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

24-25J-132

Project Proposal Report

Iroshan G.H.M

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Declaration

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We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
Iroshan G.H.M	IT21229084	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Dissanayake. H.K.I.D

(Signature of the supervisor)

22/08/2024.

Date

Abstract

The rise in the number of deaf drivers has highlighted a significant challenge in ensuring their safety, particularly during emergencies where swift and effective communication with emergency services is critical. This research aims to develop an "Integrated Emergency Support System for Deaf Drivers," a mobile application specifically designed to address the communication barriers faced by deaf drivers in critical situations. The proposed system integrates several advanced features, including predefined emergency messages, real-time location tracking, and text-to-speech conversion, to automatically relay crucial information to emergency responders.The application empowers deaf drivers to quickly select and send predefined emergency messages that describe their situation, such as an accident or sudden illness. These messages are automatically combined with real-time location data and converted into speech, enabling the system to initiate an automated call to emergency services and convey the necessary information clearly and efficiently. Deaf drivers can communicate their needs effectively without delay.Moreover, the system introduces a bidirectional communication capability that allows emergency responders to send responses back to the driver in text format, addressing a critical gap in existing communication solutions.Application also features a customizable emergency contact list and a user-friendly interface designed to accommodate the specific needs of deaf drivers. By integrating these functionalities, the proposed system offers a comprehensive and innovative solution to enhance the safety and communication capabilities of deaf drivers during emergencies. This research represents a significant advancement in assistive technology, aiming to provide deaf drivers with a reliable and user-friendly tool that can potentially save lives in critical moments.

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Introduction

Background & Literature survey

The safety and communication abilities of deaf drivers in an emergency are severely limited. More frequently deaf people endure unique emergency conditions due to the inability to communicate with emergency responders effectively. The resulting prolonged lack of assistance, additional exposure to danger, and increased impact duration significantly heightens the intensity levels during the instance. To mitigate this problem, the development of an “Integrated Emergency Support System for Deaf Drivers” is proposed. We aim at delivering a customized communication tool that integrates real-time location tracking of vehicles, predefined emergency messages in text format sent through any wireless device and converting this text into speech for broadcasting. This research work introduces an essential solution that will lead to enhancing deaf drivers’ security.

This research adds to the already available body of knowledge and works in the same direction as some related ICT solutions developed in the last years and designed to support deaf community in emergency situations. For example, for user-Centred context-aware augmented reality for emergency response, on user centered design when developing a mediated communication tool for supporting deaf people, and this proposal continues working on that topic but including real-time and automated communication facilities between operator and emergency services, a requirement for quick and accurate emergency situations, besides other needed issues when attending an accident such as location spoofing tools. The work likewise relies on state-of-the-art speech-to-text (STT) and text-to-speech(TTS) mediators with simple location systems. Similarly, Baleriola et al.implemented PAULEX system combined with design were basic position-providing applications that use speech recognition technology (as Pedius does) to allow people who are unable to write or produce understandable messages to interact by voice with their interlocutors. Also DHAENE presents a video mediation solution that uses operators who listen to spoken languageand mediate between the callers. In all these types of applications, only one operator is involved,and none of the above-mentioned solutions provides a complete context dependence or event adapts its operation according to both end-users.

Historically, deaf people have experienced challenges meeting driver licensing requirements because of the mistaken belief that people who are deaf cannot drive safely without auditory information. Most of these discriminatory barriers have been removed and deaf people can now apply for and receive driver's licenses. However, once licensed, they continue to face significant barriers, especially in emergencies when effective communication is critical. Traditional communication methods such as writing notes or using visual signals are often inadequate in emergency situations where time and clarity are important. The objective of this research is to design a mobile technology application that will help remove this communication barrier by automatically

facilitating the ability of deaf drivers to quickly and effectively communicate critical information with emergency services personnel.

The research domain of this project resides at the convergence among assistive technology, emergency response system and mobile application development. Deaf assistive technologies have tremendously improved general daily communication by introducing technologies such as speech-to-text mobile applications, visual alerting systems and the like. Nevertheless, these assistive technologies are not seamlessly integrated with emergency response systems. A number of studies have indicated the potential of using real-time location tracking and automated communication to improve emergency responses; nonetheless, there is none that customises or caters specifically to the demands of deaf drivers. This research project aims to fill in this gap by developing an integrated system that not only resolves the specific communication barriers encountered by deaf drivers but also increases their safety during emergency condition in general.

This research will help develop new knowledge and engineering recommendations on how best to serve the mobility and safety needs of deaf drivers, and it will provide solutions that could be replicated to provide better access to safety and emergency services for all people regardless of hearing status.

Research Gap

The existing literature on assistive technologies for the deaf community, particularly in the context of emergency communication, highlights significant advancements but also reveals critical gaps that remain unaddressed. The research paper titled **"Design and Usability Evaluation of Communication Board for Deaf People with User-Centered Design Approach"** emphasizes the importance of user-centered design in creating communication tools for the deaf. However, this study primarily focuses on face-to-face communication and does not address the unique challenges deaf drivers face during emergencies, such as the need for real-time location sharing and automated communication with emergency services.

Similarly, the research outlined in **"Design and Development of Mobile Application for Deaf-Mute People"** introduces a mobile application that facilitates communication for the deaf and mute community by translating sign language into text and speech. While this is a significant step forward, the application does not specifically cater to emergency situations, where quick and reliable communication is crucial. Moreover, it lacks a mechanism for automated, bidirectional communication with emergency responders, which is critical in life-threatening scenarios.

1. Existing Solutions and Their Limitations:

- The study by Nafisah et al. (2018) introduced a communication board designed with a user-centered approach to aid deaf people in communication. While it offers a structured method for conveying messages, it is largely static and does not cater to the high-stakes, time-sensitive context of emergency situations faced by drivers. The solution is effective for structured, non-urgent communication but lacks the capability to integrate real-time data like location tracking and automated responses needed during emergencies .
- The mobile application developed by Shaikh et al. (2019) advances communication for deaf-mute individuals by enabling simple text and gesture-based communication. However, this application is focused on day-to-day communication rather than on the specific and critical needs of drivers in emergency situations. It does not provide an automated, bidirectional communication system that can handle emergency alerts and responses simultaneously .

2. The Identified Research Gap:

- There is a distinct gap in the literature and existing technologies for an integrated system that not only allows deaf drivers to initiate emergency communication with predefined messages and real-time location tracking but also provides a platform for receiving and interpreting responses from emergency services. The proposed research seeks to fill this gap by developing a system that includes both outbound and inbound communication capabilities, addressing the unique challenges deaf drivers face during emergencies.

3. Contribution to Existing Knowledge:

- The proposed system will build on the strengths of the aforementioned studies by incorporating their foundational ideas into a more advanced, dynamic framework that serves the specific needs of deaf drivers. This contribution is crucial as it goes beyond static communication tools and introduces a real-time, interactive communication solution that has not been fully explored in current research. By addressing this gap, the research will enhance the safety and communication effectiveness of deaf drivers, potentially influencing future developments in assistive driving technologies.

Feature	Communication Board [1]	Mobile App for Deaf-Mute [2]	Gesture Recognition System [3]	Advanced Emergency Communication [4]	Proposed System
Target Users	Deaf individuals in general	Deaf-mute individuals	Deaf individuals using gestures	Deaf individuals in emergencies	Deaf drivers specifically
Context of Use	Face-to-face communication	General communication	Gesture-based communication	Emergency situations	Emergency situations
Real-Time Location Sharing	Not included	Not included	Not included	Not included	included
Automated Call System	Not included	Not included	Not included	Not included	included
Bidirectional Communication	One-way communication	One-way communication	One-way communication using gestures	Two-way communication, limited to text messaging	Two-way communication (text-to-speech and speech-to-text)
User-Centered Design	Yes	Yes	Yes	Yes	Yes
Emergency Response Integration	Not included	Not included	Not included	Partially integrated with manual input	Fully integrated with emergency services
Accessibility Features	Limited (basic visual aids)	Basic accessibility features	Limited to gesture recognition	Basic accessibility for text communication	Advanced accessibility (real-time alerts, customizable emergency contacts, visual interface)
Effectiveness in Emergency Scenarios	Not applicable	Not applicable	Not applicable	Moderate, with basic text communication capabilities	High, with tailored features for real-time communication in emergencie

Figure 1.Research Gap

Research Problem

1. **communication Barriers During Emergencies:** Deaf drivers face significant challenges when communicating with emergency services during critical situations. Conventional emergency systems rely on verbal communication, which is inaccessible to deaf individuals, leading to delays in receiving necessary assistance. This communication barrier increases the risk of severe consequences during emergencies, as deaf drivers may be unable to convey vital information about their location, the nature of the emergency, or their specific needs.

2. **Lack of Bidirectional Communication:** Existing solutions for deaf drivers primarily focus on enabling them to send emergency messages but do not adequately address the need for receiving real-time responses. Without the ability to understand incoming communication from emergency responders, deaf drivers remain at a disadvantage, unable to receive updates or instructions, which could be crucial in life-threatening situations. This lack of bidirectional communication hampers the effectiveness of existing support systems for deaf drivers.

3. **Integration of Advanced Technologies:** While there are applications that provide basic communication support for deaf individuals, many do not fully leverage the potential of advanced technologies like real-time location tracking, automated call systems, and text-to-speech conversion. The absence of these integrated features limits the overall efficiency and reliability of these systems, preventing them from providing a comprehensive solution that meets all the needs of deaf drivers in emergencies.

Solutions Provided by the Research Component

1. **Integrated Emergency Support System:** The proposed solution is an "Integrated Emergency Support System for Deaf Drivers," a mobile application that addresses the communication barriers during emergencies. This system allows deaf drivers to select predefined emergency messages and automatically send them to relevant parties, such as ambulance services, police stations, and insurance companies. The system uses text-to-speech conversion to ensure that the messages are delivered clearly to emergency responders, thus overcoming the communication challenges faced by deaf drivers.

2. **Bidirectional Communication:** A key feature of the proposed system is its ability to facilitate bidirectional communication. Inspired by the functionalities of the Pedius app, the system enables deaf drivers not only to send messages but also to receive voice responses from emergency services. These responses are converted into text, ensuring that deaf drivers can fully understand and act on the information provided by emergency responders, thereby enhancing their safety during critical moments.

3. **Advanced Technology Integration:** The system integrates advanced technologies such as real-time location tracking using the Google Play Services Location API and automated call systems with speech integration. These features ensure that the driver's location is continuously updated and communicated to emergency services, providing a reliable and efficient means of support during emergencies. The comprehensive integration of these technologies into a single application offers a robust and user-friendly solution specifically designed for deaf drivers.

Objectives

Main Objectives

The main objective centres on creating an innovative mobile application specifically designed to support deaf drivers in emergency situations. This system addresses the critical communication barriers that deaf drivers face, especially during high-stress scenarios where quick and effective communication with emergency services is essential.

The application will feature predefined emergency messages that the driver can quickly select and send, significantly reducing the time and effort needed to communicate during an emergency. These messages will be automatically combined with real-time location data, ensuring that emergency responders receive accurate information about the driver's situation and location.

The system will convert these predefined texts and location information into speech, enabling the automated call system to relay the information directly to emergency services. This ensures that even without direct verbal communication, deaf drivers can effectively alert and interact with first responders, leading to quicker and more efficient assistance.

This objective is crucial as it not only provides a unique solution to the communication challenges faced by deaf drivers but also enhances their safety and confidence on the road. The integration of these technologies into a user-friendly application is aimed at making the roads safer for everyone by ensuring that no driver is left without a way to call for help in an emergency.

Specific Objectives

Design a Predefined Emergency Messages Module

- Create a library of emergency-specific predefined texts.
- Develop an intuitive interface that allows users to quickly select appropriate messages during emergencies.

Implement Real-Time Location Tracking:

- Integrate with the Google Play Services Location API to continuously update and relay the driver’s real-time location to emergency services.

Develop a Communication System with Text-to-Speech Conversion:

- Utilize the Google Text-to-Speech API to convert predefined emergency messages and location data into spoken language during automated calls.

Create an Automated Call System

- Automatically initiate calls to selected emergency contacts and play the converted speech message, ensuring that responders receive accurate and timely information.

Enhance User Interface Design

- Build an accessible and user-friendly interface tailored to the needs of deaf drivers, including the ability to manage emergency contact lists.

Methodology

Overall system description

System Overview and Diagram Explanation

The proposed system for the "Integrated Emergency Support System for Deaf Drivers" is designed to provide a seamless communication experience during emergencies. The system is divided into several key components that work together to ensure that deaf drivers can effectively communicate with emergency services.

Components

1. Predefined Emergency Messages Module

- Description - This module contains a library of predefined emergency messages such as "Deaf driver in an accident, please help." The user can select the most appropriate message depending on the situation.
- Purpose - To allow for quick and clear communication of the emergency situation.

2. Real-Time Location Tracking

- Description - Utilizes the Google Play Services Location API to continuously track the driver's location and update it in real-time.
- Purpose - To provide accurate location information to emergency responders.

3. Text-to-Speech Conversion

- Description - Converts the selected predefined text message and location information into speech using a text-to-speech engine.
- Purpose - To communicate the emergency and location vocally to the emergency responders.

4. Automated Call System

- Description - Automatically initiates a call to the selected emergency service (e.g., ambulance, police) and plays the generated speech message during the call.
- Purpose - To automate the communication process, ensuring that the deaf driver’s message is conveyed clearly.

5. Bidirectional Communication System

- Description - Enables the system to receive responses from emergency services and convert them from speech to text, providing the driver with understandable feedback.
- Purpose - To facilitate two-way communication, allowing the driver to receive critical information and instructions from responders.

6. User Interface and Usability

- Description - A user-friendly interface that allows easy navigation and quick access to emergency features, designed specifically with the needs of deaf drivers in mind.
- Purpose - To ensure that the system is intuitive and accessible to the target users.

System Workflow

1. The user selects an emergency message from the Predefined Emergency Messages Module.
2. The system tracks the user's real-time location.
3. The selected message and location data are converted to speech.
4. The Automated Call System initiates a call to the selected emergency service and delivers the speech message.
5. If the emergency service responds, the Bidirectional Communication System converts the response into text, which is displayed to the driver via the User Interface.

System Overview

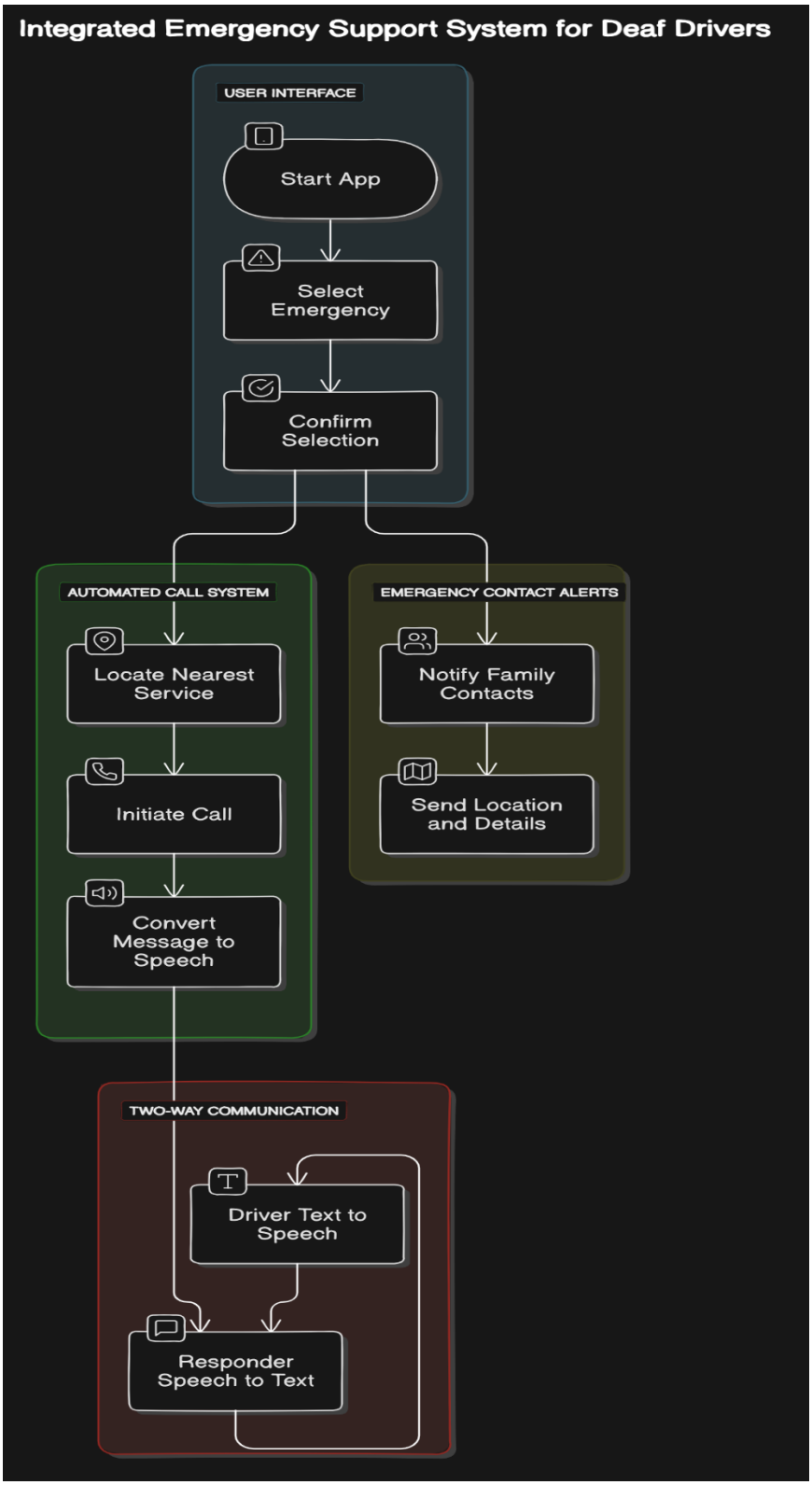


Figure 2. System Diagram

Project requirements

Functional Requirements

Predefined Emergency Messages:

- **Message Library:** The system should include a comprehensive library of predefined emergency messages tailored to common scenarios faced by deaf drivers.
- **Message Selection Interface:** Users should be able to easily select and send an appropriate emergency message from the library during a crisis.
- **Text-to-Speech Conversion:** The selected message should be converted to speech during an automated call to emergency services.

Real-Time Location Tracking:

- **Google Play Services Location API Integration:** The app should continuously track the user's real-time location.
- **Location Data Update:** The current location should be automatically included in the emergency messages sent to responders.

Automated Call System:

- **Call Initiation:** The app should automatically place a call to the relevant emergency service once an emergency message is selected.
- **Speech Integration:** The app should play the converted speech message to the responder during the call.
- **Bidirectional Communication:** The system should allow for incoming voice responses to be converted to text and displayed to the deaf driver.

User Interface Design:

- **Emergency Contact List:** Users should be able to create and customize a list of emergency contacts, including ambulance services, police, and insurance companies.
- **User-Friendly Interface:** The app should provide an intuitive, accessible interface that meets the needs of deaf drivers.

Non-Functional Requirements

Performance:

- **Real-Time Response:** The app should process and transmit emergency messages and location data with minimal delay.
- **Scalability:** The system should be capable of handling multiple users simultaneously without performance degradation.

Reliability:

- **System Uptime:** The application should maintain high availability, particularly in emergencies.
- **Error Handling:** The system should include robust error handling to manage failures in location tracking, text-to-speech conversion, or automated calls.

Security:

- **Data Encryption:** All personal and location data should be encrypted during transmission to prevent unauthorized access.
- **User Authentication:** The app should include secure user authentication mechanisms to prevent unauthorized use.

Usability:

- **Accessibility:** The interface should be designed with accessibility features to accommodate users with varying levels of technical skill.
- **Ease of Use:** The system should require minimal user input, particularly in high-stress emergency situations.

Compatibility:

- **Cross-Device Compatibility:** The app should be compatible with a wide range of Android devices and operating system versions.
- **API Integration:** The system should seamlessly integrate with external APIs like Google Play Services for location tracking and Google Text-to-Speech.

Expected test cases

Predefined Emergency Messages Module

- **Test Case 1:** Verify that the user can access the library of predefined emergency messages.
- **Test Case 2:** Ensure that the user can select an appropriate predefined message.
- **Test Case 3:** Confirm that the predefined messages can be edited or customized if needed.

2. Real-Time Location Tracking

- **Test Case 4:** Verify that the application accurately tracks the user's current location in real-time.
- **Test Case 5:** Test the integration of the Google Play Services Location API to ensure it updates location data continuously.
- **Test Case 6:** Check if the location data is accurately included in the emergency message sent to responders.

3. Text-to-Speech Conversion

- **Test Case 7:** Test the functionality of the Google Text-to-Speech library to ensure it converts the selected message and location data into speech.
- **Test Case 8:** Ensure the speech generated is clear and understandable to emergency responders.
- **Test Case 9:** Verify that the text-to-speech function works in various noise levels and environmental conditions.

4. Automated Call System

- **Test Case 10:** Verify that the system automatically initiates a call to the selected emergency service when an emergency message is chosen.
- **Test Case 11:** Test if the system correctly concatenates the message and location data before converting it to speech during the call.
- **Test Case 12:** Ensure that the call system works reliably without dropping calls or delays.

5. Bidirectional Communication

- **Test Case 13:** Ensure that incoming voice calls from emergency services are accurately converted to text.
- **Test Case 14:** Test the readability and accuracy of the converted text to ensure the deaf driver can understand the response.

6. Emergency Contact List

- **Test Case 15:** Verify that users can add, edit, and delete contacts in the emergency contact list.
- **Test Case 16:** Test if the system can correctly initiate communication with any contact from the list during an emergency.

WORK BREAKDOWN STRUCTURE

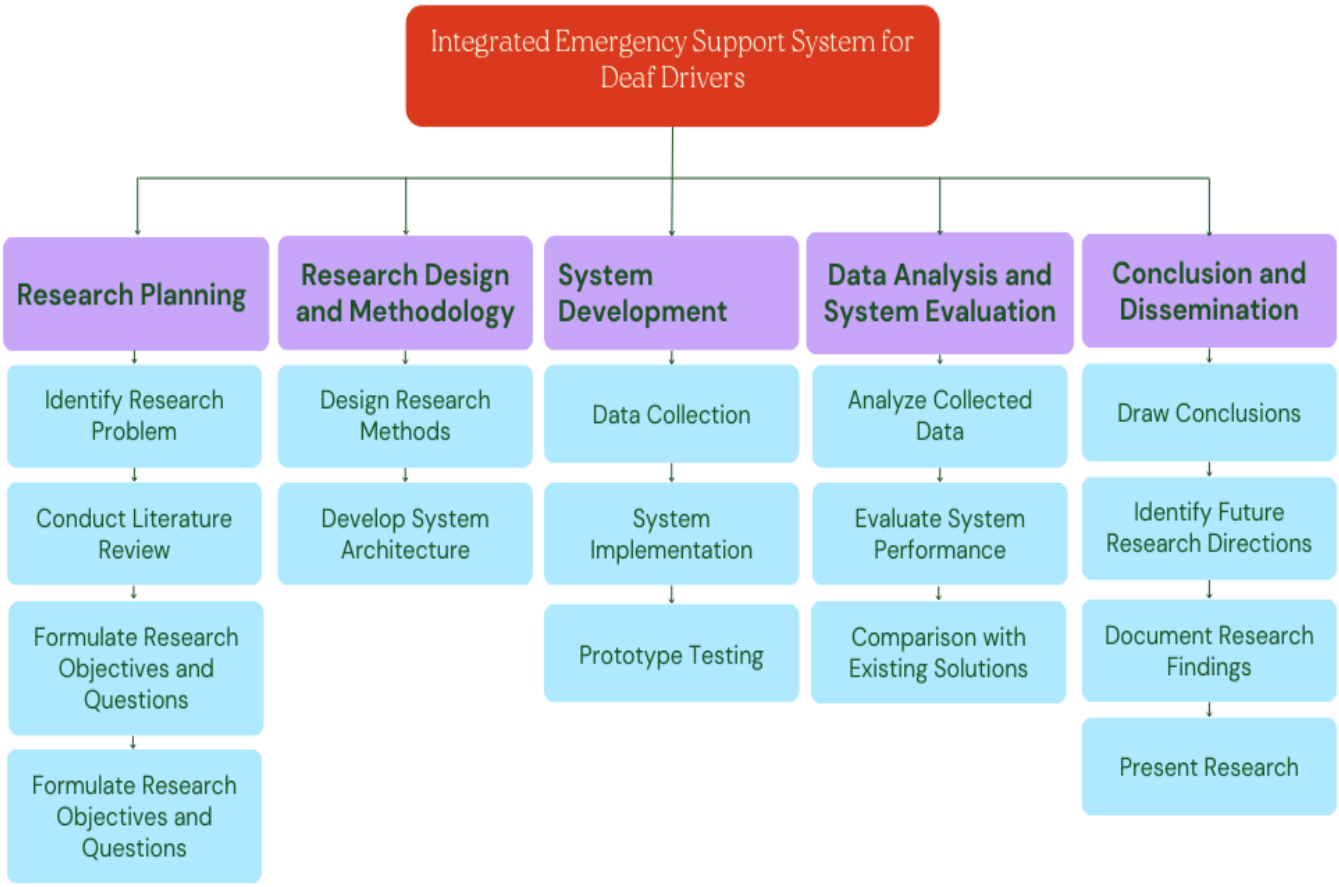
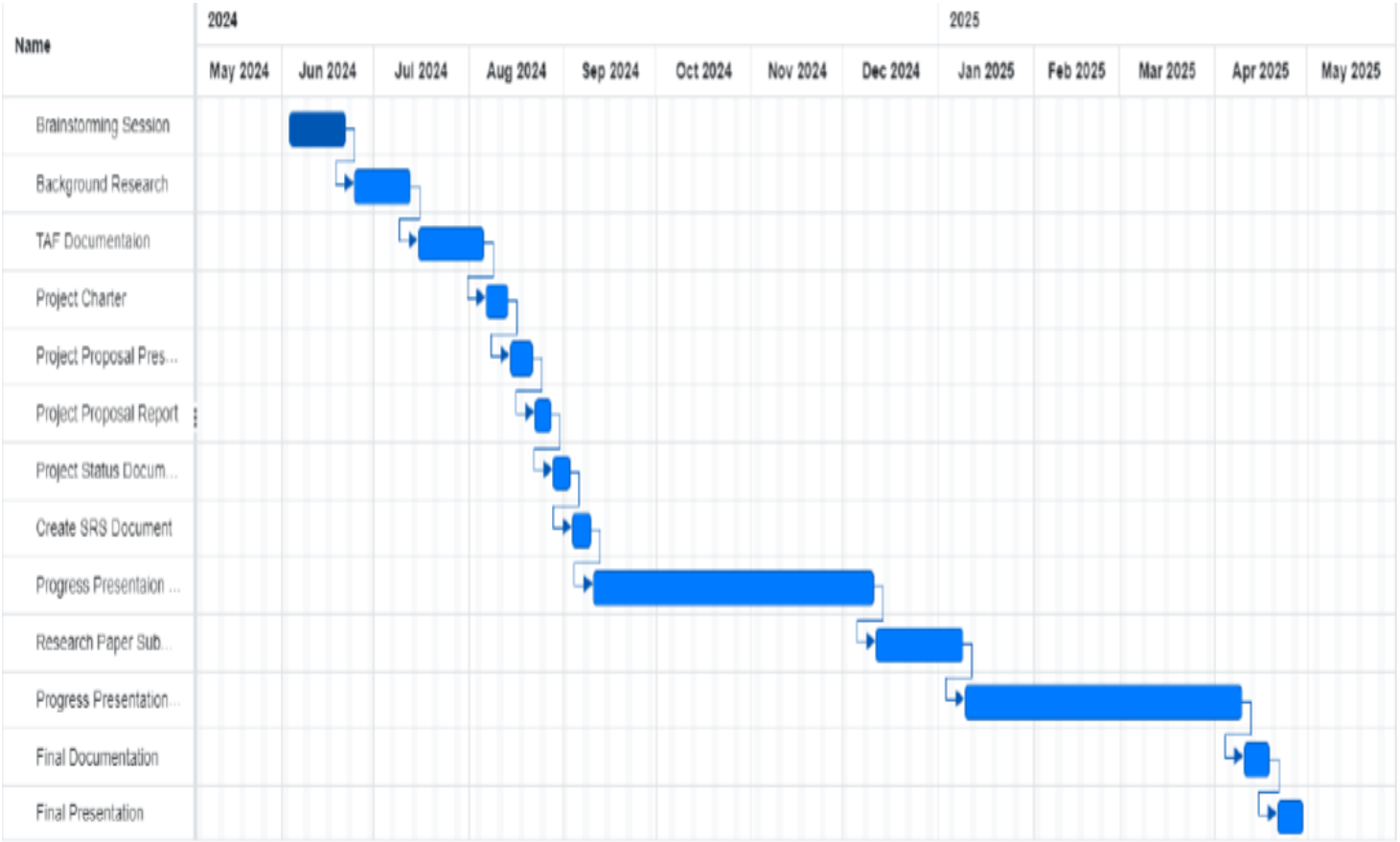


Figure 3. BreakDown Structure

Gantt Chart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Mar 2025
Apr 2025
May 2025
Brainstorming Session
Background Research
TAF Documentaion
Project Charter
Project Proposal Pres...
Project Proposal Report
Project Status Docum...
Create SRS Document
Progress Presentaion ...
Research Paper Sub...
Progress Presentation...
Final Documentation
Final Presentation

Conclusion

The development of an "Integrated Emergency Support System for Deaf Drivers" addresses a significant gap in the current landscape of assistive technologies for deaf individuals. By integrating advanced features such as automated emergency communication, real-time location tracking, and bidirectional communication capabilities, this research proposes a solution that significantly enhances the safety and independence of deaf drivers. Unlike existing solutions, which primarily focus on static or basic communication methods, this system offers a comprehensive approach tailored to the unique challenges faced by deaf drivers during emergencies. The proposed system not only initiates communication with emergency services but also allows for receiving and interpreting responses, ensuring a more reliable and effective support mechanism. The contribution of this research lies in its ability to combine multiple advanced technologies into a single, cohesive system that caters specifically to the needs of deaf drivers. This approach fills a crucial void in existing research, providing a more robust and dynamic solution to a critical problem. As such, the implementation of this system has the potential to significantly improve the quality of life for deaf drivers, offering them a reliable means of communication during emergencies and thereby enhancing their overall safety on the road.

In conclusion, this research offers a novel and essential advancement in the field of assistive technologies, addressing an underserved need within the deaf community. The proposed system represents a meaningful step forward in ensuring that deaf drivers have access to the tools and support they need to navigate emergencies effectively, thereby contributing to broader efforts to enhance inclusivity and safety in driving environments.

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