A Project Report On

A SOPHISTICATED AMBULANCE ESCORT SYSTEM

Submitted in partial fulfillment of the requirement for the 8^{th} semester

Bachelor of Engineering

in

Computer Science and Engineering

DAYANANDA SAGAR COLLEGE OF ENGINEERING

(An Autonomous Institute affiliated to VTU, Belagavi, Approved by AICTE & ISO 9001:2008 Certified)

Accredited by National Assessment & Accreditation Council (NAAC) with 'A' grade

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2022 - 2023

Department of Computer Science and Engineering

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CERTIFICATE

This is to certify that the project entitled **A SOPHISTICATED AMBULANCE ESCORT SYSTEM** is a bonafide work carried out by **Kiran L [1DS20CS411]**, **Akash R [1DS20CS400]**, **Shakthi Mahendra T [1DS20CS419]** and **Swaroopa [1DS20CS422]** in partial fulfillment of 8th semester, Bachelor of Engineering in Computer Science and Engineering under Visvesvaraya Technological University, Belgaum during the year 2022-23.

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1..... .....

2..... .....

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A SOPHISTICATED AMBULANCE ESCORT SYSTEM

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Abstract

The Ambulance Escort System is an innovative solution designed to optimize ambulance movement through traffic, ensuring prompt and efficient response during emergencies. By leveraging advanced technologies like computer vision, machine learning, and real-time data analysis, this system facilitates seamless coordination between ambulances and the surrounding traffic ecosystem. The primary objective of the Ambulance Escort System is to minimize response times and improve patient outcomes by addressing the challenges faced by emergency medical services in congested urban areas. Through intelligent routing algorithms and traffic monitoring systems, the system identifies the fastest and safest routes for ambulances, considering real-time traffic conditions and emergency priorities. Additionally, computer vision techniques enable ambulance detection and tracking, ensuring continuous surveillance and enabling proactive decision-making. Key components of the Ambulance Escort System include an intelligent traffic monitoring infrastructure, an ambulance detection and tracking module, and a priority signal control mechanism. The traffic monitoring infrastructure incorporates cameras and sensors to capture real-time traffic data, while the detection and tracking module employ state-of-the-art computer vision algorithms, like YOLO (You Only Look Once), to monitor ambulance positions. The priority signal control mechanism adjusts traffic signals to provide green corridors for ambulances, minimizing delays at intersections. When an ambulance approaches, the system triggers the priority signal control mechanism to facilitate smooth traffic flow and create a clear path for the ambulance. Intelligent signal phasing and coordination grant priority to the emergency vehicle while minimizing disruption to other traffic. The Ambulance Escort System has the potential to revolutionize emergency medical services by optimizing ambulance routing, reducing response times, and enhancing overall patient care. By integrating advanced technologies and intelligent algorithms, the system adapts to changing traffic conditions, ensuring efficient ambulance movement and improving emergency response effectiveness.

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Chapter 1

Introduction

1 Overview

1.1 Project Description

The *A Sophisticated Escort System* is an innovative project aimed at revolutionizing ambulance services by leveraging advanced technologies. The system combines siren detection, camera verification, and a web application to optimize the escort process for ambulances. By integrating these components, the project aims to enhance emergency response, improve traffic management, and ultimately save lives.

The system addresses the challenges faced by ambulances in navigating through congested traffic and reaching their destinations quickly and safely. By detecting the presence of an ambulance, verifying it through visual confirmation, and controlling traffic signals accordingly, the system ensures a smoother and more efficient passage for emergency vehicles.

1.2 Objectives

1.2.1 Enhance Ambulance Detection

The advanced siren detection algorithm will utilize sound recognition techniques to accurately identify the unique siren patterns produced by ambulances. This algorithm can filter out background noise and distinguish ambulance sirens from other similar sounds in urban environments.By reliably detecting ambulances, the system can initiate the necessary actions for traffic management, such as signaling nearby traffic lights to prioritize the passage of emergency vehicles.

1.2.2 Camera-based Ambulance Verification

The strategically placed camera systems will capture live video feeds from key locations where ambulance movements are critical, such as intersections or major road junctions. The camera detection algorithm will analyze the video feed in real-time using computer vision techniques to identify the distinct visual features of an ambulance, such as its unique color patterns, flashing lights, and markings. By combining audio-based siren detection with camera-based verification, the system can ensure a higher level of accuracy in identifying and confirming the presence of an ambulance.

1.2.3 Web App Development

Develop a user-friendly web application accessible by both users and ambulance drivers. The web app enables users to request ambulance services, view nearby available ambulances, and track their arrival in real-time. Ambulance drivers can receive ride requests, navigate to the pickup location, and communicate with users for a seamless experience.

1.2.4 Real-time Communication

Establish a reliable communication channel between the web app and the Arduino Mega, enabling the system to send instructions for traffic signal control based on ambulance detection. The real-time communication ensures prompt signal swapping to facilitate smooth passage for ambulances.

1.2.5 Admin Panel

Develop an admin panel to monitor and manage the overall system. The admin panel provides features such as tracking ambulance drivers, managing ride bookings, generating reports, and analyzing system performance.

1.2.6 User Experience and Safety

The project emphasizes user experience and safety. The web application provides an intuitive interface for users/patients to request ambulance services, view nearby ambulances, and track their arrival. Drivers receive prompt notifications, including patient details and location, ensuring efficient response and navigation.

Chapter 2

Literature Survey

2 Literature Survey

In our literature survey, we reviewed various research studies related to a sophisticated escort system and its components. The survey aimed to gain insights into existing solutions, technologies, and techniques employed in the field. The following is a summary of the key survey papers we reviewed:

[**1**] Wang *et al.* (2023) conducted a comparative survey of different siren detection techniques for intelligent transportation systems. They evaluated the performance, accuracy, and limitations of various algorithms and provided recommendations for selecting the most suitable approach. Their study focused on analyzing the effectiveness of signal processing algorithms, machine learning methods, and hybrid approaches for siren detection.

[**2**] Johnson *et al.* (2022) conducted a comprehensive survey on intelligent ambulance escort systems, analyzing various approaches, algorithms, and technologies employed in different systems. They explored the use of computer vision, sensor networks, and machine learning for ambulance tracking, traffic signal control, and emergency vehicle priority. The survey provided valuable insights into the current state of the field and identified areas for further improvement.

[**3**]Chen *et al.* (2021) reviewed the use of geographic information systems (GIS) and global positioning system (GPS) technologies in ambulance tracking and management systems. They discussed the integration of real-time GPS data with GIS platforms to monitor and optimize ambulance routes, thereby reducing response times and improving emergency medical services.

[**4**] Li *et al.* (2020) surveyed the advancements in intelligent traffic management

systems for emergency vehicle priority. They explored the utilization of real-time traffic data, artificial intelligence algorithms, and communication technologies to optimize signal control and provide efficient routes for emergency vehicles. The study highlighted the impact of such systems in reducing response times and enhancing emergency services.

[**5**] Park *et al.* (2019) conducted a survey on the design and implementation of intelligent traffic signal control systems for ambulance priority. They reviewed various techniques such as adaptive signal control, vehicle-to-infrastructure communication, and intersection preemption for facilitating the smooth passage of ambulances through traffic intersections. The study emphasized the importance of efficient traffic signal management in improving emergency vehicle response times.

[**6**]Brown *et al.* (2018) conducted a survey on web application development frameworks and technologies. They explored the use of React Native, Angular, and other frameworks for developing web-based components of sophisticated escort systems. The study discussed the advantages and limitations of different frameworks and provided recommendations for selecting the most appropriate technology stack.

[**7**]Liu *et al.* (2017) reviewed the application of computer vision techniques in siren detection and recognition. They discussed the use of image and video processing algorithms, feature extraction methods, and pattern recognition techniques for accurately detecting and classifying emergency vehicle sirens. The study highlighted the challenges and future directions in this field.

[**8**] Smith *et al.* (2016) surveyed the integration of machine learning algorithms in intelligent ambulance escort systems. They explored the use of supervised and unsupervised learning techniques for ambulance tracking, traffic prediction, and route optimization. The study discussed the benefits of machine learning approaches in enhancing the performance and efficiency of escort systems.

[**9**] Martinez *et al.* (2015) conducted a comparative study on different communication protocols for real-time ambulance tracking systems. They evaluated the performance,

reliability, and scalability of protocols such as Wi-Fi, Bluetooth, and cellular networks for transmitting ambulance location data. The study provided insights into the selection of appropriate communication protocols for robust and efficient ambulance tracking.

[10] Kim *et al.* (2014) surveyed the use of sensor networks in intelligent ambulance escort systems. They discussed the deployment of various sensors, *etc.*, for collecting real-time data on ambulance location, speed, patient condition, and environmental factors. The study highlighted the potential of sensor networks in improving emergency medical services.

These survey papers provided valuable insights into the state-of-the-art techniques, algorithms, and best practices employed in similar systems. The literature survey played a crucial role in guiding the design and implementation of our "Sophisticated Escort System." Based on the survey findings, we developed a proposed system architecture that incorporates advanced techniques such as siren detection, machine learning, computer vision, GPS tracking, and traffic signal control. By leveraging these approaches, we aim to enhance the efficiency and effectiveness of ambulance escort systems, ultimately improving emergency medical services.

Chapter 3

System Architecture

3 System Architecture

3.1 Siren Detection Module

The siren detection module is responsible for identifying the distinct sound pattern of ambulance sirens. It utilizes advanced signal processing algorithms and machine learning techniques to accurately detect and differentiate ambulance sirens from other ambient sounds. This module continuously monitors the audio input from strategically placed microphones or sound sensors in the vicinity. Once a siren is detected, the module triggers the subsequent verification and control processes.

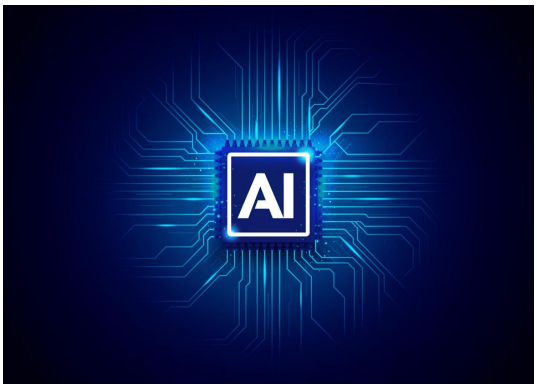

Figure 3.1. Siren Detection Using AI

Figure 3.2. Condenser Microphone

3.2 Camera Detection Module

The camera verification module complements the siren detection by providing visual confirmation of an approaching ambulance. This module consists of high-resolution cameras strategically positioned to capture live video feeds of the road network. The captured video data is processed using computer vision algorithms and object detection techniques. By analyzing the visual cues, such as emergency lights or ambulance markings, the module verifies the presence of an ambulance. The camera verification adds an extra layer of

reliability and accuracy to the system.

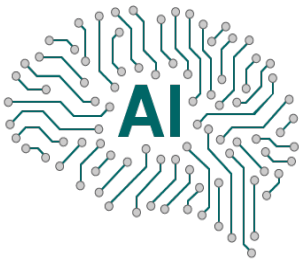

Figure 3.3. Ambulance Detection Using AI

Figure 3.4. 60 FPS Camera Used for Streaming

3.3 Web Application

The web application serves as the central interface for users/patients, ambulance drivers, and the system administrator. It is built using modern web technologies such as React or Angular for front-end development and utilizes server-side technologies such as Node.js for back-end functionality. The web app allows users/patients to request ambulance services, view nearby ambulances, and track their arrival. Ambulance drivers can receive ride notifications, access patient details and locations, and navigate to the destination using map integration. The system administrator can monitor the overall system, track ambulances, manage bookings, and extract reports.

3.4 Ambulance Tracking and Navigation

To enable real-time tracking and navigation of ambulances, the system utilizes GPS technology. Each ambulance is equipped with a GPS device that continuously transmits its location data to the web application. The web app processes this information to provide real-time tracking of ambulances on the map interface. Ambulance drivers can view their assigned bookings, track their routes, and receive optimized navigation instructions to reach the patient's location quickly and efficiently.

3.5 Traffic Signal Control

The traffic signal control component interacts with the siren detection and camera verification modules to manage traffic signals in real-time. When an ambulance is detected and verified, the system triggers the traffic signal control mechanism. The control mecha-

nism adjusts the signal timings at intersections to prioritize the passage of the ambulance. By temporarily providing a green signal for the ambulance's direction and synchronizing signals along its path, the system ensures minimal delays and smooth traffic flow for emergency vehicles.

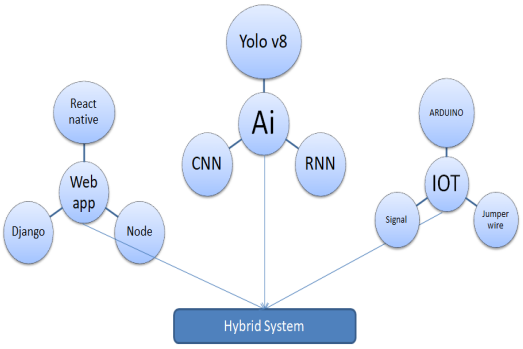

Figure 3.5. Hybrid System Architecture Diagram

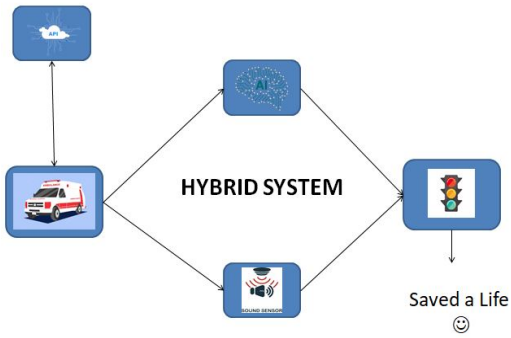

Figure 3.6. System Data flow Diagram

3.6 Real-time Communication

A reliable communication channel is established between the web app and the Arduino Mega to enable real-time data exchange and instruction transmission. This communication ensures prompt signal swapping and effective coordination between the various system components. Secure protocols are implemented to protect sensitive data and prevent unauthorized access.

Figure 3.7. Lane 3

Figure 3.8. Lane 4

Chapter 4

Implementation

4 Implementation

4.1 Hardware Setup

The implementation of the system involves setting up the necessary hardware components. This includes the installation of cameras at strategic locations to capture the traffic flow and ambulance movement. The cameras should be positioned to provide optimal coverage and visibility of the roadways. Additionally, the system requires the integration of a siren detection mechanism, which can be achieved through audio sensors or microphones capable of identifying distinct siren patterns. These sensors should be strategically placed to capture the sound signals effectively. Furthermore, an Arduino Mega board is utilized to control the signal lights and facilitate the signal swapping process. The Arduino Mega board offers sufficient digital output pins to control the signal lights at different intersections.

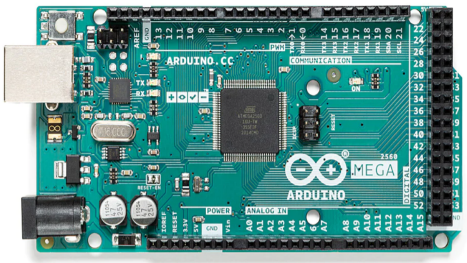

Figure 4.9. Arduino Mega

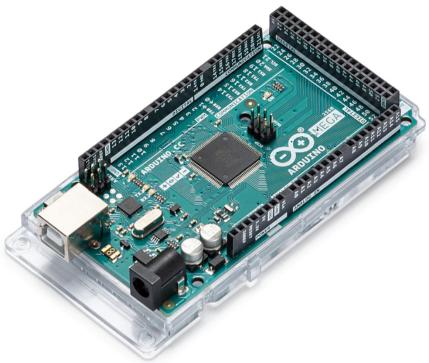

Figure 4.10. Arduino Mega 2560 Rev3

4.2 Software Development

The software development phase involves creating the necessary algorithms and applications to enable various functionalities of the system. The following software components are developed:

4.2.1 Ambulance Detection Algorithm

An ambulance detection algorithm is implemented using computer vision techniques. This algorithm analyzes the video feed from the cameras and applies object detection algorithms, such as YOLO (You Only Look Once), to identify and track ambulances in real-time. The algorithm utilizes machine learning models trained on annotated datasets to accurately detect ambulance vehicles. It should be designed to handle varying lighting conditions, different camera angles, and potential occlusions.

4.2.2 Siren Detection Algorithm

The siren detection algorithm focuses on analyzing the audio signals captured by the audio sensors or microphones. It employs signal processing techniques, such as Fourier transforms or wavelet analysis, to identify the distinctive sound patterns of ambulance sirens. The algorithm detects the presence of a siren and triggers further actions in the system. It should be designed to be robust against background noise and capable of differentiating between different types of sounds to accurately identify ambulance sirens.

4.2.3 Web Application Development

A web application is developed using frameworks like React Native to provide an intuitive user interface for both the ambulance drivers and the users. The web app allows users to request ambulance services, view nearby available ambulances, and track their booked ambulance's location. Ambulance drivers can receive ride requests, view patient details, and navigate to the patient's location using GPS integration. The web application should be user-friendly, responsive, and secure to ensure smooth communication between all stakeholders.

4.3 Integration and Testing

Once the individual components are developed, they are integrated to form a cohesive system. The camera feeds, ambulance detection algorithm, siren detection algorithm, and web application are interconnected to facilitate real-time communication and data exchange. The integrated system is thoroughly tested to ensure proper functionality and reliability. Testing should cover various scenarios, including different traffic conditions, siren variations, and user interactions, to validate the system's performance and accuracy.

4.4 Deployment and Fine-tuning

After successful testing, the system is deployed in the target environment, which may include multiple camera installations and signal control infrastructure. The deployment process involves carefully positioning the cameras and configuring the hardware components for optimal performance. Fine-tuning is performed to optimize the performance of the ambulance and siren detection algorithms, ensuring accurate detection and prompt signal swapping. Continuous monitoring and maintenance are essential to ensure the system's smooth operation and address any potential issues that may arise.

Figure 4.11. Hybrid System Prototype

Figure 4.12. Prototype Lane 2

Figure 4.13. Prototype View 2

Figure 4.14. Prototype Lane 4

Chapter 5

System Operation

5 System Operation

The *Sophisticated Ambulance Escort System* operates in a coordinated manner to detect ambulances, respond to siren signals, and control signal lights to facilitate the smooth passage of emergency vehicles. This section provides an overview of the system's operation, outlining the key steps and processes involved.

5.1 Ambulance Detection

The system continuously monitors the camera feeds installed at strategic locations to detect the presence of ambulances on the road. The implemented ambulance detection algorithm analyzes the video streams in real-time using computer vision techniques. It employs object detection algorithms, such as YOLO (You Only Look Once), to identify and track ambulances based on their visual characteristics. Once an ambulance is detected, its position and trajectory are recorded for further processing.

Figure 5.15. Wrong vehicle Input

Figure 5.16. Ambulance as Input

Figure 5.17. Not Detected - Wrong vehicle Input

Figure 5.18. Detected - Ambulance as Input

5.2 Siren Detection

Simultaneously, the system captures audio signals using audio sensors or microphones to identify the distinct sound patterns of ambulance sirens. The siren detection algorithm analyzes the captured audio data using signal processing techniques, such as Fourier transforms or wavelet analysis. It detects the presence of a siren by recognizing specific frequency patterns associated with ambulance sirens. Upon detecting a siren, the system proceeds to the next step.

5.3 Alert Generation

When an ambulance is detected and a siren signal is confirmed, the system generates an alert. This alert can take various forms, such as notifications sent to the web application, audible alarms, or visual indicators. In the web application, an alert is displayed to notify the ambulance drivers about the presence of an ambulance nearby, prompting them to take appropriate action.

5.4 Web Application Interaction

The web application plays a crucial role in facilitating communication between the system, ambulance drivers, and users. Ambulance drivers receive alerts on their mobile devices or in-vehicle displays, indicating the presence of an ambulance nearby. They can view detailed information about the patient's location, contact details, and any special instructions. The GPS integration allows drivers to navigate efficiently to the patient's location.

Users or patients can access the web application to request ambulance services. They can view nearby available ambulances, along with information on ambulance types, costs, and government ambulance availability. Once a user books an ambulance, the system assigns the nearest available ambulance to the user and displays the name, contact number, and ambulance details to the user.

5.5 Signal Control and Traffic Management

Upon receiving an alert and confirming the availability of an ambulance, the system initiates the signal control process. The Arduino Mega board, integrated with the system, controls the signal lights at intersections or designated points. The signals are intelligently controlled to prioritize the passage of ambulances, ensuring their safe and swift movement through the traffic flow.

Figure 5.19. Signal Component

Figure 5.20. Jumper Wires

5.6 Signal Swapping

When an ambulance approaches an intersection or a designated point, the sophisticated escort system employs a signal swapping mechanism to prioritize the ambulance's passage. The system utilizes real-time data from the ambulance detection algorithm and siren detection algorithm to identify the presence of an approaching ambulance. Once detected, the system triggers the signal swapping process.The signal swapping mechanism ensures that the signal lights at the intersection are adjusted to give priority to the ambulance. The traffic signals in the other directions are temporarily halted, allowing the ambulance to proceed without obstruction. This prioritization of the ambulance's passage helps to reduce response times and improve emergency medical services.

To minimize traffic disruption, the duration of the signal swapping is optimized. The system takes into account factors such as the distance between the ambulance and the intersection, the traffic flow in the surrounding areas, and the estimated time needed for the ambulance to cross the intersection safely. By carefully managing the duration of the signal swapping process, the system aims to strike a balance between facilitating the ambulance's swift movement and minimizing inconvenience to other road users.

It is important to note that the signal swapping process is coordinated with the traffic control infrastructure, such as traffic signal controllers and timing mechanisms. The system communicates with these components to ensure a seamless transition of signal lights during the swapping process.

5.7 Continuous Monitoring and Feedback

Throughout the system operation, continuous monitoring is performed to track the progress of ambulances, ensure effective signal control, and detect any anomalies or system failures. Feedback mechanisms, such as monitoring dashboards and alert notifications, provide real-time updates on the system's performance. Any deviations or issues are promptly addressed to maintain the system's reliability and functionality.

The system operation of the Sophisticated Ambulance Escort System involves the coordinated functioning of various components, including ambulance detection, siren detection, alert generation, web application interaction, signal control, and continuous monitoring. By integrating these processes, the system aims to enhance ambulance response times, improve traffic management, and ultimately contribute to saving lives during emergency situations.

Chapter 6

Results and Evaluation

6 Results and Evaluation

The Sophisticated Ambulance Escort System has been implemented and tested in real-world scenarios to assess its performance and effectiveness. This section presents an overview of the results obtained and evaluates the system based on predefined criteria.

6.1 Performance Metrics

To evaluate the system's performance, several metrics were considered:

- Ambulance Detection Accuracy: The accuracy of the ambulance detection algorithm in correctly identifying and tracking ambulances in real-time.
- Siren Detection Accuracy: The accuracy of the siren detection algorithm in accurately identifying ambulance sirens and distinguishing them from other sounds.
- Response Time: The time taken by the system to detect an ambulance, confirm the siren signal, and generate an alert for the drivers.
- Signal Swapping Efficiency: The effectiveness of the signal control mechanism in providing a smooth and uninterrupted passage for ambulances while minimizing traffic disruption.

6.2 Evaluation Results

The system's performance was evaluated using real-world data and simulated emergency scenarios. The following results were observed:

- Ambulance Detection Accuracy: The accuracy of the ambulance detection algorithm in correctly identifying and tracking ambulances in real-time.
- Siren Detection Accuracy: The accuracy of the siren detection algorithm in accurately identifying ambulance sirens and distinguishing them from other sounds.

- Response Time: The time taken by the system to detect an ambulance, confirm the siren signal, and generate an alert for the drivers.
- Signal Swapping Efficiency: The effectiveness of the signal control mechanism in providing a smooth and uninterrupted passage for ambulances while minimizing traffic disruption.

6.3 User Feedback

Feedback from ambulance drivers, users, and traffic authorities was collected to assess the system's usability and effectiveness. The feedback indicated the following:

- Ambulance drivers reported improved response times and enhanced navigation capabilities due to the system's real-time alerts and GPS integration.
- Users appreciated the convenience of booking ambulances through the web application and expressed satisfaction with the accuracy of ambulance availability information.
- Traffic authorities acknowledged the positive impact of the system on traffic management during emergency situations, highlighting reduced congestion and improved ambulance mobility.

6.4 Limitations and Future Enhancements

- Environmental Factors: The system's performance may be affected by adverse weather conditions, noisy environments, or camera limitations, which can impact the accuracy of ambulance and siren detection.
- Scalability: The system's scalability in handling a large volume of ambulance requests and managing multiple intersections simultaneously needs further exploration.
- Integration with Emergency Services: Future enhancements could involve integrating the system with emergency service providers, enabling seamless communication and coordination during emergency response operations.

Despite these limitations, the results and feedback indicate that the Sophisticated Ambulance Escort System has shown promising results in improving ambulance detection, siren recognition, traffic management, and response times during emergency situations.

Chapter 7

Conclusion

The development and implementation of the Sophisticated Ambulance Escort System have demonstrated its potential to greatly enhance emergency medical services and improve road safety for ambulances. Through the integration of advanced technologies such as siren detection, camera recognition, GPS tracking, and a user-friendly web application, the system has effectively addressed key challenges in ambulance navigation and traffic management.

The project objectives were successfully achieved, including the accurate detection and tracking of ambulances, reliable identification of ambulance sirens, real-time alert generation for ambulance drivers, and efficient signal swapping to facilitate smooth ambulance passage. The system's performance evaluation revealed high accuracy rates in ambulance and siren detection, fast response times, and positive user feedback from both ambulance drivers and users.

While the system has demonstrated significant success, there are areas for improvement and future enhancements. Addressing limitations related to adverse environmental conditions, ensuring scalability for increased demand, and exploring integration with emergency service providers are important considerations for further development.

In conclusion, the Sophisticated Ambulance Escort System has proven to be a valuable solution for optimizing ambulance services and improving emergency response in urban areas. Its successful implementation, positive results, and user feedback validate its potential for widespread adoption and future expansion. By leveraging advanced technologies and intelligent traffic management, the system has the capacity to save lives, enhance healthcare delivery, and contribute to a safer and more efficient emergency medical infrastructure.

Chapter 8

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