A Real-Time Horn Detection and Directional Alert System for Drivers with Hearing Loss

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Abstract: Hearing-impaired individuals face significant challenges in perceiving auditory signals in daily life, especially in traffic scenarios where auditory cues such as vehicle horns are critical for safety. This study proposes a cost-effective, sound-detecting vehicle assistive system designed specifically for the hearing-impaired. The system utilizes a microphone array to detect and localize vehicle horn sounds, determining their direction (left or right). Upon detecting a horn, the system visually alerts the user through an LCD display, indicating both the presence and direction of the sound source. This approach ensures enhanced situational awareness for the user without relying on auditory feedback. The proposed design incorporates economical components like condenser microphones, a microcontroller (such as Arduino), and a compact LCD module, making it affordable and accessible for widespread adoption. The solution aims to enhance the mobility and safety of hearing-impaired individuals by bridging the communication gap between auditory signals and visual cues.

***Index Terms*: Horn sound, Hearing impaired, Display.**

I. INTRODUCTION

Driving is a complex activity that relies heavily on auditory cues such as sirens, honks, and other vehicle sounds for safe navigation and quick decision-making. For hearing-impaired individuals, the inability to perceive such sounds significantly compromises their situational awareness, increasing the risk of accidents. One of the most critical cues while driving is the honking of nearby vehicles, often used to signal urgency or warn of danger. Unfortunately, conventional vehicles lack built-in support to assist drivers with hearing impairments in recognizing these auditory events. This study proposes a cost-effective sound detection and direction-identification system, specifically designed to be integrated into vehicles operated by hearing-impaired individuals. The system uses a dual-microphone setup to detect horn sounds and determine their direction—left or right. It then provides real-time visual alerts on an LCD display mounted on the dashboard. This allows the driver to be visually notified when a nearby vehicle sounds its horn and from which direction it originated. Beyond in-vehicle integration, the system can be extended to other assistive applications such as wearable devices or mobility aids for the hearing-impaired, making it a scalable and inclusive technology solution.

A. . Objectives of the Study

- To develop a vehicle-integrated alert system that detects horn sounds in real-time for hearing-impaired drivers.
- To implement direction-detection using a microphone array to differentiate whether the sound source is approaching from the left or right side of the vehicle.
- To design an intuitive LCD-based visual interface that alerts the driver about the horn and its direction promptly and clearly.
- To ensure the system is cost-effective, compact, and easily mountable within standard vehicle interiors without extensive modifications.
- To explore the system's scalability for broader assistive technology applications, such as wearable or portable aids for hearing-impaired pedestrians or cyclists.

II. LITERATURE REVIEW

This study in [1] presents a participatory sensing approach for traffic monitoring by detecting horn sounds using smartphone sensors and transmitting extracted features to a server for classification. The use of a Modified MFCC method tailored to car horn spectral characteristics enhances robustness to phone placement variations while preserving user privacy and minimizing power consumption. The study given in [2] proposes a Smartphone application that alerts hearing-impaired drivers through on-screen notifications and vibrations upon detecting car horns using real-time sound frequency analysis via Fast Fourier Transform. The study addresses challenges like Doppler effect in real traffic scenarios and demonstrates a functional, user-customizable app validated through simulations and real-world testing.

This study [3] employs a wearable device for the hearing-impaired that uses an audio fingerprinting method to identify various environmental sounds in real time, achieving over 90% accuracy across multiple sound types, including 91% for horn detection. Extensive testing on deaf and simulated-hearing-impaired individuals demonstrated high user satisfaction, with 97% finding it useful and 100% willing to use it again. This study in [4] proposes a deep learning-based siren identification system for hearing-impaired individuals, using a convolutional neural network that classifies spectrograms generated from incoming audio signals. By augmenting data with various environmental noises and integrating a visual alert interface, the system achieved 98% accuracy in realistic conditions and reliably detected sirens even at -6 dB below background noise.

III. EXPLANATION OF THE PROPOSED BLOCK DIAGRAM

The proposed system is a cost-effective, in-vehicle assistive solution designed specifically for hearing-impaired drivers, enabling them to detect and interpret critical auditory signals like horn sounds from nearby vehicles. Figure 1 shows the block diagram of the proposed system. The system is composed of three main components: a sound detection unit, an ultrasonic distance measurement module, and a visual display system. The sound detection module uses microphones or sound sensors capable of recognizing the unique frequency pattern of a vehicle horn.

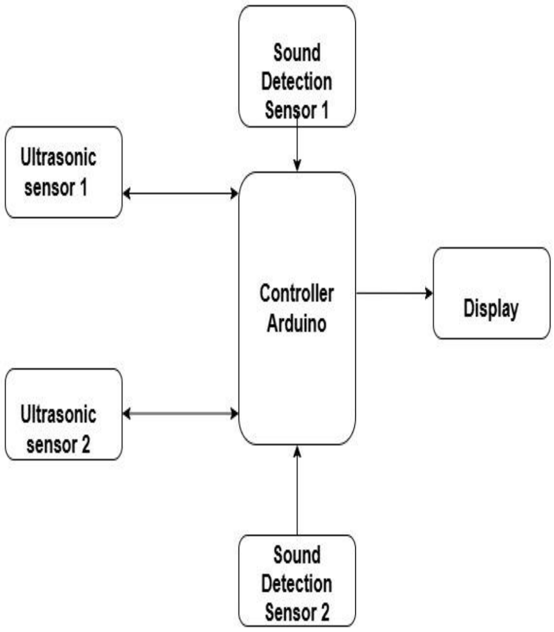

Fig 1 Block diagram of the Proposed System

Upon detecting a horn, the system immediately activates the ultrasonic module to determine the proximity of the approaching vehicle. The ultrasonic sensors, mounted at the rear end of the vehicle, continuously monitor the distance between the host vehicle. and any trailing vehicle. If a detected vehicle crosses a predefined safety distance threshold, the system interprets it as a potential danger or urgency scenario. The ultrasonic sensors are oriented in a way that allows basic directional detection—whether the vehicle is approaching from the left or right side. This directional information, along with an alert, is displayed on an LCD screen mounted on the vehicle's dashboard, providing clear and immediate visual cues to the driver. The entire system is implemented using Arduino, along with compatible sound sensors, ultrasonic modules (e.g., HC-SR04), and an LCD display, making the solution affordable and easy to deploy in existing vehicles without complex modifications. This system not only enhances safety for hearing-impaired drivers but also offers a scalable platform for further enhancements and wider applications in pedestrian or cyclist safety. Figure 2 illustrates the flowchart representing the operational workflow of the proposed system.

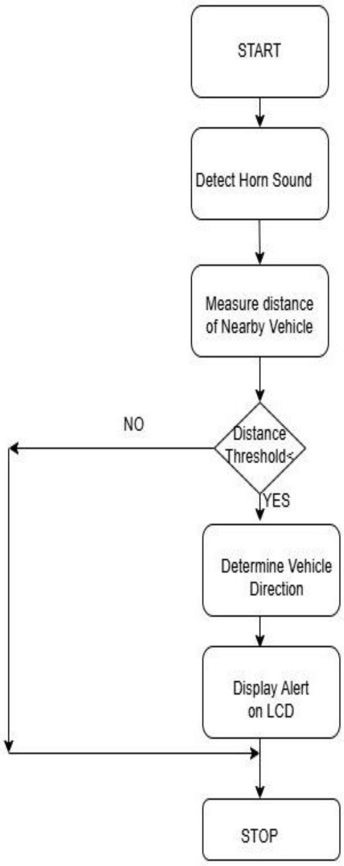

Fig 2 Flowchart of the proposed system.

IV. RESULTS AND DISCUSSION

Fig. 3: Internal view of the system showcasing its components. The sound detection sensor successfully identified horn sounds by capturing acoustic signals through a microphone and processing them using an LM393 op-amp. By fine-tuning the onboard potentiometer, the sensor was calibrated to trigger output only when horn-level sound intensities were detected. The digital output (DO) reliably interfaced with the Arduino to indicate horn detection, confirming the system's responsiveness under real-world traffic conditions. Two ultrasonic sensors and two sound-detecting sensors are connected each on the left and right sides of the system. The sound detection sensors turn on only if the distance of the object producing the horn is within a range of 20 cm from the driver’s vehicle. Here, we are using a smartphone as a horn module, as shown in Figure 4. To alert a deaf driver, the output signal is important and necessary. Among many options, the LCD display is chosen. A 2x16 LCD with I2C is used in our project. The I2C(Inter-Integrated Circuit) interface simplifies the wiring required to connect the LCD to a microcontroller. It uses a serial communication protocol, allowing multiple devices to communicate over just two wires: SDA (data line) and SCL (clock line). The Arduino board is connected to LCD display to display the direction and distance. Here, we are using the HC-SR04 ultrasonic distance sensor, which consists of four pins: VCC, GND, TRIG (Trigger), and ECHO. Here, we are using a smartphone as a horn module, as shown in Figure 5. The LCD screen displays the direction of the horn and also the distance of the object producing the horn.

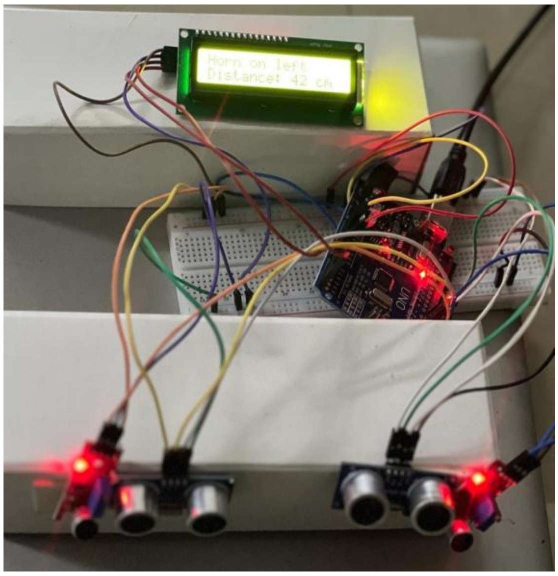

Fig. 3: Internal view of the system.

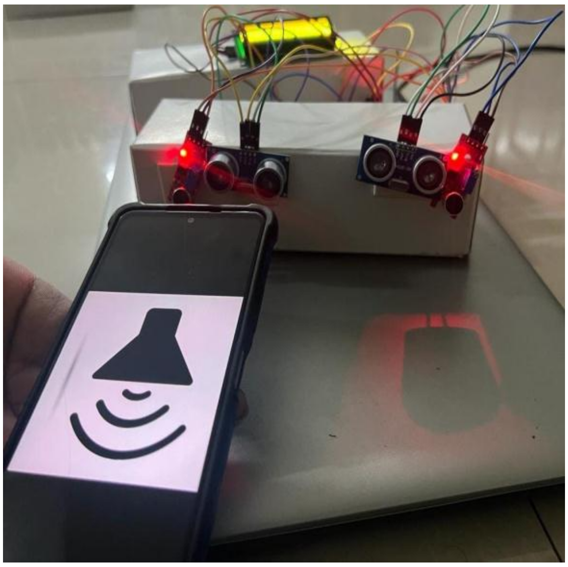

Fig. 4: Horn sound fed into the system through a smart phone.

Fig 5 Output shown on LCD display

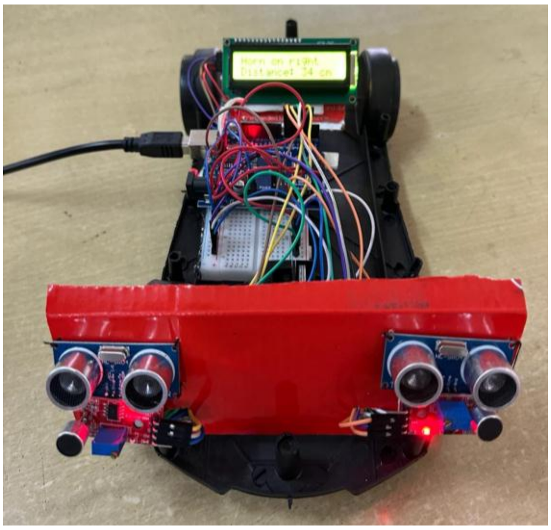

Fig. 6: A prototype is developed for the system, and its appearance is shown in Figure

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V. CONCLUSION

The proposed system provides a practical and cost-effective solution for enhancing the situational awareness of hearing-impaired drivers. By integrating sound detection, distance measurement using the HC-SR04 ultrasonic sensor, and directional alerts through an LCD display, the system ensures timely visual notifications of nearby honking vehicles. The use of affordable components like Arduino, I2C-based LCD, and sound sensors makes this assistive technology accessible and scalable, with potential for further development in both vehicular and wearable applications aimed at improving road safety for the hearing-impaired community.

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