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AI Based Emergency Vehicles Detecting and Traffic Controlling System

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Abstract : - Intersection congestion presents a formidable obstacle to the efficient movement of emergency vehicles, such as ambulances and fire trucks, jeopardizing prompt responses to life-threatening situations. Despite ongoing efforts, existing solutions have struggled to adequately address this pressing issue. However, our innovative artificial intelligence (AI)-based system offers a superior alternative. Leveraging advanced AI algorithms, our technology intelligently detects and prioritizes approaching emergency vehicles, enabling dynamic adjustments to traffic signal timings at intersections. This strategic allocation of green signal intervals minimizes transit delays, resulting in significantly reduced response times for emergency vehicles. Notably, our system seamlessly integrates with pre-existing infrastructure, requiring minimal additional hardware or upgrades. Furthermore, its adaptability to various intersection layouts and traffic conditions ensures versatile applicability. Through collaborative partnerships with municipalities and transportation authorities, our solution aims to achieve widespread implementation, thereby enhancing emergency response capabilities and safeguarding the safety and well-being of individuals within our communities.

IndexTerms **- Emergency Vehicles, Artificial Intelligence, Video Processing, Traffic Signals, Traffic Congestion, Intelligent Traffic Management System, Scheduling Algorithm, Integrated Circuit**

1. INTRODUCTION

1. 1 Context

Our innovative system, powered by artificial intelligence, offers a superior alternative to address this challenge effectively. By harnessing the capabilities of AI, our technology excels in identifying approaching emergency vehicles at intersections and dynamically adjusting traffic signal timings based on priority. This strategic allocation of green signal intervals is meticulously tailored to the density and location of emergency vehicle congestion, thereby minimizing delays in transit and ensuring timely responses to emergencies. Our solution holds the promise of significantly reducing response times for ambulances and fire trucks, particularly at intersections where multiple lanes converge, thus optimizing emergency vehicle movement through congested areas. Furthermore, our system operates seamlessly within the existing infrastructure, requiring minimal additional hardware or infrastructure upgrades. Its adaptable nature ensures compatibility with various intersection layouts and traffic conditions, making it a versatile solution for urban environments with diverse traffic patterns and needs. Through strategic partnerships with municipalities and transportation authorities, we are committed to implementing our solution on a widespread scale, ultimately enhancing emergency response capabilities and safeguarding lives within our communities.
Moreover, our dedication to continuous improvement drives ongoing research and development efforts, ensuring that our solution remains at the forefront of innovation in traffic management and emergency response technology. By staying agile and responsive to evolving challenges and opportunities, we aim to continuously refine and enhance our system to meet the dynamic needs of modern urban environments.
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1.2 Motivation

The motivation for this idea is to address the escalating issue of intersection congestion has become a contemporary challenge that demands urgent attention. The hindrance posed to emergency vehicles, such as ambulances and fire trucks, underscores the critical nature of the problem. As traffic snarls at intersections intensify, they create precarious situations, endangering the lives of patients

in transit and impeding the swift arrival of emergency responders at critical destinations, such as hospitals or sites of fire emergencies. Despite efforts, existing solutions have proven insufficient in tackling this pressing issue, leaving room for innovation and improvement.

1.3 Need of Study

The need of research in this domain arises due to various problems occurred which are as follows :

1. Enhanced Safety**:** One of the primary concerns in emergency situations is ensuring the safety of both emergency responders and civilians. By employing AI to detect emergency vehicles and control traffic accordingly, the system can minimize the risk of accidents and collisions, thereby enhancing overall safety on the roads.

2. Efficient Emergency Response: Time is often of the essence in emergency situations. By quickly identifying and prioritizing the passage of emergency vehicles, the system can help ensure that responders reach their destinations promptly, potentially saving lives and minimizing damage.

3. Reduced Response Time: Traditional traffic control methods may not always efficiently clear the way for emergency vehicles, leading to delays. AI-based systems can dynamically adjust traffic signals and routes in real-time, allowing emergency vehicles to navigate through traffic more effectively and reducing response times.

4. Improved Traffic Flow : In addition to aiding emergency vehicles, AI-based systems can optimize traffic flow overall. By analyzing traffic patterns, congestion points, and other factors, the system can adjust traffic signals and route assignments to minimize delays and improve the overall efficiency of the road network.

5. Adaptability and Scalability: AI algorithms can continuously learn from real-world data, allowing the system to adapt to changing traffic conditions and improve its performance over time. Moreover, such systems can be scaled up to cover larger geographical areas or integrated with other smart city initiatives for comprehensive traffic management.

Overall, an AI-based emergency vehicles detecting and traffic controlling system addresses critical needs related to safety, efficiency, and resource optimization in urban transportation environments, making it an essential component of modern smart city infrastructure.

2. LITERATURE SURVEY

There are a number of papers published with an aim to overcome the major problem of "Traffic Congestion". Surging traffic levels and increasingly busier roads as well as transportation delays are increasing worldwide. Emergency vehicles, such as ambulances, fire engines and police cars, should be capable of responding to emergency calls with minimum delay. That's why there is an increasing requirement to develop intelligent traffic surveillance systems that can play a crucial role in Traffic Management Systems. If the emergency vehicle gets stuck in a traffic jam and its arrival at the incident location is delayed it can cause loss of lives and property.

Title: Automatic Traffic Monitoring System Using Lane Centre Edges
Publication Year: August 2012

This paper emphasizes the necessity for a robust traffic monitoring system to enhance traffic control and management. It highlights the significance of vehicle flow detection in monitoring traffic states and regulating flow. The proposed automatic traffic monitoring system utilizes vision-based cameras to estimate crucial traffic parameters and detect traffic flow across different lanes. Specifically, the paper focuses on lane and vehicle detection methods.[01]

Title: Advanced Traffic Signal Control System for Emergency Vehicles
Publication Year: September 2019

This paper presents a novel approach to facilitate the timely passage of emergency vehicles such as ambulances and fire trucks through traffic, aiming to save lives. The system, based on Internet-of-Things (IoT) technology with a central cloud architecture, utilizes real-time GPS tracking to update vehicle locations. Smart traffic signals along the vehicle's route are informed accordingly.

By prioritizing emergency vehicles and minimizing waiting times, the system reduces fatalities during hospital transport and mitigates property damage in fire emergencies.[02]

Title: Efficient dynamic traffic control system using wireless sensor networks.
Publishing Year: June 2014

This paper presents the Efficient Dynamic Traffic Control System (EDTCS), which dynamically adjusts traffic signals based on real-time conditions detected by sensors. Incorporating RFID technology and proximity switches, EDTCS accurately counts normal and emergency vehicles, enabling the Traffic Control Unit (TCU) to prioritize emergency vehicles like ambulances. This system enhances travel time efficiency and ensures timely responses in emergency situations.[03]

Title: Detection and Prioritization of Emergency Vehicles in Intelligent Traffic Management System
Publication Year: November 2021

Ensuring timely emergency services is crucial for public safety. This study proposes a method to prioritize emergency vehicles (EVs) at traffic signals using the Shortest Job First (SJF) scheduling algorithm. By detecting the sound of an EV siren via the Goertzen algorithm and identifying EVs and their types from roadside units (RSUs), the approach predicts EV positions relative to the traffic signal. This information, along with EV type and traffic density, is utilized in an IoT-based Intelligent Traffic Management System (ITMS) to prioritize EV movements efficiently. [04]

Title: Traffic Management for Emergency Vehicle Priority Based on Visual Sensing
Publishing Year: Nov 10

This paper tackles traffic congestion at intersections, proposing a method using visual sensing and vehicle counting to prioritize emergency vehicles efficiently. By employing Euclidean distance measurement and introducing the PE-MAC protocol, it significantly reduces transmission delays. Simulation results in NS-2 demonstrate PE-MAC's superiority over IEEE 802.11p and IEEE 802.15.4 protocols, ensuring prompt emergency message delivery to Traffic Management Centers. This research contributes to intelligent urban traffic management systems, enhancing emergency vehicle response efficiency and saving lives and property.[05]

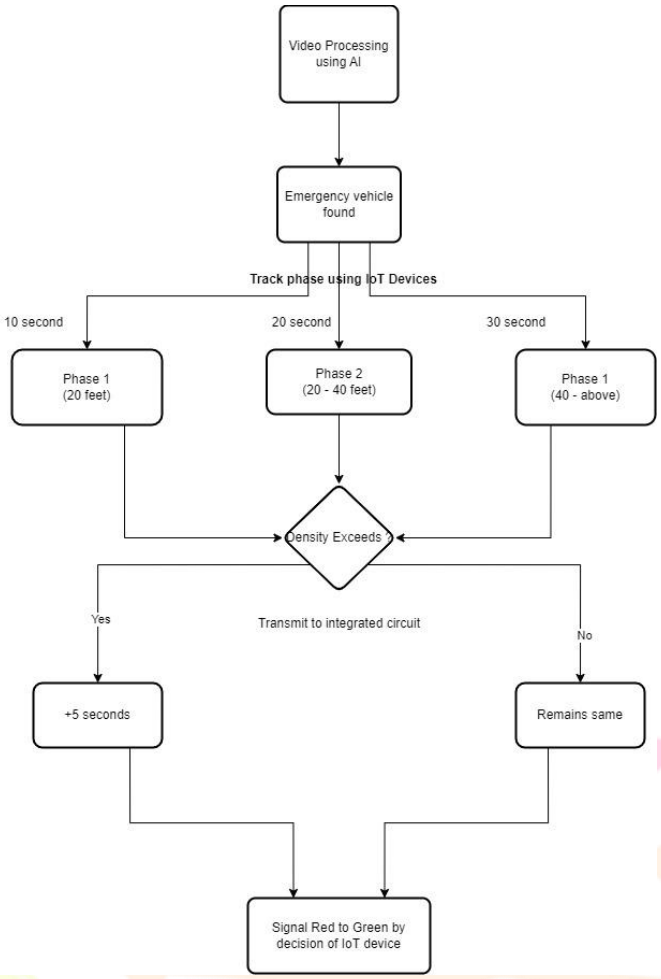
Title: Intelligent Traffic Control System for Ambulance Clearance and Stolen Vehicle Detection
Publishing Year: March 2016

This paper focuses on utilizing wireless technology and high-speed microcontrollers to ensure smooth traffic flow for emergency vehicles, allowing them to reach their destinations promptly. The system employs ARDUINO and RFID technology to detect emergency vehicles, transmitting this information to the traffic system via RF communication. Traffic lights are then automatically controlled to facilitate the passage of emergency vehicles. Additionally, IR sensors are utilized to gauge traffic congestion, with updates sent to ambulance drivers via GSM. Furthermore, the system detects stolen vehicles, alerting the control room via GSM for swift action.[06]

an approach that combines the measurement of distance between the emergency vehicle and an intersection using visual sensing methods and PE-MAC for fast transmission of emergency vehicle information is proposed.

All the techniques related to the subject have their own advantages and disadvantages. This paper uses Latest technologies and advancements in Artificial Intelligence, IoT devices, etc. Our technology uses smart AI to spot emergency vehicles coming towards a traffic light and changes the light timings to help them get through faster. This means emergency vehicles don't have to wait as long.

3. METHODOLOGY



This technology harnesses Artificial Intelligence (AI) to alleviate traffic congestion encountered by emergency vehicles at intersections. The methodology consists of four integral phases:

3.1 Video processing and Emergency Vehicles Detection using AI

Utilises AI algorithms to identify emergency vehicles such as ambulances or fire trucks amidst traffic.Trained with diverse datasets comprising images of various emergency vehicle types for accurate identification. Upon detection, the system proceeds to the next phase.

3.1.1 Data Collection

Before an AI system can accurately identify emergency vehicles, a significant amount of data must be collected. This data may include images, videos, or audio recordings of emergency vehicles captured from various sources, such as traffic cameras, emergency dispatch centers, or publicly available datasets.

3.1.2 Data Processing

Once the data is collected, it must be preprocessed to remove noise, normalize the features, and enhance the quality of the input. This step is crucial for improving the accuracy and reliability of the AI model.



3.1.3 AI Model Training

In this phase, the collected and preprocessed data is used to train an AI model. The AI model, typically based on deep learning techniques such as Convolutional Neural Networks (CNNs), is trained to recognize and classify emergency vehicles based on their unique visual and auditory features.

3.1.4 Real Time Detection

After the AI model is trained, it can be used to perform real-time detection of emergency vehicles in live video streams. The detection process involves feeding the video frames into the AI model, which then analyzes the frames and identifies whether an emergency vehicle is present or not.

3.1.5 Integration with Traffic Control Signals

To effectively control traffic and facilitate the smooth passage of emergency vehicles, the AI-based emergency vehicle detection system can be integrated with existing traffic control systems. This integration allows traffic signals to automatically adjust to prioritize the passage of emergency vehicles, ensuring swift and uninterrupted movement.

3.2 Determining the Traffic Phase of Emergency Vehicle Obstruction

Traffic is categorized into three phases based on the distance of obstruction from the intersection.

Phase 1: Obstruction within the first 20 feet.

Phase 2: Obstruction between 20 to 40 feet.

Phase 3: Obstruction beyond 40 feet.

Phase	**Low Density**	**High Density**
Phase - 1 (20 Feet)	10 Seconds	15 Seconds
Phase - 2 (20 to 40 Feet)	20 Seconds	25 Seconds
Phase - 3 (Beyond 40 Feet)	30 Seconds	35 Seconds

3.3 Accessing the Traffic Density Within the Identified Phase

Within each phase, traffic density is evaluated to further refine response actions.If vehicle density exceeds predefined thresholds, an additional 5-second extension is allocated to the traffic signal.Conversely, if vehicle density remains below the threshold, signal timings remain unchanged.

3.4 Dynamic Adjustment of Traffic Signals

Data from AI detection and traffic phase assessment are related to IoT enabled traffic signals.Upon confirmation of an emergency vehicle and determination of its traffic phase and density, traffic signals adapt accordingly.Red lights transition to green only when all criteria are met, facilitating the passage of emergency vehicles.This system ensures timely and efficient management of traffic signals, prioritizing the passage of emergency vehicles without compromising overall traffic flow.

4. SYSTEM DESIGN

4.1 Aim

The primary aim of this technology is to minimize the response time of emergency vehicles that encounter delays due to traffic congestion, potentially endangering lives. The system is meticulously crafted to prioritize the swift passage of emergency vehicles, ensuring they reach their destinations with minimal delay caused by intersection traffic. By addressing this critical issue, we aim to optimize emergency response efforts and mitigate the risks associated with delays in high-pressure situations.

4.2 Objectives

1. Faster Emergency Response : By prioritizing the passage of emergency vehicles through traffic, the system aims to reduce response times, potentially saving lives and minimizing property damage.

2. Real-time monitoring : Through real time monitoring of traffic conditions and predictive algorithms, the system can dynamically adjust traffic signals and route assignments to provide the fastest possible route for emergency vehicles.

3. Optimized Traffic Flow : This objective involves using AI algorithms to analyze traffic patterns, congestion points, and other factors to optimize the overall flow of traffic on roadways.

4. Real-time Adaptability : The system must be capable of adapting in real-time to changing traffic conditions and emergency situations. This adaptability ensures that traffic management strategies remain effective even as circumstances evolve.

5. Enhanced Efficiency : By reducing delays, minimizing fuel consumption, and optimizing the use of infrastructure resources, the system improves the overall efficiency of urban transportation systems.

6. Data-driven Decision Making : The system relies on real-time data and AI analytics to make informed decisions regarding traffic management and emergency response strategies.

7. Cost-effectiveness : Achieving cost savings through improved resource utilization, reduced fuel consumption, and optimized maintenance of transportation infrastructure

By addressing these objectives in detail, an AI-based emergency vehicles detecting and traffic controlling system can significantly improve the safety, efficiency, and effectiveness of urban transportation systems, particularly during emergency situations.

4.3 Problem Statement

The problem statement for this technology aims to minimize emergency vehicle response times, which are often hindered by traffic congestion at intersections. In India, approximately 95% of traffic intersections rely on traditional control systems that lack efficiency in managing traffic flow to accommodate emergency vehicles. Our proposed system utilizes AI algorithms to detect emergency vehicles trapped at intersections, enabling the allocation of appropriate signal phases to expedite their passage. By addressing this bottleneck, we aim to significantly enhance the efficiency of emergency responses and improve overall road safety.

5. TECHNOLOGIES USED

Various technologies are used to identify emergency vehicles efficiently, find in which phase they are stuck, find density of that particular phase and make changes in the signal timings, etc.These technologies are specified as follows :

5.1 CCTV Camera

In this system the CCTV camera is installed at the intersection where traffic occurs and our system is going to be deployed. Using these CCTV cameras we are going to collect the data, capture videos and this data will be used by Artificial Intelligence for the further process. CCTV cameras must be there at the intersection to collect the real time traffic data and videos for the processing and take the decisions accordingly .

5.2 Artificial Intelligence (AI)

AI is utilized for the detection of emergency vehicles amidst traffic scenarios, chosen for its superior efficiency over alternative technologies such as Deep Learning, Machine Learning, RFID, and IoT devices. Its recent advancements and versatility render it the optimal choice for this project. Artificial Intelligence aids in identifying traffic congestion where emergency vehicles are trapped, enabling informed decisions to minimize congestion in specific lanes, thereby expediting their passage to destinations without delays. AI also plays a major role in detecting the emergency vehicles stuck in traffic and determining the phase in which they are stuck. Subsequently, it checks whether the density of that phase exceeds the limit or not. On the basis of this data our technology further makes changes in the traffic control system accordingly.

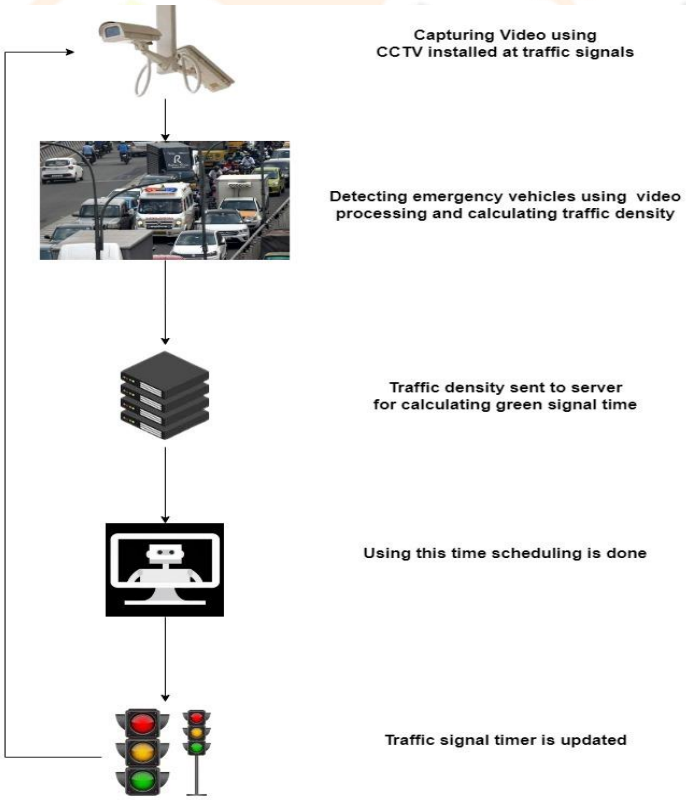
5.3 Server

The server serves as the central repository for storing and managing the data and information transmitted by the AI. Its pivotal role lies in collecting this data, as it forms the basis for implementing future system improvements. This data is indispensable for tracking the progress and assessing the impact of our system, particularly in facilitating the timely arrival of emergency vehicles at their destinations.

5.4 Integrated Circuit

Integrated circuits serve to implement changes in traffic signal lights based on data and decisions furnished by the IoT device. Once AI detects an emergency vehicle and the IoT device allocates green signal time accordingly, the integrated circuit executes these decisions in real-time, ensuring efficient traffic management.

These technologies operate synergistically to enhance the efficacy of the traffic management system, ensuring timely responses to emergency situations while optimizing traffic flow.



6. ALGORITHM

1. Capturing Video through CCTV
2. Real time analysis / processing of video
3. Find out emergency vehicle(ambulance / fire-truck) in traffic
4. If found, find out phase in which it stuck
5. Find density of that phase

6. Check whether it exceeds the vehicles limit or not
7. Make changes in traffic signals according to density in that phase
8. Make changes in traffic signals
9. End the current phase
10. Save the data in servers
11. Repeat it again

7. FUTURE SCOPE

1. Enhanced AI Algorithms: Continuous research and development efforts can further refine the AI algorithms used in the system to improve accuracy in detecting and prioritizing emergency vehicles. This can include incorporating machine learning techniques to adapt to evolving traffic patterns and emergency response needs.

2. Integration with Smart City Initiatives: As cities continue to adopt smart infrastructure technologies, there is potential to integrate this system with broader smart city initiatives. This could involve incorporating data from various sensors, cameras, and IoT devices to enhance real-time traffic management and emergency response coordination.
3. Predictive Analytics for Traffic Management: By analyzing historical traffic data and emergency response patterns, predictive analytics can be employed to anticipate congestion hotspots and proactively adjust traffic signal timings to facilitate smoother emergency vehicle passage.

4. Multi-Model Integration: Future iterations of the system could expand beyond traditional road intersections to include integration with other modes of transportation such as railways, airports, and waterways. This holistic approach to emergency response management can further optimize overall transit times and improve coordination across different transportation networks.

5. International Collaboration and Standardization: Collaborating with international partners and standardization bodies can help establish common protocols and best practices for implementing AI-based traffic management systems for emergency vehicle prioritization. This can facilitate interoperability between systems deployed in different regions and ensure seamless emergency response across borders.

6. Continuous Evaluation and Improvement: Regular evaluation and feedback loops will be essential to assess the performance of the system in real-world conditions and identify areas for improvement. This iterative approach to development will ensure that the system remains effective and adaptable to evolving traffic patterns and emergency response needs.

8. CONCLUSION

This technology effectively minimizes the time delay encountered by emergency vehicles such as ambulances and fire trucks in reaching their destinations despite intersection traffic. By optimizing traffic signal timings based on real-time detection of emergency vehicles, this system ensures prompt and efficient passage, prioritizing lives at stake.Moreover, it's paramount to note that the implementation of this technology ensures fairness and equity across all lanes, avoiding any form of discrimination. The system manages timings impartially, guaranteeing that all vehicles, regardless of lane occupancy, benefit from optimized traffic flow.
Ultimately, this system represents a significant stride towards safeguarding lives dependent on timely emergency response. By mitigating the impact of traffic congestion on emergency vehicle transit, it stands as a crucial initiative in ensuring rapid and effective emergency services, potentially saving countless lives.

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