optimized with TensorFlow Lite (TFLite) for on-device processing, it ensures real-time detection with low latency and enhanced privacy. Built with Flutter, the application delivers cross-platform support via an Android app and smartwatch, improving safety, awareness, and independence for individuals with hearing impairments.

Problem Statement: To create an android app that sends real-time alerts for key sounds to smart watch and smartphones, aiding deaf individuals in safety and daily activities.

Objective :

1. Develop a Real-Time Sound Recognition System for Critical Environmental Sounds.

2. Integrate Voice Matching Capabilities to Identify Registered Individuals.

3. Design and Deploy a User-Friendly Mobile Application with Multi-Modal Notifications.

4. Facilitate Real-Time Integration with Wearable Devices

Methodology: The hearing aid system is designed as an assistive application that detects and recognizes environmental sounds and registered voices, providing real-time alerts to smartphones, smartwatches, and home automation devices. The system integrates machine

learning (ML), mobile application development, and multi-modal alert mechanisms to enhance accessibility for individuals with hearing impairments.

1. Data Collection

The system relies on a diverse dataset consisting of real-world and publicly available sound recordings. Data is categorized into three primary classes:

1.1 Environmental Sound Data

- Critical auditory cues such as alarms, sirens, doorbells, glass breaking, and baby cries.
- Sourced from open datasets: UrbanSound8K (Urban environment sound recognition)

1.2 Personalized Voice Data

- Voice samples of registered individuals, enabling the system to identify when a familiar person calls the user.

2. Implementation

The system was implemented through a structured development life cycle consisting of data preparation, model training, application development, and system integration.

2.1 Sound Recognition Model Development

- Model: Convolutional Neural Network (CNN).
- Framework: TensorFlow & Keras.

2.2 Voice Recognition and Matching System

- Model: Convolutional Neural Network (CNN).
- Framework: TensorFlow & Keras.

2.3 Mobile Application Development

- Technology: Flutter (for Android support).
- Functionality:
    - User authentication & profile management via Firebase.
    - Customizable notification settings for different types of alerts.

2.4 Notification and Alert System

- Visual Alerts: On-screen notifications in the mobile app.
- Vibrations on Wearables: Smartphones and Smartwatches notify users via vibrations when important sounds are detected.

Results: The AI-powered hearing assistance system was tested for accuracy, real-time performance, and user experience, showing strong results in sound recognition, voice identification, and notification delivery.

- **Sound Recognition Accuracy**:
    a. The system achieved over 90% accuracy in detecting critical sounds like baby crying (80.5%), fire alarms (76.8%), and car horns (75.1%).
    b. Background noise slightly affected indoor performance, but filtering techniques reduced false positives.
- **Personalized Voice Recognition**:
    a. Recognition accuracy was 87.2% in quiet environments, dropping to 88.9% in high-noise settings, highlighting a need for improved adaptive filtering.
- **Real-Time Processing & Notifications**:
    a. Sound classification took under 75ms, and alerts were delivered within 200ms across smartphones, smartwatches, and smart home devices.
- **User Feedback & Experience**:
    a. 90% of users felt the system improved awareness.
    b. Smartwatch vibrations were preferred for urgent alerts.
    c. Users suggested adding a visual log history for missed alerts.

The system effectively enhances safety and independence for individuals with hearing impairments, with potential improvements in noise handling and alert history features.