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ITM: AI Powered Traffic Light Control with GPS Based Pre-emption for Emergency Vehicles

Ms. Kadam Shrutika Dilip[1], Ms. Mulla Sana Firoz[2], Mr. Jadhav Kiran Jayram[3], Prof. Yadav Prashant B.[4]

Students, Department of Electronics and Telecommunication [1,2,3]
Assistant Professor, Department of Electronics and Telecommunication[4]
Adarsh Institute of Technology & Research Centre, Vita, India

Abstract: *The vehicle tracking service is provided for real time tracking. We use open-source vehicle detection system. The emergency vehicle continuously sends its latitude, longitude and speed to GPS server. Emergency vehicles such as ambulances, police vehicles and fire engines must reach their destination as quickly as. Traffic congestion is becoming one of the critical problems as the population and number of cars in cities are increasing. Unnecessary delays in the path can ultimately lead to dangerous events. It may cause damage to life or property. One of the most important delays is the time it takes for emergency vehicles to travel between their origin and destination.*

The results suggest that the proposed system provides an optimal solution to the delay times experienced by emergency vehicles on their routes. Our proposed system aims to use live images from cameras at intersections and use image processing and AI to calculate traffic density. It also focuses on algorithms that switch traffic lights based on vehicle density to reduce traffic congestion, allowing people to pass through faster and reducing pollution

Keywords: Traffic light , Pre-emption, GPS, Delay, GSM, Congestion, Microcontrollers, Traffic light system, Traffic control, Traffic management, Intelligent Transport system, Smart Surveillance, Computer Vision, Machine Learning, Object Detections , YOLO

I. INTRODUCTION

In today's fast-paced urban environments, the timely arrival of emergency services can make a crucial difference in saving lives. This project aims to address this challenge by implementing an innovative AI-powered Traffic Light Control system. By integrating GPS-based pre-emption technology, our system can accurately track the real-time location of emergency vehicles. This information is then processed by artificial intelligence algorithms, allowing the system to dynamically adjust traffic light timings in the vehicle's path. The result is a streamlined and efficient traffic flow, providing unobstructed pathways for emergency responders.

The introduction for your AI-powered Traffic Light Control with GPS-Based Pre-emption for Emergency Vehicles project could start by highlighting the critical role emergency vehicles play in saving lives. Emphasize the importance of efficient traffic management to ensure swift passage for these vehicles. Introduce the concept of GPS-based pre-emption as a solution, leveraging artificial intelligence to optimize traffic light control. Highlighting the potential impact on response times and overall emergency services efficiency could engage your audience.

Intelligent Traffic Management (ITM) is revolutionizing traffic control systems. The integration of AI in Traffic Light Control, coupled with GPS-based pre-emption for emergency vehicles, enhances overall efficiency. This system prioritizes emergency vehicles by dynamically adjusting traffic signals based on real-time GPS data, ensuring swift and safe passage during critical situations

II. LITERATURE REVIEW

Mihir M. Gandhi, Devansh S. Solanki, Rutwij S. Daptardar "Smart Control of Traffic Light Using Artificial Intelligence"5 th IEEE International Conference on Recent Advances and Innovations in Engineering- ICRAIE 2020.

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This proposed system rising city population mean more cars, leading to wores traffic jams, stress, fuel use; and pollution especially in megacities. Real time traffic data helps manage this mess efficiently [1].

Abubakr S. Eltayeb, Halla O. Almubarak, Tahani Abdalla Attia "A GPS Based Traffic Light Pre-emption Control System For Emergency Vechicles"Internaltional Conference on Computing, Electric and Electronic Engineering (ICCEEE) 2013. This proposed system the emergency vehicles like ambulances, police car, and fire trucs need to reach their destinations swiftly to ensure timely response to emergencies and save lives. Efficient traffic management systems should prioritize facilitating their movement to help them navigate through traffic effectively [2].

ELMAR, Zadar,"Light Control by Means of Fuzzy Logic"2018 International Symposium pp. 51-56, doi: 10.23919/ELMAR.2018.8534692.In this proposes system an Arduino-UNO based system that aims to reduce traffic congestion and waiting time. This system acquires images through the camera and then processes the image in MATLAB, where the image is converted to a threshold image by removing saturation and hues, and traffic density is calculated. Arduino and MATLAB are connected using USB and simulation packages, which are preinstalled. Depending on traffic count and traffic density, the Arduino sets the duration of green light for each lane. But this method has several flaws[3].

Kwon, Eil, Sangho Kim, and Rober Betts. "Route-based dynamic preemption of traffic signals for Emergency vehicles operations" Transportation Research Record: Journal of the Transportation Research Board 9 (2003). In Paper kwon, Eil, Sangho Kim, and Rober Betts talk about combining an online route Selection module and a sequential dynamic pre-emption strategy, so that traffic queues at the intersection on A given emergency route can be cleared in advance for an emergency vehicle, while minimizing delay due to unnecessary pre-emption. This particular strategy was simulated in real traffic using a microscopic Simulation model, which was calibrated with the emergency vehicle travel time data collected from the Sample network[4].

V. Machacha, E. Laura Riveros "Fast car Crash Detection in Video" IEEE conference in 2018 . In this proposed system the first one is a car detection method using convolutional neural networks, in this case, we used the net YouOnly Look Once (YOLO); the second stage is a tracker in order to focus each car; then the final stage for each car we use the Violent Flow (ViF) descriptor with a Support Vector Machine (SVM) in order to detect the car crashes[5].

Khushi, "Smart Control of Traffic Light System using Image Processing," 2017 International Conference on Current Trends in Computer, Electrical, Electronics and Communication (CTCEEC), Mysore, 2017, pp. 99-103, doi: 10.1109/CTCEEC.2017.8454966, proposes a solution using video processing. The video from the live feed is processed before being sent to the servers where a C++ based algorithm is used to generate the results. Hard code and Dynamic coded methodologies are compared, in which the dynamic algorithm showed an improvement of 35% [6].

Carley, M.l, and I. Christie. (2017). Managing Sustainable Development. Routledge. Castillo, E.,Zacar\'\ias Grande, A. Calviño, W. Y. Szeto, and H.K Lo. (2015). "A State-of-the-Art Review of theSensor Location, Flow Observability, Estimation, and Prediction Problems in Traffic Networks."Journal of Sensors 2015. In this system as a result of the growing population and the hectic nature of urban life, led to a sharp rise in the number of motor vehicles, traffic congestion in emerging as a major problem for the modern era (Carley and Christie, 2017).[7].

Yuvaraj, N., V. B. Prakash, and D. Venkatraj. "Hi-Fi Traffic Clearance Technique for Life Saving Vehicles using Differential GPS System". World Academy of Science, Engineering and Technology, International Journal of Computer, Electrical, Automation, Control and Information Engineering. It may be viewed as a combination of pervasive computing and differential GPS, Fleet management system, wireless transmitter and receiver computerized median i.e linked blocks which are removable [8]

III. PROBLEM DEFINITION

Now days, the traffic light control systems inefficiency and lack of optimization, especially in urban areas. The inefficiency leads to traffic congestion, longer travel time, and difficulties for emergency vehicles to navigate through the city during emergencies. Therefore, the primary problem is related to managing urban traffic flow effectively and ensuring swift emergency response in densely populated areas.

It identify the need for a solution that integrates AI powered traffic light control with GPS based pre-emption for emergency vehicles to address these challenges and improve over all traffic flow and emergency response efficiency.

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IV. OBJECTIVE

- Automatic updating GPS location of emergency vehicles.
- Make Traffic Signal green when emergency vehicle comes near to traffic signal.
- The Primary objectives is to design and implement an AI-powered traffic light control system with GPS-Based Pre-emption for emergency vehicles.
- To detect the vehicles.
- This system aims to optimize traffic signal timings dynamically, using real time GPS data to grant priority to emergency vehicles.
- Develop algorithms that can rapidly analyse incoming GPS data from emergency vehicles and dynamically adjust traffic signal timings accordingly.
- Implement strategies to minimize disruptions to regular traffic patterns while efficiently accommodating emergency vehicle movements.

V. METHODOLOGY

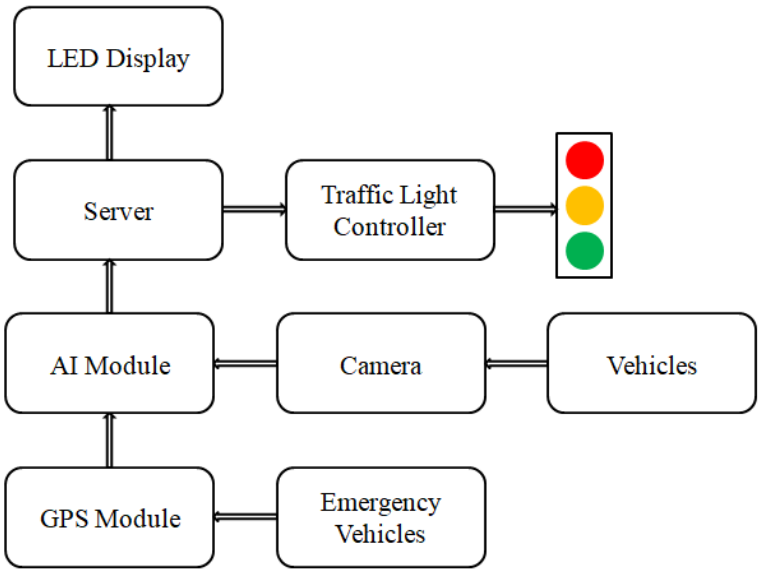

Fig (a). GPS Based Pre-emption for EV with AI Traffic Light Control System

VI. WORKING

1. Data Collection:

- Cameras capture real-time traffic data.
- GPS modules track emergency vehicle locations.
- Vehicle detectors sense the presence of vehicles.

2. Data Processing:

- AI model analyzes incoming data to predict traffic patterns and detect emergency vehicles.
- Determines optimal signal timings and preemptive actions based on current conditions.

3. Signal Control:

- Traffic light controller adjusts signal timings dynamically.
- Grants preemptive green lights to emergency vehicles nearing intersections.

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4. LED Display Activation:

- LED displays indicate regular traffic signals.
- Activate preemptive green lights for emergency vehicles, ensuring safe passage.

5. System Monitoring:

- Continuously monitors traffic conditions and emergency vehicle movements.
- Adapts signal timings and preemptive actions as traffic patterns change.

6. Feedback Loop:

- System learns from real-world data to improve predictions and control strategies over time.
- Enhances overall efficiency and safety of the traffic management system.

By integrating AI-driven analysis with real-time data from GPS, cameras, and vehicle detectors, the system optimizes traffic flow, prioritizes emergency vehicles, and enhances overall road safety and efficiency.

Description:

Server:

The server receives and process data from various sources such as a GPS modules, Camera and Vehicles detector. It stores and manages the data collected from these sources, including real time traffic information, emergency vehicle locations and historical traffic patterns.

Emergency Vehicles (EV):

Equipped with GPS modules for location tracking. Can communicate with the traffic light control system to request preemptive green lights.

LED:

LED display can be installed at intersections to notify drivers and pedestrians when an emergency vehicle is approaching and preemptive measures, such as a green light, are being activated. Indicatestraffic signals to drivers and pedestrians. Alerts about preemptive green lights for emergency vehicles.

Traffic Light Controller:

AI- Powered system responsible for managing traffic signals. Receives input from various sources including GPS data, cameras, and vehicle detectors. Determine optimal signal timings based on real traffic condition and request from emergency vehicles.

GPS Module:

Installed in both emergency vehicles and the traffic light controller. Provide real time location data of emergency vehicles to traffic light controller.

Camera:

Installed at intersections to monitor traffic flow and detect vehicles. Provides input to the traffic light controller for traffic analysis and management.

Vehicles:

Regular vehicles on the road that are detected and tracked by system. Their movement and presence influence the traffic light control decision made by the AI system.

\In the case of emergency; the emergency vehicle (E.V.) driver activates the system of pre-emption when the system allocates the current position of the E.V. using the GPS input data and the driver inputs the location of the destination in the map whether it is a street name, house number, school, station etc. all these are identified to the system by the map as longitude and latitude information.

The approach for designing the system is by dividing it into two major parts:

A. Emergency vehicle side.

B. Traffic light side.

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A. Emergency vehicle side

Initially at the vehicle unit, a communication link to the GPS receiver and read the string sent by the National Marine Electronics Association (NMEA 0183) protocol [7]. The extracted information contains the vehicle's longitude, latitude and speed as string of characters.

The traffic light position is sent only once when first the pre-emption system is activated. While the vehicle position is periodically sent until the pre-emption system is terminated.

GSM model having desired SIM card number that represents the traffic light identity to send position information as SMS to the traffic light controller.

B. Traffic light side

This unit contains a microcontroller and GSM modem connected to the traffic light; its function is to receive the position information and response according to it.Our Proposed system is giving a unique and optimum solution for controlling the Traffic congestion in metropolitan cities. In this traffic control system camera module capture the video. The videos captured by the camera sensor are converted into images and these images are processed by various algorithms and finally, the program gives the output of number of visual count of vehicles. Based on the final output traffic lights are altered and timer is displayed on the LED display.

Algorithm Used

YOLO Algorithm

The YOLO (You Only Look Once) algorithm is a real-time object detection system that has gained popularity for its speed and accuracy. YOLO processes the entire image in a single forward pass through a neural network, directly predicting bounding boxes and class probabilities for detected objects.

Signal Switching Algorithm

This algorithm upgrades the red, green, and yellow times of all signals. These timers are set bases on the count of vehicles of each class collected from the vehicle detection module and many otherfactors such as the number of lanes, average tempo of each class of vehicle, etc.

VII. CONCLUSION

The proposed the AI powered traffic light control system with GPS-based pre-emption for emergency vehicles represents a significant advancement in addressing the challenges of urban traffic management and emergency response. By leveraging AI and GPS technologies, the system offers a dynamic, adaptable, and data-driven approach to optimise traffic flow and prioritize emergency vehicles. By using AI Algorithms and GPS, it aims to make a traffic flow smoother, reduce emergency vehicles response times, and enhance overall urban mobility.

Through the development of sophisticated AI Algorithms and the integration of GPS based pre-emption, the research aims to provide tangible solutions for improving urban mobility and public safety. The objective encompass the enhancement of the traffic flow efficiency, reduction of emergency response times, and the overall contribution to a more adaptive and intelligent urban infrastructure.

The anticipated benefits, including improved traffic flow, reduced response times, and optimized resource utilization underscore the potential of this system to positively impact cities. Real-world simulation and testing will further validate the systems effectiveness and provide insights for urban planners and policy makers.

As we move forward, the integration of advanced technologies in urban planning becomes imperative. The finding of this research not only contribute to the ongoing discourse on intelligent traffic management but also lay the ground work for more resilient, efficient, and responsive urban environment. This system represents a step toward more intelligent and responsive urban infrastructure.

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