IT4010 – Research Project - 2024

Topic Assessment Form

Project ID: 24-25J-132

1. Topic (12 words max)

Autonomous IoT-Enabled Hazard Detection and Communication System for Deaf Drivers.

2. Research group the project belongs to

Autonomous Intelligent Machines and Systems (AIMS)

3. Research area the project belongs to

Internet of Things (IoT)

4. If a continuation of a previous project:

Project ID	
Year	

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

Deaf drivers face significant challenges in perceiving auditory hazards such as emergency vehicle sirens and honking from other drivers and Railway gate warning alarms. Traditional hazard detection systems primarily rely on auditory signals, which can be ineffective for those with hearing impairments. The lack of effective hazard communication mechanisms for deaf drivers can lead to increased risks on the road, potentially resulting in accidents or delayed responses to critical situations.

Current solutions in automotive safety do not adequately address the needs of deaf drivers, who require alternative modes of hazard notification to ensure their safety and the safety of others. Visual and tactile alert systems are not commonly integrated into standard vehicle designs, and there is a significant gap in research and development focused on inclusive hazard detection systems that cater specifically to the needs of deaf drivers.

This research project aims to bridge this gap by developing an advanced hazard detection and communication system that leverages IoT and AI technologies to provide real-time alerts through visual and tactile means. By integrating a comprehensive network of sensors including cameras, ultrasonic sensors, and LIDAR, the system will collect and process environmental data in real-time to identify potential hazards. The processed data will then trigger multi-modal alerts to inform the driver of any imminent dangers.

The innovative aspect of this research lies in its inclusive design approach, ensuring that deaf drivers receive timely and effective hazard notifications. This will not only enhance the driving experience for deaf individuals but also contribute to overall road safety by reducing the risk of accidents caused by delayed hazard perception.

References:

1. World Health Organization. (2021). Deafness and hearing loss. Retrieved from https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss

2. National Highway Traffic Safety Administration. (2020). Traffic Safety Facts. Retrieved from https://www.nhtsa.gov/research-data

3. Jiang, W., & Doudoumis, P. (2021). IoT-based intelligent vehicle monitoring and management system for autonomous cars. IEEE Transactions on Intelligent Transportation Systems, 22(5), 3015-3023.

4. Chen, C., & Liu, Y. (2020). Real-time multi-sensor data fusion for autonomous driving perception. IEEE Sensors Journal, 20(16), 9448-9456.

6. Brief description of the nature of the solution including a conceptual diagram (250 words max)

The proposed solution is an integrated hazard detection and communication system designed to meet the unique needs of deaf drivers. This system employs a comprehensive network of IoT sensors, including cameras, ultrasonic sensors, and LIDAR, to gather real-time data about the vehicle's surroundings. These sensors are strategically placed to monitor various aspects of the driving environment, ensuring comprehensive coverage and accurate hazard detection.

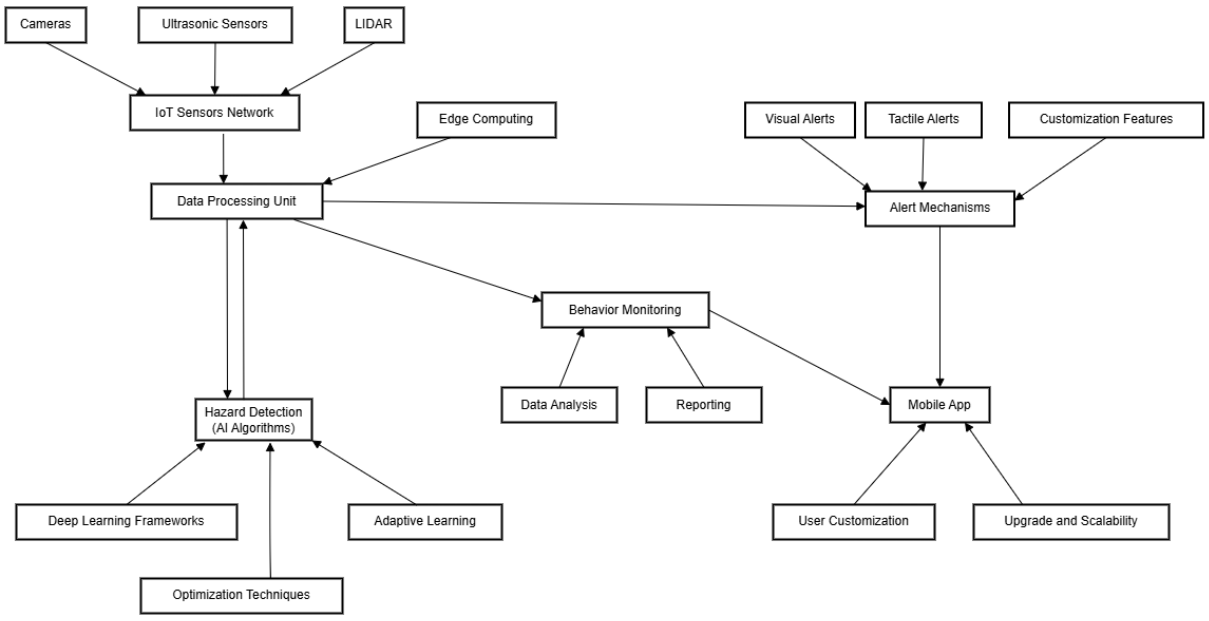
The gathered data is processed using advanced AI algorithms capable of real-time hazard detection. These algorithms, developed using deep learning frameworks like TensorFlow or PyTorch, analyze the sensor data to identify potential hazards such as emergency vehicle sirens and honking from other drivers and Railway gate warning alarms. The system is optimized to run on affordable hardware, such as Raspberry Pi, ensuring cost-effectiveness and feasibility for wide-scale deployment.

Once a hazard is detected, the system triggers a multi-modal alert mechanism to inform the driver. This includes:

- **Visual Alerts:** Displayed on a mobile app or an in-car display, showing the nature and location of the hazard.
- **Tactile Alerts**: A vibrating steering wheel or seat to provide immediate, non-visual feedback.

In addition to hazard detection, the system features a Driver Behavior Monitoring and Assistance component. It uses sensors such as cameras, accelerometers, and gyroscopes to track attentiveness and driving patterns. The system analyzes this data to generate insights and recommendations, enhancing driver safety and habits through continuous feedback and performance reports.

The mobile app allows for user customization, enabling drivers to adjust the types and intensities of alerts according to their preferences. The system's modular design supports easy upgrades and scalability, ensuring it can incorporate new sensors and technologies as they become available.



7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

The development of an autonomous IoT-enabled hazard detection and communication system for deaf drivers requires expertise across several specialized domains:

1. **Artificial Intelligence and Machine Learning:**
   - Expertise in developing and training deep learning models is crucial for real-time hazard detection. Knowledge of frameworks like TensorFlow or PyTorch is essential to create models that can accurately interpret sensor data and identify potential hazards. Experience with computer vision techniques will aid in processing and analyzing visual data from cameras.
2. **IoT and Embedded Systems:**
   - Proficiency in integrating and synchronizing multiple sensors, such as cameras, ultrasonic sensors, and LIDAR, is vital. Understanding embedded systems, particularly platforms like Raspberry Pi or ESP32, ensures efficient data acquisition and processing. Skills in edge computing will help in optimizing the system for real-time performance.
3. **Human-Computer Interaction (HCI):**
   - Designing intuitive and effective alert mechanisms that communicate hazards to deaf drivers through visual and tactile means requires expertise in HCI. Knowledge of user-centered design principles ensures that the system is accessible and user-friendly for deaf drivers.
4. **Mobile Computing:**
   - Developing a mobile application that displays real-time alerts and interacts with the vehicle's sensor network necessitates proficiency in mobile app development. Skills in cross-platform development frameworks like Flutter or React Native can ensure broad compatibility.
5. **Data Analysis and Visualization**:
   - The ability to process and visualize collected data is essential for generating insights and providing detailed reports to users. Expertise in data analysis tools and techniques will help in interpreting sensor data and improving system performance.

Data Requirements:

- Access to diverse datasets for training AI models is critical. This includes images, audio, videos, and sensor data from various driving scenarios. Collaboration with organizations that can provide real-world driving data and testing environments will be beneficial.

- User feedback data is necessary to continuously refine and adapt the system. This can be collected through pilot testing with deaf drivers, ensuring that the system meets their specific needs and preferences.
- Publicly available datasets on traffic conditions, road layouts, and environmental factors will also be useful for training and validating the system's AI models.

8. Objectives and Novelty

Main Objective			
The main outcome is an advanced safety system for deaf drivers, featuring real-time hazard detection and alerting through visual and tactile notifications. This system enhances situational awareness, safety, and independence for deaf drivers. To develop a comprehensive and modular sensor network integrated with advanced AI algorithms and a multi-modal alert system. This project utilizes affordable edge computing hardware for real-time data acquisition, hazard detection, and deaf driver behavior monitoring.			
Member Name	Sub Objective	Tasks	Novelty
Rathnayake R.M.S.N	Develop Advanced AI Algorithms for Real-Time Hazard Detection. Creating AI algorithms to detect driving hazards in real-time involves using deep learning models trained on diverse datasets. These algorithms process sensor data quickly and accurately, utilizing frameworks like TensorFlow or PyTorch. Optimized for efficiency, they	1. Model Development: • Develop deep learning models for detecting various driving hazards using frameworks like TensorFlow or PyTorch. • Train and fine-tune models using a diverse dataset to ensure high accuracy and reliability in	Developing AI algorithms capable of real-time hazard detection with high accuracy and efficiency. By leveraging deep learning frameworks like TensorFlow or PyTorch, models are trained on diverse datasets to handle various driving conditions. The system uses affordable hardware (e.g., Raspberry Pi) for local data processing and sensor

	run on affordable hardware such as Raspberry Pi, enabling immediate hazard detection. Adaptive learning mechanisms allow the AI to improve continuously based on new data and user feedback.	different driving conditions. 2. Data Processing: • Implement data preprocessing steps to clean and prepare the sensor data for AI model input. • Utilize central or cost-effective local processing units (e.g., Raspberry Pi) to handle real-time data processing and sensor fusion. 3. Algorithm Optimization: • Optimize AI algorithms for real-time performance, ensuring they can process data quickly enough for immediate hazard detection. • Implement techniques to reduce computational load and improve efficiency, such as	fusion, minimizing latency and ensuring real-time performance. AI algorithms are optimized for quick data processing, employing techniques like quantization and model pruning to reduce computational load. Adaptive learning mechanisms allow the system to improve continuously based on new data and user feedback.

		quantization or model pruning. 4. Adaptive Learning: • Incorporate adaptive learning mechanisms to continuously improve the model's performance based on new data and user feedback. • Develop methods for the AI to learn from user interactions and environmental changes, enhancing its adaptability over time.	
Fernando W.T.R.P	Develop a Modular IoT Sensor Network for Real-Time Data Acquisition, with Emphasis on Software Engineering and Programming Efficiency. Integrate sensors like cameras, ultrasonic sensors, and LIDAR into a system that collects and processes data in	1. Sensor Integration : • Develop and implement software to integrate multiple types of sensors (cameras, ultrasonic sensors, LIDAR). • Ensure synchronization and communication between sensors for	Integrating diverse sensors into a modular, cost-effective system using edge computing enhances real-time data processing. Leveraging affordable hardware like Raspberry Pi or ESP32 minimizes latency and costs while maintaining performance. The modular design allows

	real-time using affordable hardware (Raspberry Pi or ESP32). The modular design allows for easy upgrades. Initial data processing on microcontrollers ensures efficient handling and enhances real-time hazard detection.	accurate data collection. 2. Data Collection : • Write and optimize algorithms for continuous data acquisition. • Implement initial data processing steps, such as filtering and noise reduction, on microcontrollers like Arduino or Raspberry Pi. 3. Edge Computing Implementation : • Utilize cost-effective hardware (Raspberry Pi or ESP32) to perform local data processing. • Develop and deploy edge computing solutions to reduce latency and enhance real-time performance.	for scalability and easy upgrades. Employing a multi-sensor approach, including cameras, ultrasonic sensors, and LIDAR, provides comprehensive environmental insight. Initial data processing on microcontrollers filters and reduces noise early, ensuring efficient data handling and prompt hazard detection.

		4. Modular Design : • Design a modular sensor network architecture that supports easy upgrades and scalability. Ensure the system can accommodate new sensors and technologies with minimal changes.	
Iroshan G.H.M	Design and Implement a Multi-Modal Alert System for Real-Time Driver Notification. Creating a multi-modal alert system involves generating real-time visual, auditory, and tactile notifications to inform drivers of hazards. This includes features like a vibrating steering wheel that communicates via Bluetooth and a mobile app that shows alerts, such as a red screen for high-priority hazards. The system is customizable,	1. Alert Mechanism Development: • Develop software for generating visual and tactile alerts. • Ensure alerts are clear, concise, and effectively communicate the nature of the detected hazard. • Implement a vibrating steering wheel system that uses Bluetooth for parallel	Designing a multi-modal alert system that provides real-time notifications through visual, and tactile means, including a vibrating steering wheel system that communicates via Bluetooth. The system integrates with a mobile app to display intuitive graphics and notifications, such as a red screen on the phone for high-priority hazards, ensuring seamless communication with the vehicle's sensor network.

	allowing drivers to adjust alert types and intensities based on their preferences.	communication and alert delivery. 2. Mobile App Integration: • Create a mobile application to display real-time alerts using intuitive graphics and notifications. • Implement visual alerts such as a red screen on the phone to indicate high-priority hazards. • Ensure seamless communication between the mobile app and the vehicle's sensor network. 3. Customization Features: • Implement user customization options for alert types and intensities. • Allow drivers to adjust settings based on personal preferences and needs.	User customization features allow drivers to personalize alert types and intensities, enhancing usability and effectiveness. Extensive testing and validation ensure the system's reliability and performance across different driving conditions.

Thathsara S.M.K	Develop a System for Comprehensive Driver Behavior Monitoring and Reporting. Create a system that utilizes advanced sensors and vehicle data to analyze driver behavior. This system will track key metrics such as driver attentiveness and driving patterns. It will provide detailed reports and visualizations to offer actionable insights and recommendations, aimed at enhancing driving safety and performance.	1. Driver Behavior Monitoring: • Develop algorithms to monitor driver behavior using sensors (e.g., cameras, accelerometers, gyroscopes) and data from the vehicle's onboard systems. • Track key metrics such as driver attentiveness and driving patterns. 2. Data Analysis and Reporting: • Collect and analyze data on driver behavior over time to provide insights and recommendations for improvement. • Generate reports and visualizations for drivers to review their performance and identify areas for improvement.	Developing algorithms to monitor driver behavior using advanced sensors (e.g., cameras, accelerometers, gyroscopes) and vehicle data is innovative in its continuous real-time feedback for correcting unsafe actions. Tracking key metrics such as driver attentiveness and driving patterns provides a detailed understanding of driver behavior. The system's capability to collect and analyze this data over time enables the generation of comprehensive reports and visualizations. These insights and personalized recommendations help drivers review their performance and identify areas for improvement, enhancing overall safety and driving performance.

9. Supervisor checklist

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes	✓	No	

b) Does the proposed topic exhibit novelty?

Yes	✓	No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes	✓	No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes	✓	No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

I recommend this project since it considers enough technical depth in all the research components, which is suitable for an undergraduate project. However, the students who propose this project must consider achieving their goals in a cost-effective way since the application is not for the general public but for a limited community.

10. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Dr	Kapila	Dissanayaka	Dissanayaka KL 21/7/2024
Co-Supervisor	Ms	Ishara	Weerathunga	(Signed) 21/07/2024
External Supervisor				
Summary of external supervisor's (if any) experience and expertise				

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Topic Assessment Form

<u>This part is to be filled by the Topic Screening Panel members.</u>

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes (should be followed up by the supervisor)*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

The Review Panel Details

Member's Name	Signature

*__Important__:

1. According to the comments given by the panel, make the necessary modifications and get the approval by the **Supervisor** or the **Same Panel**.
2. If the project topic is rejected, identify a new topic, and follow the same procedure until the topic is approved by the assessment panel.