IoT Based Traffic Congestion Management and Accident Detection System

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Abstract

This review proposes a traffic congestion management and accident detection system to reduce congestion at junctions and to provide emergency assistance during accidents. The proposed system employs advanced computer vision and image processing techniques like You Only Look Once (YOLO) to monitor and analyze real-time traffic conditions and accidents. The pivotal feature of this system lies in its adaptive decision-making capability, automatically adjusting traffic signal timings based on observed density patterns and updating and reporting about the congestions and accidents for which Internet of Things (IOT) technologies are used. Nowadays many junctions and roads are equipped with surveillance cameras connected to traffic management systems. Therefore, techniques like YOLO can be viable tools for automatic accident detection and traffic control.

Keywords: YOLO, Computer vision, IOT, Automation, Accident Detection.

1. Introduction

Traffic congestion is a major problem in urban areas, with a variety of negative impacts on travel efficiency, environmental sustainability and overall quality of life. Existing traffic management systems are often unable to cope with the dynamic and complex nature of congestion. Fixed traffic signal times present many disadvantages to urban traffic control. One

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notable drawback is their inability to adapt to changing traffic conditions, reducing efficiency when traffic patterns change. This lack of response can lead to unnecessary delays and congestion, especially during rush hour or off-peak traffic periods. Introduction to the planning, analysis and decision-making process of traffic management activities and processes [1].

Inflexible fixed times result in lost passenger time, increased fuel consumption, and increased emissions from prolonged idling. Fixed times can result in underutilization or congestion of certain lanes at busy intersections, resulting in uneven traffic distribution and delays on certain routes. Various algorithms help control the timing of traffic lights, which in turn helps achieve the goal of automatically managing traffic situations [2].

As cities develop and experience changes in infrastructure and population, fixed signal times may become outdated and inadequate for changing traffic dynamics. In contrast, adaptive traffic signal control systems that adjust timing based on real-time data are gaining popularity due to their ability to overcome these limitations and improve overall transportation efficiency in dynamic urban environments. The introduction of a computer vision-based traffic management system based on vehicle density at intersections represents a significant advance in urban traffic management.

However, transmitting the two types of messages separately requires large computational and communication costs, which is impractical for vehicles with limited resources. Therefore, it is possible to implement a privacy-preserving Lightweight Traffic Condition Monitoring (L-TCM) scheme that uses sanitized signatures to allow vehicles to broadcast safety-related messages and download traffic condition messages through a single message transmission. [3].

Equipped with a network of strategically placed cameras, the system uses sophisticated computer vision algorithms to detect and track vehicles while continuously recording and analysing live feeds, calculating traffic density in each lane in real time. Of particular interest to traffic engineers are traffic flow parameters such as traffic volume, speed, vehicle type, queuing parameters, traffic flow at intersections, etc. This approach is based on applying edge detection techniques to key areas or windows. This method of measuring traffic parameters does not require background frames, which is an important but unreliable method for background-based image detection methods [4]. This dynamic response optimizes traffic flow, reduces congestion and improves overall efficiency.

As the population grows, the number of accidents increases every minute. These traffic accidents are unpredictable. Most accidents cannot be reported in time to a nearby ambulance. In many cases, emergency services are not available and lack of first aid and timely services can result in loss of life within minutes. Therefore, it is necessary to develop a system that can solve all these problems, overcome delays caused by medical vehicles, and function effectively.

Advanced smartphone performance is the question of the hour to design and develop low-cost solutions for advanced transportation systems that can be used on legacy vehicles and demonstrate promising results in terms of accuracy [5]. If vehicles are equipped with technology that can detect an accident, emergency responders should be immediately alerted [6]. To achieve this goal, vehicles are equipped with smart devices that record data about the vehicle and transmit it to the vehicle owner or third parties on a regular basis [7].

However, the centralization and remoteness of cloud resources can lead to long latency, raising serious concerns about their usefulness in emergency situations. In life-threatening situations, all possible delays must be minimized. To address latency issues, fog computing has emerged as a middleware paradigm that brings cloud resources closer to end devices. Accordingly, the research proposed here proposes and develops a low-cost, delay-aware incident detection and response system by leveraging the sophisticated capabilities of smartphones and fog computing. This is called the Emergency Response and Disaster Management System (ERDMS). [8].

2. Proposed Work

The system monitors the movement of vehicles on each road and adjusts the timing of traffic signals accordingly. The more vehicles there are on the road, the more delay time is assigned to that intersection lane. The proposed system uses a network of IoT devices including cameras, microcontrollers, and NodeMCU ESP8266 WIFI module to collect comprehensive real-time data on traffic conditions. Computer vision algorithms such as YOLO are used to analyze the collected data and extract important information such as vehicle density. Figure 1 shows a simple workflow of a traffic congestion management

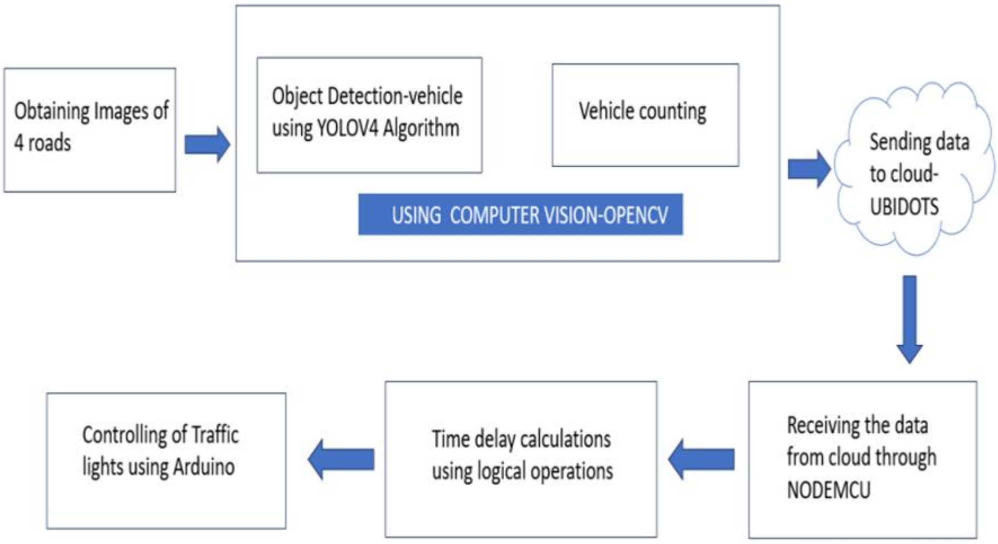

Figure 1. Proposed Traffic Congestion Management System

Collected images of roads with traffic from Google sources were placed in a separate folder. Vehicles are detected using YOLOv4 configuration and weight files. Vehicle count, the number of vehicles is determined by counting the bounding boxes. The same was repeated for all four lanes of the intersection. The data received from Lane 4 is sent to UBIDOTS using the API token for each account. For further time delay calculations, data is obtained from four lanes and then a logical operation is performed to determine which lane has the maximum density. This is done using an Arduino microcontroller. The data sent to the IOT cloud is used to update surrounding signals.

Integrating the YOLO algorithm into an incident detection system is a systematic process, as shown in the flowchart in Figure 2 below.

- Data collection: The process begins with collecting video streams from traffic cameras. These video streams serve as input to the YOLO algorithm.

- Preprocessing: Video frames are preprocessed to improve image quality and reduce noise. Preprocessing includes operations such as resizing, normalization, and augmentation.

- Model initialization: The YOLO model is initialized using pre-trained weights obtained from a large dataset. This initialization helps the model learn features efficiently.

- Training: The YOLO model was fine-tuned using a labeled dataset containing collision images. The training process involves adjusting model weights to minimize the loss function.

- Real-time detection: After training, YOLO model can detect incidents in real-time. We identify incidents by processing video frames and drawing bounding boxes around the objects associated with the incident.

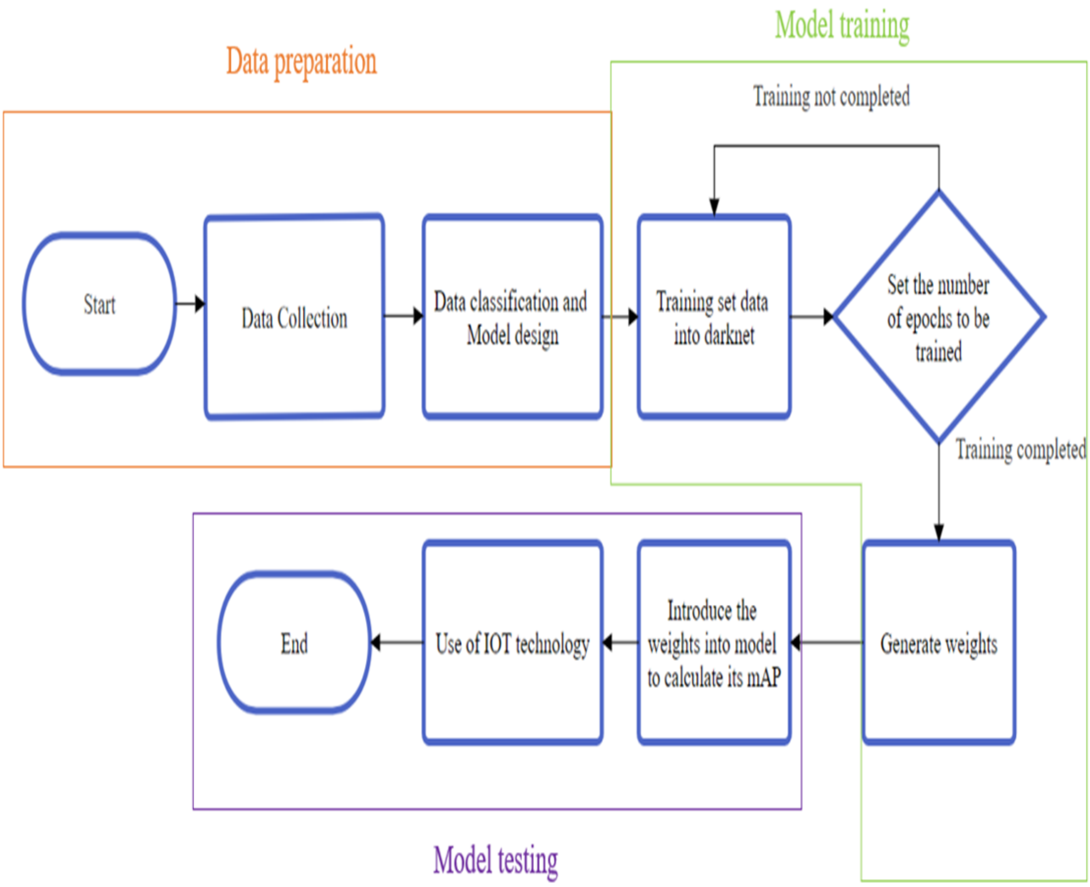

Figure 2. Accident Detection System

- Alert generation: When an incident is detected, the system immediately generates an alert. These alerts can be sent to relevant authorities and emergency services or integrated into wider traffic management systems.

- Performance evaluation: System performance is evaluated using accuracy, speed, and reliability metrics. The results are important for evaluating the performance of YOLO-based incident detection components.

3. Results and Discussion

Based on the collected data, roads with the highest traffic density are determined and a green signal is sent for a long period of time. Vehicle detection and counting are shown in Figure 3. IoT plays an important role in connecting nearby roads and enabling communication between them. Traffic signals on the road will be automatically updated following the previous intersection based on data collected and stored on the UBIDOTS platform, further reducing traffic congestion.

Figure 3. Vehicle Detection and Counting

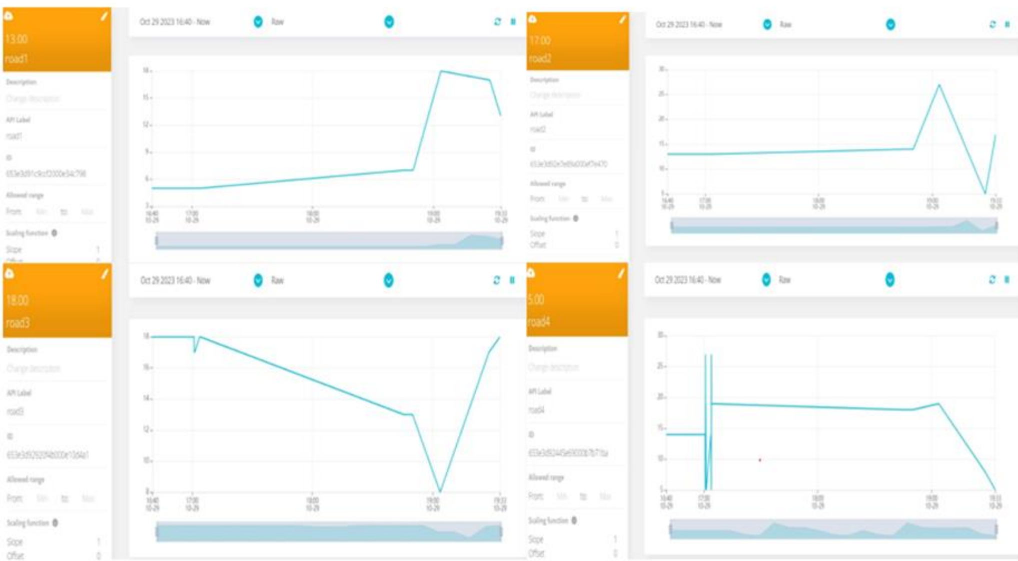

Figure 4. Traffic Density Variations on Each Road of the Junction

UBIDOTS allows you to visualize data in the form of graphs as shown in Figure 4, charts, tables, indicators, maps, indicators and management widgets. Images collected from various sources are individually annotated using a tool called Roboflow. When annotating, images without an incident were displayed as NULL, and images with an accident were marked with a box.

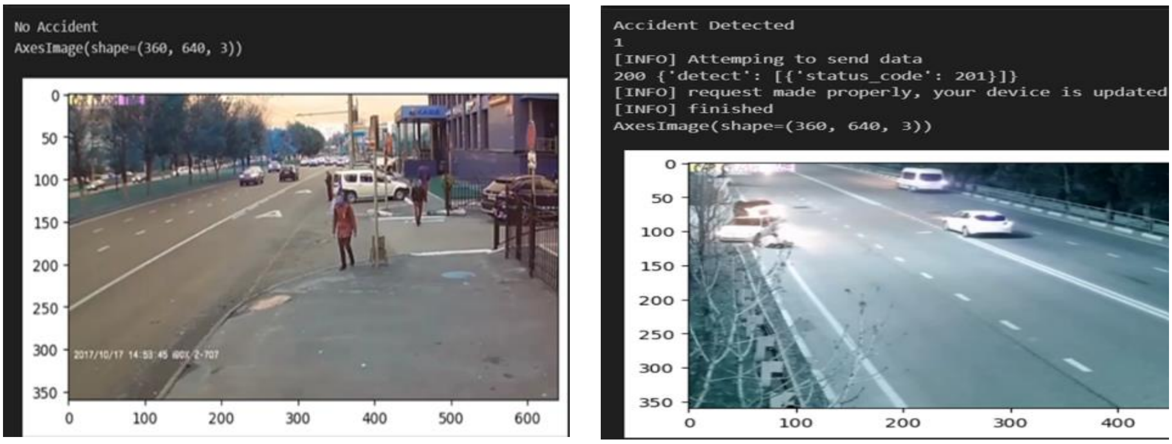

Figure 5. Accident Detection

After training the YOLO model, it is important to evaluate its performance. This includes measuring metrics such as mean average precision (mAP) and analyzing the model's ability to correctly detect objects in the image, as shown in Figure 6. Depending on the evaluation results, model is further fine-tuned to achieve optimal performance. Figure 5 shows the accident detection results.

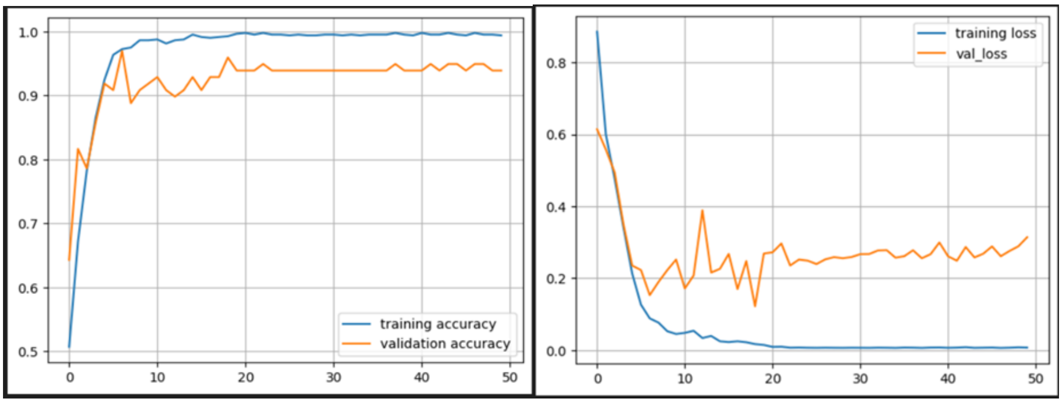

Figure 6. Accuracy and Loss Curves.

4. Conclusion

Through the integration of Internet of Things (IoT) technologies, real-time data collection and smart analytics, this system has successfully demonstrated its potential to improve the efficiency of traffic flows, respond quickly to emergency situations, reduce congestion and improve overall urban mobility. This approach to intelligent traffic management and incident detection is expected to significantly reduce travel times, fuel consumption, carbon dioxide emissions and loss of life. It also contributes to creating a more sustainable and environmentally friendly transportation ecosystem.

In conclusion, this framework highlights how important it is to prioritize road safety in today's fast-changing world, where accidents cause great grief, death, serious injury and significant financial loss.

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