**SmartFlow: Integrated Emergency Vehicle Detection and Traffic Rule Monitoring System**

**Introduction:**

In urban areas, traffic congestion poses challenges like delays and safety concerns. Smart flow systems, integrating cameras and AI, address these issues. Cameras monitor traffic in real-time, detect emergencies like accidents, and prioritize emergency vehicles. This paper explores how these systems improve transportation by enhancing safety, efficiency, and responsiveness.

The traffic management system of a metropolitan city is a keystone for urban mobility. With the rise of the population, the demand for vehicles grows up and hence the requirement of transportation has also increased. Infrastructural development becomes an indispensable part of complementing the population growth to augment urban mobility. But the traditional traffic management system is shown not only ineffective for accompanying the increased number of vehicles with the use of police control and traffic light system but also incompetent enough to handle this growth of traffic on road systems. This traffic congestion consequentially consumes precious working time for being incapable of handling extensive traffic congestion and eventually leads to the environmental pollution for an extended period of vehicle emission. Adequate pre-measures and proper planning can help to reduce the number of traffic problems and manage an increased number of vehicles on the road. Traffic system utilize the concept of automation with IoT is called as “Smart Traffic”. Smart Traffic Management System is an advanced and integrated solution designed to optimize traffic flow, reduce congestion, enhance road safety, and improve overall transportation efficiency within urban or metropolitan areas. This system relies on various sensors placed strategically throughout the road network to monitor traffic conditions.

* This system will monitor the traffic using camera.
* The system can control traffic signals at intersections dynamically based on real-time traffic data.
* Adaptive traffic signal systems adjust signal timings to minimize waiting times and reduce idling.
* Reducing congestion and energy consumption at intersection.
* Ensuring immediate clearance for emergency vehicles. Facilitating safer and shorter commute time.
* The emergency vehicle is detected, which gives ambulances priority to pass through traffic lights.

**Literature survey:**

Manual Traffic Control Management this refers to the traditional method of traffic management where traffic personnel or officers manually regulate the flow of vehicles and pedestrians at intersections or road junctions. While effective, this approach can be labor-intensive and may not always adapt well to changing traffic conditions. Roadside sensors are installed along roads to detect the number of vehicles at specific distances. These sensors continuously monitor traffic levels and provide data on congestion, which can be used to regulate traffic flow and manage congestion more effectively [1][2].

Integration of GPS and GSM for Ambulance Dispatch: This involves integrating GPS technology to track the location of ambulances in real-time and GSM technology to communicate with the ambulance dispatch center and hospitals. This integration ensures that ambulances can be dispatched quickly to emergency situations, and the destination hospital can be notified in advance [5][7]. Utilization of Machine Learning Algorithms for Emergency Detection and Response: Machine learning algorithms are used to analyze data from various sources, such as sensors and cameras, to detect emergencies such as accidents or fires. These algorithms can identify patterns and anomalies in the data to provide early warnings and facilitate prompt response by emergency services [16][17].

Implementation of YOLOv3 for Traffic Violation Detection: YOLOv3 is a state-of-the-art object detection algorithm used to detect traffic violations such as vehicles running red lights, riders without helmets, and drivers without seat belts. By analyzing video footage or images from cameras, YOLOv3 can accurately identify and classify traffic violations in real-time [18].

|  |  |  |  |
| --- | --- | --- | --- |
| **Technology** | **Description** | **Advantages** | **Disadvantages** |
| Manual traffic control management | Manual traffic control management involves the direct intervention of traffic personnel or officers to regulate the flow of vehicles and pedestrians at intersections, road junctions, or other points where traffic congestion or safety concerns arise | 1. Easy to implement 2. Less chances of error due to human involvement | 1. Time Consuming 2. It is possible that accidents happen on the crossings 3. Chances of conflicts are very high   Emergency vehicles have only one human to communicate |
| Infrared Sensor (IR) | Roadside sensors will detect the number of vehicles at a particular distance. Whenever any lane is crowded than other lanes then that busy lane will get more time to pass the vehicle. | 1. By detecting the number of vehicles in each lane, the system can dynamically adjust traffic signal timings to allocate more green time to congested lanes. | 1. Initial setup cost is high 2. An emergency cannot be automated and normally requires human intervention. |
| Ultrasonic sensors | Array of ultrasonic sensors equipped at roadside for monitoring traffic levels. Roadside sensors are detecting vehicles and find the traffic level at that lane. Such levels are low, medium and high which mounted at the particular distance gap. The data sensed continuous and send to controller for detecting traffic levels | 1. provide continuous and accurate data on vehicle presence and traffic levels in real-time, enabling efficient traffic management. 2. Based on the traffic levels detected by the sensors, traffic signal timings can be dynamically adjusted to optimize traffic flow and reduce congestion. | 1. The range of ultrasonic sensors is limited, which may require multiple sensors to cover larger areas, increasing installation and maintenance costs. |
| surveillance cameras, and RFIDs embedded on roadsides | The system works in a distributed manner, it processes sensors’ data at the node level and videos’ data at the local server, calculates cumulative density to regulate the traffic according to density. In addition to this, it also tackles emergency vehicles such as ambulance, fire brigade. it also helps the users to know the congestion status at a road through prediction. | 1. The system can reduce latency in detecting and responding to traffic congestion, improving overall system responsiveness. | 1. Distributed systems can be complex to design, implement, and manage, requiring specialized expertise 2. Building and maintaining a distributed traffic control system can involve significant upfront and ongoing costs |
| RFID Tag | The main objective of system is to make it possible for the ambulance to reach a particular location without having it to stop anywhere until the destination is reached. This paper proposes monitoring of traffic lights and its controlling by the driver of the ambulance. Basic information of the patient is taken along with the status of the patient such as critical or non-critical. This information is further used to send it to the hospital. Depending upon the emergency, the driver sends the direction towards which it wants to travel. | 1. The system ensures that ambulances can reach their destination quickly, reducing response times and potentially saving lives. 2. Prioritizing ambulance passage at intersections reduces the risk of accidents and ensures the safety of both patients and emergency responders. | 1. The effectiveness of the system relies heavily on the reliability of technology components such as sensors, communication networks, and traffic control algorithms |
| SIM28 GPS Module and ESP8266 Node MCU Wi-Fi module | Our project focuses on swift commutation of the ambulance right from the dispatch to the accident zone and to the hospital. There needs to be an effective strategy to reduce the congestion from the dispatch of the ambulance to the hospital. | 1. Swift commutation ensures that ambulances reach accident zones and hospitals faster, improving the chances of saving lives and minimizing patient suffering. | 1. Any interruptions or failures in critical infrastructure, including roads, traffic signals, or communication networks, could impede emergency response efforts and compromise the effectiveness of the project. |
| Image Processing | The code in python which uses KERAS, OpenCV and TensorFlow, scikit-learn modules for image processing that is used for ambulance detection and traffic control. The proposed system also calculates the current speed of the detected ambulance and predicts the time at which the ambulance might reach the signal and accordingly sends the alert to the microprocessor embedded on the signal. | 1. The system enables faster response times for emergency vehicles like ambulances by predicting their arrival times at traffic signals and clearing the path ahead. | 1. Inaccurate predictions may lead to inefficient traffic control or delays in emergency response |
| GPS Module | An ambulance the driver chooses the destination hospital. The link of the live location will be automatically sent to the traffic control room and the hospital. The Google Maps will provide the shortest path from the source to the destination hospital and the traffic control room will clear the traffic on the route. | 1. Utilizing Google Maps for navigation ensures ambulances take the shortest path to the nearest hospital, minimizing response times. 2. Live location sharing enables the traffic control room to adjust traffic signals and clear routes in real-time, facilitating faster ambulance travel. | 1. Reliance on GPS and communication modules introduces the risk of system failures due to technical issues or signal interference. |
| ESP32 and sensors for accident detection | The prototype system integrates an ESP32 microcontroller, leveraging its efficient power usage and built-in Wi-Fi and Bluetooth capabilities. It employs various sensors like IR, ultrasonic, accelerometer, and MQ-3 gas sensor to monitor vehicle operations and driver behavior, promptly detecting accidents and alerting healthcare services. he system utilizes GPS and GSM modules to determine vehicle location and notify healthcare centers, respectively. A user-friendly LCD displays messages. | 1. The system improves road safety by promptly detecting accidents and alerting healthcare services, enabling faster response times. 2. Integration with GPS, GSM, and mobile applications facilitates efficient communication and coordination, ensuring timely assistance. | 1. Sensors detecting factors like sudden speed reduction or vehicle tilting may trigger false alarms, leading to unnecessary alerts and disruptions. 2. Dependency on technology, such as Wi-Fi and GPS connectivity, introduces the risk of system failures due to technical issues or signal disruptions. |
| IR sensor and RFID | The proposed system aims to optimize traffic flow and prioritize ambulance movement to ensure rapid and uninterrupted transport of patients to their destination. Roadside sensors detect vehicle density, allowing busy lanes to receive more green light time for smoother traffic flow. Additionally, the system enables ambulance drivers to control traffic lights, ensuring uninterrupted passage to the destination hospital. | 1. By detecting the number of vehicles in each lane, the system can dynamically adjust traffic signal timings to allocate more green time to congested lanes. 2. The system ensures that ambulances can reach their destination quickly, reducing response times and potentially saving lives. | 1. The effectiveness of the system relies heavily on the reliability of technology components such as sensors, communication networks, and traffic control algorithms. 2. Initial setup cost is high |
| Sound detection | The proposed method involves utilizing roadside units (RSUs) equipped with sound detection technology to detect the siren sound of emergency vehicles (EVs). Each EV emits a unique frequency to communicate with the RSU of a recipient traffic signal controller at a junction. This setup allows for the timely detection of approaching emergency vehicles and facilitates communication with the traffic controller to prioritize their passage. The method builds upon existing siren sound detection techniques to enhance traffic management and improve emergency vehicle response times. | 1. Utilizing unique frequencies emitted by emergency vehicles allows for faster and more accurate detection, enabling traffic signal controllers to prioritize their passage efficiently. | 1. Sound detection technology may occasionally misinterpret non-emergency sounds as siren signals, leading to false alerts and unnecessary prioritization of traffic signals. |
| Bluetooth module | Bluetooth module and a phone whose Bluetooth is active. Once the ambulance is near the signal, the person driving the emergency vehicle can send a command to the Bluetooth module thereby guiding the traffic signal to change accordingly | 1. Using a Bluetooth module allows for wireless communication between the ambulance and the traffic signal controller, providing flexibility in controlling traffic signals without the need for physical connections. | 1. Bluetooth has a limited range, which may restrict the effectiveness of the system to only nearby traffic signals, potentially leaving intersections further away uncontrolled. |
| GPS and android application | The driver will provide the details of the situation once he reaches the accident spot or the fire spot. The details will be recorded to the google cloud service (firebase). The application is developed with the GPS service to track the staffs of the emergency vehicle. The staffs are provided with a username and the password by the service agencies. The repetition of the authentication will result in unsuccessful way of accessing the route map from the cloud service. Once the data has been stored in the cloud storage, it will be analyzed by the machine learning algorithms to decide the level of emergency and the situation. | 1. The integration of GPS service allows for real-time tracking of emergency vehicle staff, enabling better coordination and communication between them and service agencies. 2. Recording and analyzing situation details with machine learning enables accurate emergency assessment, optimizing routes for faster response. | 1. Reliance on various sensors, Wi-Fi modules, and cloud services introduces the risk of technical failures or malfunctions, potentially disrupting emergency response operations. |
| GSM  and GPS module | When an accident occurs, the coordinates of the  location of accident obtained by GPS, are sent via GSM  network to the registered mobile numbers. This paper  provides the work to not only detect an accident but also  to prevent that. | 1. The system's ability to not only detect accidents but also prevent them suggests proactive safety measures, which could potentially reduce the frequency and severity of accidents over time. | 1. The system may occasionally trigger false alarms or inaccurately detect accidents, leading to unnecessary notifications and potential confusion among emergency contacts. |
| Machine learning and Deep learning Algorithm | In addition to monitoring the intensity of the collisions impacts during road accidents, it is also records of the location for taking supportive action by using following technologies and algorithms Face and Eye Detection by Machine Learning (ML) and Deep Learning (DL) Algorithms, FPGA-Based Drowsiness Detection System and Eye Recognition System Based on Wavelet Network Algorithm. The alert message helps in locating the location so that the medical services can be provided on time and this way the precious lives can be saved. | 1. Advanced technologies monitor driver behavior, detect hazards, and issue warnings in real-time, improving road safety. 2. Location recording and alert messages facilitate prompt medical services, potentially saving lives. | 1. Implementing advanced technologies requires significant investment in equipment and expertise. |
| YOLO and openCV | The YOLOv3 algorithm is used to detect the traffic violation. The violations detected are vehicles jumping red signals, vehicle riding without helmets and vehicle drivers without seat belts | 1. YOLOv3 reliably detects traffic violations like jumping red signals, helmetless riders, and drivers without seat belts. 2. Enables prompt intervention by law enforcement as violations occur. | 1. Needs extensive annotated data for training. |

**References:**

1. Sunny Hossain and Farzana Shabnam researched on paper A Comparative Study of IoT Based Smart Traffic Management System published paper in IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering (2021) <https://ieeexplore.ieee.org/document/9829636>
2. Varsha Sahadev Nagmode and Prof.Dr.S.M.Rajbhoj researched on An IoT Platform for Vehicle Traffic Monitoring System and Controlling System Based on Priority published by IEEE in 2017 <https://ieeexplore.ieee.org/document/8463825>
3. Sabeen Javaid, Ali Sufian, Saima Pervaiz and Mehak Tanvee worked on Smart Traffic Management System Using Internet of Things published in International Conference on Advanced Communications Technology (2018)

<https://www.researchgate.net/publication/324464391_Smart_traffic_management_system_using_Internet_of_Things>

1. Dr. Vikram Bali, Ms. Sonali Mathur, Dr. Vishnu Sharma, Dev Gaur researched on Smart Traffic Management System using IoT Enabled Technology, 2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN). <https://ieeexplore.ieee.org/document/9362753>
2. Prof. Deepali Ahir, Saurabh Bharade, Pradnya Botre, Sayali Nagane, Mihir Shah worked on Intelligent Traffic Control System for Smart Ambulance paper released in International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 06 June-2018. <https://www.irjet.net/archives/V5/i6/IRJET-V5I675.pdf>
3. Karthik B,Manoj M,Rohit R Kowshik,Akash Aithal,Dr. S. Kuzhalvai Mozhi worked on Ambulance Detection and Traffic Control System published by International Research Journal of Engineering and Technology (2019) <https://www.irjet.net/archives/V6/i4/IRJET-V6I4239.pdf>
4. S. Mahalakshmi a, T. Ragunthar b, N. Veena a, S. Sumukha a, Pranav R. Deshkulkarni a worked on Adaptive ambulance monitoring system using IOT Published by Elsevier Ltd (2022) <https://www.sciencedirect.com/science/article/pii/S2665917422001891>
5. Mohammad Moazum Wani, Samiya Khan, Mansaf Alam worked on IoT - Based Traffic Management System for Ambulances published by IEEE in 2005 <https://arxiv.org/ftp/arxiv/papers/2005/2005.07596.pdf>
6. Shruti Gatade, Shreeram V Kulkarni, Samanvitha N worked on Automated Vehicle Accident Detection and Healthcare Unit Alerting Using IoT published in IEEE 2nd Mysore Sub Section International Conference (2022)
7. Mohammed Fayaz, Pooja K, Pranitha P Reddy, Swathi T worked onvDensity based Traffic Control System with Ambulance Detection released by International Journal of Engineering Research & Technology (2019) <https://www.ijert.org/research/Density-based-Traffic-Control-System-with-Ambulance-Detection-IJERTCONV7IS08100.pdf>
8. Dalia Nandi,Krishnendu Choudhury worked on Detection and Prioritization of Emergency Vehicles in Intelligent Traffic Management System released by IEEE 2021
9. Varsha Srinivasan, Yazhini Priyadharshini Rajesh, S Yuvaraj and M Manigandan worked on Smart traffic control with ambulance detection released in 2nd International conference on Advances in Mechanical Engineering (ICAME 2018) <https://iopscience.iop.org/article/10.1088/1757-899X/402/1/012015/pdf>
10. Sangmesh S B, Sanjay D H, Meghana S, M N Thippeswamy worked on Advanced Traffic Signal Control System for Emergency Vehicles published by International Journal of Recent Technology and Engineering (2018)

<https://www.ijrte.org/wp-content/uploads/papers/v8i3/C4323098219.pdfC4323098219>

1. Pankaj Chourasia, Sakshi Choubey, Riya Verma worked on Vehicle Accident Detection, Prevention and Tracking System published by International Research Journal of Engineering and Technology (2020) <https://www.irjet.net/archives/V7/i8/IRJET-V7I8445.pdf>
2. Sarfraz Fayaz Khan researched on Health Care Monitoring System in Internet of Things (loT) by Using RFID paper released in 2017 the 6th International Conference on Industrial Technology and Management. <https://ieeexplore.ieee.org/document/7917920>
3. Pedro Maximino, Rui S. Cruz, Miguel L. Pardal worked on Smart Healthcare Monitoring System For Healthy Driving in Public Transportation published paper in 2023 18th Iberian Conference on Information system and Technologies (2023) <https://ieeexplore.ieee.org/document/10211847>
4. Anil Kumar Biswal, Debabrata Singh, Binod Kumar Pattanayak, Debabrata Samanta and Ming-Hourb Yang worked on IoT-Based Smart Alert System for Drowsy Driver Detection ( Received 29 December 2020; Revised 18 January 2021; Accepted 10 February 2021; Published 10 March 2021). <https://www.hindawi.com/journals/wcmc/2021/6627217/>
5. Roopa Ravish, Shanta Rangaswamy, Kausthub Char worked on Intelligent Traffic Violation Detection paper released on 2021 2nd Global Conference for Advancement in Technology (GCAT) Bangalore, India. Oct 1-3, 2021. <https://ieeexplore.ieee.org/document/9587520>