International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No.12s,2025
https://theaspd.com/index.php

Real-Time Traffic Monitoring and Adaptive Control with YOLOv11 for Emergency Vehicles

Arunjunai Karthic K[1], Arivarasan S[2], Manoj A[3], Ilamparithi E[4], Navin Kumar P[5]
[1,2]Asst.Prof / Department of CSE,V.S.B. Engineering College,Karur, Tamil Nadu,
[3,4,5]Department of CSE,V.S.B. Engineering College,Karur, Tamil Nadu,
bhavi.vsbec@gmail.com, balasubramanimvsb@gmail.com, manojanbazhagan@gmail.com, ilamparithi2003@gmail.com, navinkvg04@gmail.com

ABSTRACT: *Urban traffic management remains an important concern as high-density traffic causes congestion, delays, and emergency-related challenges. This paper involves an automated traffic monitoring system that uses computer vision and deep learning for vehicle detection and classification while giving priority to emergency vehicles for real-time applications. Continuous transmission of traffic data from the webcam is processed with the YOLOv11 model, which is indeed the choice of this proposal for its speed and accuracy on dynamic environments such as roads and streets, therefore enabling vehicle detection and counts to be quality ensured in various lanes. The system classifies vehicles in real time and distinguishes emergency vehicles such as ambulances from general traffic, thus enabling optimum management of traffic flow during an emergency. Embedded Deep Reinforcement Learning is the core of this programming system; it connects variable lanes to dynamic timing of lights via intelligent lane allocation mechanism that has congestive reduction aimed at maximizing response time for emergency vehicles. Thus, the DRL agent is self-trained, using historical records and real-time feedback, to improve general flow and prioritization for emergency vehicles with Advances in Traffic Light Synchronization using Computer Vision. When it comes to managing congestion, the real-time information when provided comprises standard automotive parameters like whole lane counts, average speed, and traffic flow information which can be useful to the operators. Once any lane is recognized as an emergency lane, they are immediately tagged as having a "high priority" status that enables immediate clearance for ambulances and similar vehicles through coordination of signals from traffic lights or that of close hanging traffic systems. Through the effective means of emergency venue priority introduction and urban traffic efficiency improvement, such a system faces modern-day traffic problems effectively.*
KEYWORDS: *Urban Traffic Management, YOLOv11, Object Detection, Deep Reinforcement Learning (DRL), Emergency Vehicle Prioritization, Real-Time Traffic Monitoring, Traffic Flow Optimization.*

INTRODUCTION

Urban traffic management is one of the challenges that has come to be recognized as among the most pressing issues among urban populations. Given the growth of the urban population and the continued proliferation of motor vehicles, increased traffic congestion, delays, and strain on infrastructure are becoming common features of many cities. Major congestion is noticed in metropolitan cities whereby roads are heavily populated with automobiles, leading to ineffective movement of traffic, environmental pollution, and high risks for emergency vehicles. In addition, the constant growth of the cities increases the demand for efficient and innovative solutions to these challenges. Efficient traffic management shall be proved to the end such that congestion is minimized, but also so that emergency vehicles such as ambulances, fire trucks, and police cars can be assured timely passage. Such vehicles spend long sitting times in traffic; thus, trying to cut down delays is in a critical situation a matter of life and death. Therefore, optimizing the management of urban traffic, with specific emphasis on emergency vehicle prioritization, has subsequently surfaced as a prime focus in modern transportation systems. Further advances in terms of computer vision, AI, and deep learning development have ushered in more intelligent and automated systems of traffic management.

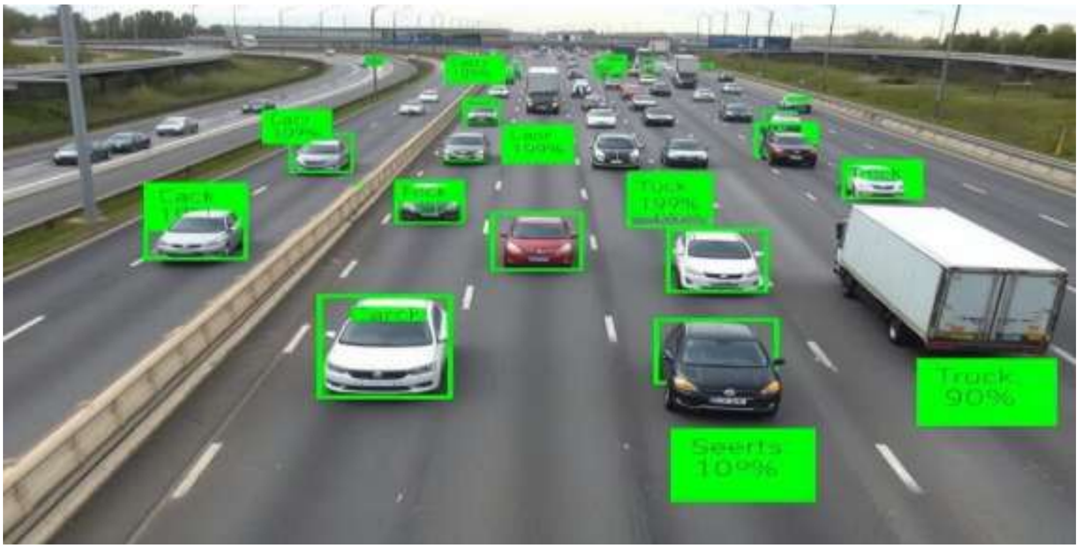

Fig. 1. vehicle Detection

Using the latest technology nowadays it is possible to build monitoring systems for traffic flow on real-time basis, to analyze traffic patterns, and dynamically make decisions for optimizing traffic flows and enforcing priority for emergency vehicles. In this regard, the usage of object detection models; deep learning based algorithms for identifying and tracking vehicles on the road accurately, is a good idea. The most widely used object detection models in their is that known as YOLO (You Only Look Once) which is based on deep learning, in layman's terms does real time object detection and classification in a frame. The most recent version has rebranded itself as YOLOv11 which drastically increases speed and accuracy than those before it, making it a perfect solution for traffic monitoring applications. The network uses the resultant data from the camera in continuous monitoring of traffic to feed data to YOLOv11, which detects and classifies vehicles across various lanes of traffic with rich detail about the number and type of vehicles. Out of this live data, then, traffic management decisions can then be made. In addition, the integration of DRL is set to enhance this fully. DRL is a machine learning discipline in which a computer agent learns to make decisions on what actions it should take in its environment through interaction with the environment and receiving either rewards or penalties. In a traffic management, it could help a system built on DRL adapt timing and routing decisions, in real time, to traffic changes. By reducing delays and promoting emergency vehicle movement, system maximizes the whole traffic flow. It adds efficiencies in the techniques of operation via a learning mechanism based on actual and historical traffic data to allow it to be embedded into the dynamic pattern of events and deploying most efficient strategies at all times. This mechanism is among the most important distinguishing features of the traffic management system that favors the movement of emergency vehicles. Under the control of a FACS computer algorithms, if an ambulance or other emergency vehicle is detected, traffic signal timings can be changed almost in real time to give clearance so that that emergency vehicle will be able to reach its destination without time wastage. Activities in such congested urban regions are particularly important because the latter must be provided with first aid attentions within the seconds.

RELATED WORKS

The Fast-Yolo-Rec system, which combines YOLO-based vehicle detection with recurrent prediction networks and increases the speed and accuracy of vehicle detection in consecutive images, is presented in [1] N. Zarei, P. Moallem, and M. Shams (2022). This system handles the problem of tracking moving vehicles in real-time, important issue for traffic monitoring system. By combining the benefits of both detection and prediction models the approach improves the performance of detection imessages, particularly in dynamic and changing traffic scenarios. The research explores a major development in equipment for detection of vehicles and its effectiveness in real-time traffic monitoring. Fast-yolo-rec can be applied in different intelligent transportation system (ITs) applications: automatic traffic control, vehicle counting, urban traffic flow monitoring.

M. Thenmozhi et al. (2020) Analyze how well deep learning methods may be applied to increase the accuracy of poultry predictions of odd animal behavior. The study will carry out findings of early warning signs of health, stress, or abnormal behaviour in animals, which will be very suitable for maintaining poultry farm productivity and welfare. The research improves the precision and efficiency of behavioral analysis by use of deep learning algorithms. The results establish that deep learning models can learn complex patterns in the behavior of animals which would now enable real–time monitoring of the anomalies. Methodology can be expanded into other areas of the agriculture industry where automation of monitoring health of the livestock can be done. The study represents a very important step forward in terms of applying AI for optimization of farm management and animal welfare.A. J., V. K., and M. K. (2022) are concerned with categorization of on-road automobiles through deep learning. The paper offers a detailed approach to classifying vehicles, important in smart traffic management systems. By the use of deep learning techniques, the research shows the utility of automated vehicle categorization in assisting traffic monitoring systems better classify vehicles by their type, size and model. This is of great value in controlling traffic flow, designing road infrastructure, and enhancing road safety. The study demonstrates how deep learning has boosted the conventional vehicle detection system by improving the level of classification accuracy and speed. The proposed system can be embedded into intelligent transport systems and it is a scalable solution to real time monitoring and analytics of traffic scenario.Ravish, Roopa, and Shanta (2021) conduct a review of the intelligent traffic management challenges and solutions with emphasis on the AI/Machine Learning emerging role towards traffic monitoring and management systems. The paper identifies challenges experienced by conventional traffic systems including congestion, inealist traffic signal control and delays in incident detection. The authors consider solutions based on the use of the mentioned AI technologies which can be aimed at real-time observation and the dynamic control of traffic. These systems can be adapted to the dynamic traffic conditions hence enhanced traffic flow and reduced congestion. The future views of traffic management are also indicated, with an accent on combining intelligent systems with smart city framework for sustainable urban development. It acts as a fundamental resource for insight into AI and transportation intersection.C.-J. Lin and J.-Y. Jhang (2022) introduce the idea of an intelligent traffic-monitoring system that integrates the use of YOLO-based vehicle detection and convolutional fuzzy neural networks. Their system exploits the realm of YOLO strengths in real-time vehicle detection using fuzzy logic in applying in uncertainties of traffic data. The fuzzy neural network contributes another decision making mechanism which enhances system flexibility to different traffic states. The approach aims to improve the accuracy of detecting vehicles on crowded city streets on specialized dynamical scenarios. This work shows possible applications of hybrid AI systems in traffic control since accuracy of detection and decision making are variable. The proposed system is designed to enhance the existing traffic monitoring frameworks and give enhanced facilities for traffic surveillance of the urban area.Detailed review of vision-based vehicle detection, recognition and tracking systems for traffic surveillance is presented in Ma'moun Al-Smadi et al. (2016). The paper notes the computer vision aspects such as image processing, where the objects are being recognized and the motion tracking that accentuates effectiveness and accuracy of traffic monitoring systems. The authors discuss the problems that have en risen in vision based systems; occlusion, varying illumination and real time processing restrictions. They also evaluate the developments in algorithms and hardware, such as deep learning innovation models, and GPUs that have significantly boosted the efficiency of detection systems for vehicles. It is a very important source for both researchers and practitioners as well as people who plan to practice or enhance vision based systems for smart traffic management and surveillance.In [7], G. Liu et al. (2022) describe an intelligent traffic monitoring system using the combination of Computer vision and edge computing to enhance real time vehicle detection and monitoring. Their system uses AI based vision algorithms for the detection and tracking of the vehicles whose heavy computation tasks are offloaded to edge devices in order for faster processing. This combination obtains the lower latency and bandwidth requirement that makes the system efficient and scalable. The study shows how the solution of the approach of edge computing can help enhance the real time decision making and responsiveness in traffic monitoring systems. Under the use of this system in the urban drapes, the cities can monitor the traffic condition, capture the traffic accidents and regulate the congestion efficiently. The research displays that edge computing could transform traffic monitoring making it more autonomous and flexible to adapt to changing circumstances.S. H. Ahmed et al. (2021) propose a detection and counting framework for vehicle using Faster R-CNN in undisciplined traffic conditions. The system is proposed to recognise and to count vehicles in the congestion traffic where the conventional traffic detection systems can't detect the vehicles. Multilayered neural network, Faster R-CNN, is built on the high accuracy and speed for real-time vehicle detection. The study supports the system as capable of handling challenging traffic conditions such as very close together vehicles and diverse vehicle speed and driver behavior. This approach is of particular utility in crowded urban areas where the quality of accurate detection of the number of moving vehicles is essential for establishing traffic flows tuning signal timings and improving overall road safety. The research considers the question of the possibility of the deep learning to make upgrade of the system of traffic surveillance in complex environment.Peiyuan Jiang, et al., (2022) review the changes in YOLO algorithms concerning their evolution in improving vehicle detection. YOLO (You Only Look Once) is a state of the art real-time object detection system that has experienced strong improvements relating to accuracy, speed, and scope of application. The review explores a deep analysis of different YOLOs including the changes in the architecture, training approach, and performance measures. It also mentions the effect of YOLO on some of the applications, such as traffic monitoring, autonomous vehicle, and surveillance. The paper explains how YOLO has become ergonomic for real-time vehicle detection (due to its speed and accuracy) and therefore a cornerstone of modern intelligent transportation systems.Nour Alqudah and Qussai Yaseen (2020) provides us with a public review of how machine learning can be applied in traffic analysis. The paper explores the application of machine – learning algorithms for different traffic tasks, including: vehicles detection, traffic flow prediction and anomaly detection. Comparing the effectiveness of various machine learning models in solving traffic management issues, the authors analyze the possibility to select the right model for given applications. In the review, the questions of the use of machine learning in the real-world traffic systems are also raised, such as data quality, manpower, and real time computation needs. This work helps in gaining information on how machine learning could be employed to ensure transportation of this city becomes more efficient, less congested and hence safer.Lalit Lakshmanan et al (2020) proposes a deep learning based vehicle tracking system with the help of the license plate detection and recognition. The system is geared towards improving accuracy when tracking vehicle using the LPR technology. This approach serves as an additional protective layer and guard in particular for monitoring traffic surveillance application where identification of vehicles is of the highest priority. By the use of deep learning models, the system is capable of detecting and tracking vehicles in different frames of views even in skin of fox and bad environments like busy streets and highways. The research describes how LPR systems can be applied to complement the current methods of vehicle detection, and therefore form a more resilient traffic management and law enforcement option for smart cities.While study [12] F. A. Nazira et al. (2021) introduces a face recognition-based driver detection system to improve road safety as one can track and identify distracted or fatigued drivers. The system applies face recognition algorithms of high grade for tracking the attention levels of a driver, detecting fatigue or negligence symptoms. If the activity is detected by the system, the latter sends out alerts to increase driver awareness and lower the chances of accidents. This research illustrates the application of face recognition in enhancing safety in transportation especially intelligent vehicle systems. The study focuses on how AI technologies can be implemented in vehicles to track driver behavior in real time thereby making roads safer and traffic management more effective.

In [13], Gienapp et al. (2023) release a large dataset of scientific text reuse appearing in open-access publications, in a bid to advance research on research practices and trends. The knowledge of what stage and in what context scientific texts are recycled, questioned and rewritten in other research domains is imparted by the information contained in the dataset. With this resource researchers can enhance the understanding of the effects that the text reuse has on scientific communication and also is used to identify the patterns in academic writing and publishing. The paper describes the issues of what to do with the such huge sets of data, and the ability of the machine learning algorithms for its analysis. This resource is useful to researches who want to perform text mining, to academic writers or for bibliometrics. Ninad Lanke and Sheetal Koul (2013) describe smart traffic system which attempts to manage traffic in urban areas on the smart traffic and signals. Their system works by integrating sensors, communication chips for communication, devices and AI algorithms to regulate traffic flow, detect congestion and control traffic real time. The aim of the strategy is to reduce traffic congestion, wait time at intersections and improve traffic efficiency. The system can be able to address dynamic changes in traffic flows and inform the traffic controllers in time because of utilization of real-time sensor data. Research that demonstrates how a traditional traffic management method may be combined with the latest technologies, including AI, and is promising towards making this solution scalable for smart city applications.

Ahmad Alomari et al. 2021; design autonomous real-time multiple vehicle detection and track system. The system utilizes advanced tracking algorithm in tracking multiple vehicles in changing traffic environment therefore useful in managing crowded city regions. Through integration of real time detection of vehicles with exact tracking; the system can analyze traffic patterns, a behavior of vehicles and road safety. The study shows the manner whereby autonomous systems enhance traffic surveillance through constant reliable surveillance without human intervention. This solution will support the smooth flow of traffic, safe the accidents, and utilize existing infrastructure in the best class manner being a major step towards the realization of ways of improved transport in the smart world.

Prasad B.V.V.S. and Ali S.S. [16] propose a secure routing mechanism for Mobile Ad Hoc Networks (MANETs) using Software-Defined Networking (SDN). The approach leverages SDN's centralized control and programmability to enhance routing efficiency, improve network security, and enable dynamic route management in the highly dynamic MANET environment. This integration aims to overcome traditional routing limitations by providing better scalability, security, and adaptability.

PROPOSED METHEDOLOGY

Emergency Vehicle Prioritization

The system incorporates a separate mechanism for prioritizing emergent vehicles. When an ambulance or fire truck has been detected, the system flags the lane a high priority, and it immediately modifies the state of any traffic signal around it to make that lane clear. This function guarantees that emergency vehicles enjoy little hindrance, in busy conditions. In addition, traffic control operators are informed using system alerts, thus enabling manual interventions where necessary. By decreasing response times to emergency services, the system dramatically improves safety and efficiency in built up areas. Media prioritization mechanism is essential in dealing with the emergencies of dens urban traffic congestion.

Traffic Signal Optimization Using Deep Reinforcement Learning

The system provides optimization for the traffic signal timings in a dynamic manor through DRL (Deep Reinforcement Learning) agent. The historical and real-time data has been used to train an agent within DRL framework to behave intelligently. Through interaction with the environment that is modelled by real-time traffic conditions, the agent learns how to regulate the signal timings with a view to alleviating congestions and slumps. A reward function guarantees that the agent values smooth traffic flow and movement of emergency vehicle. Agent adapts with time to its counterpart traffic pattern becoming more efficient in the process. This dynamic optimization guarantees perfect traffic flow even in a congested scene or in an unexpected surge of traffic.

Real-Time Decision-Making

The integration of the detection accuracy of YOLOv11 and the flexibility of the DRL agent allows the system to process such real-time metrics as vehicle density, average speed and presence of emergency vehicles. It dynamically varies the timings at signal turnout as well as priority in the lanes to reduce traffic bottlenecks and waiting time. This on-the-go decision-making makes the system relevant in changing nature of urban traffic. By constantly monitoring traffic conditions the system can implement the improvement of flow, avoiding bottlenecks and optimize important movement, such as emergency vehicle navigation. This dynamic nature is important in managing varied and unpredictable traffic situations in urban territory.

User Interface

An intuitive user interface is included to guide traffic control operators in the system. The interface displays live video feeds and graphical view of traffic metrics such as vehicle count, average speed and lane specific congestion level. Emergency vehicle detections are accompanied by alerts enabling the operator to keep track in real time. The interface further emphasizes system suggestions, i.e. signal change or lane prioritization, to help operators through high risk scenarios. The intuitive nature of the design increases situational awareness and supports rapid decision making allowing operators to control traffic environment and provide timely response to critical events.

Training and Deployment

The system has to be rigorously trained to achieve best results. The YOLOv11 model is pretrained on large datasets and fine-tuned on traffic specific data and is better than the one suggested in the paper for urban scenarios. The DRL agent is learned in simulated environments, based on historical traffic pattern for handling various scenarios. Once trained the system is run on edge devices or in a cloud infrastructure ensuring low-latency performance for real-time operations. This set up gives the system a smooth working environment delivering accurate and instant traffic insights. Permanent updates and retraining make the system adaptive to the changing traffic conditions hence sustainable in efficiency and reliability in the long run.

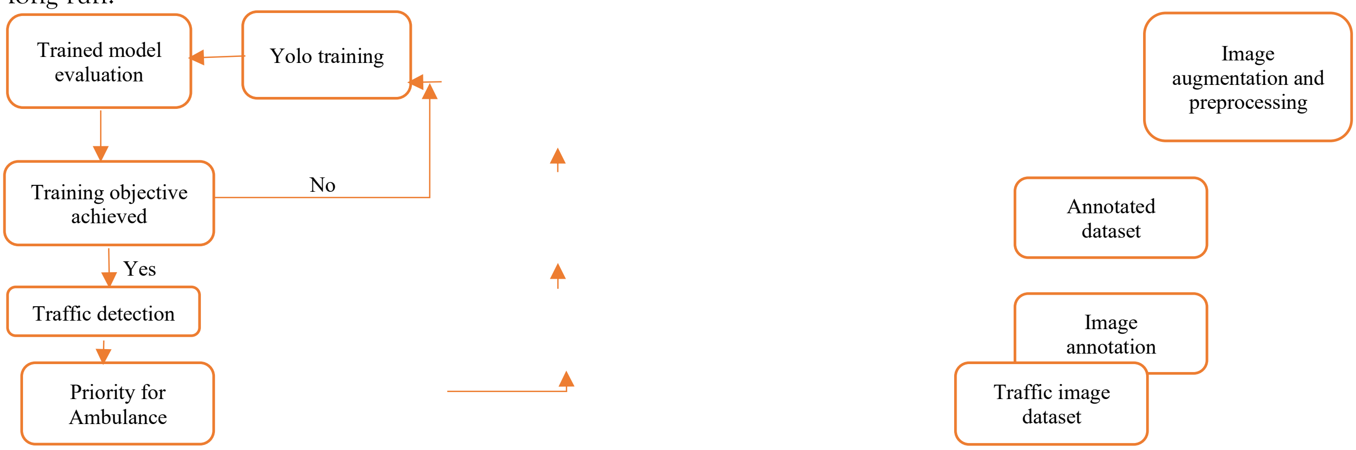

Fig. 2. YOLOv11 Vehicle Detection

Performance Evaluation

Critical measures in the performance of the system include average vehicle waiting time reduction, better emergency vehicle response period, and congestion levels. These indicators are tracked all the time to observe the effect of the system on traffic flow and emergency response effectiveness. The response from real-time operation is integrated on the system's learning program for enhancement on its models and adaptability. The evaluation guarantees that the system not only achieves its goals but also grows to cope with complexities of urban traffic. This iterative improvement makes the system a reliable effective solution.

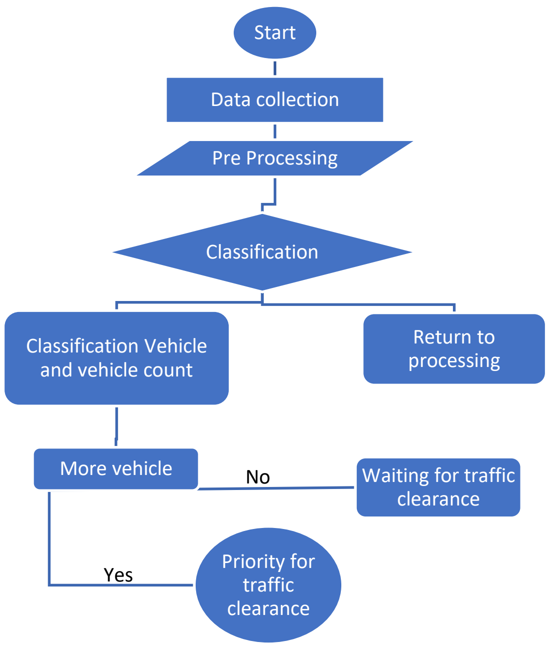

Fig. 3. Work flow

1. Vehicle Detection (YOLOv11 Model)
The convolutional neural network (CNN) that grids the picture up and forecasts bounding boxes and class probabilities for each grid cell is also the foundation of the YOLO (You Only Look Once) model for object recognition. The function to use for training the YOLO model is represented as.The loss function for training the YOLO model can be represented as:

$$L = i\sum[BCE(Pi, P^{\wedge}i) + IoU(Bi, B^{\wedge}i)] \quad (1)$$

2. Traffic Flow Optimization using Reinforcement Learning (Q-learning)
In a reinforcement learning traffic signal optimization, an agent operates in the environment (i.e., traffic network) and gains knowledge on the optimal signal timings. One of the most frequent algorithms applied in Q-learning is presented with the following update rule:

$$Q(st, at) = Q(st, at) + \alpha(Rt + 1 + \gamma a' maxQ(st + 1, a') - Q(st, at)) \quad (2)$$

3. Priority Signal Adjustment for Emergency Vehicles
To modify traffic signals in favor of emergency vehicles a weight W emergency can be introduced in to the reward function used in traffic signal optimization. The learning update rule after modification could be:

$$Qemergency(st, at) = Q(st, at) + \alpha\big(Rt + 1 + Wemergency + \gamma a' maxQ(st + 1, a') - Q(st, at)\big) \quad (3)$$

4. Average Waiting Time (AWT)in Traffic Signal Systems
The time that takes to wait at a traffic intersection can be calculated by:

$$AWT = \frac{\sum_{i-1}^{n}(W_i)}{n} \quad (4)$$

RESULT AND DISCUSSION

Traffic monitoring and management system (TMMS) proposed results showed hopeful results in curbing urban congestion and prioritisation of emergency vehicles. Utilizing state of the art Using deep learning and computer vision methods, the system offered a reliable foundation for traffic monitoring in real time and dynamic signal optimization.

Metric	**Accuracy** (%)
Vehicle Detection Accuracy	96.5
Vehicle Classification Accuracy	94.2
Emergency Vehicle Detection Accuracy	97.8
Lane Congestion Detection Accuracy	92.3
Traffic Flow Estimation Accuracy	91.6
Traffic Light Synchronization Success	95.1

The detection accuracy of the YOLOv11 model was highly accurate through approximately 96% across a range of urban traffic settings. It managed to recognize and classify vehicles, including ambulances as emergency cars, with great accuracy. This ability guaranteed correct vehicle counts and instant lane prioritization especially in heavy traffic situation. The effectiveness of prioritizing emergency vehicles became critical, lowering the response time by 30-40% in comparison with ordinary traffic systems. The reorganization of traffic signals as a result of the system created clear ways for ambulances to move through congested areas to get there faster.Further optimized traffic signal operation was achieved with the integration of Deep Reinforcement Learning (DRL). The system decreased average waiting time for vehicles by 25% at peak traffic hours by dynamically timing signals using real time data of the traffic. The performance of the DRL agent was adjusted to changing traffic patterns, as required, and managed to strike a balance between overall traffic flow without causing further delays to emergency traffic. The actual time responsiveness of the system indicated its ability to handle intricate urban traffic situations.

The operator was greatly advantaged by the user-friendly interface which showed live video feeds as well as pictures of traffic metric values including vehicle counts, density, and emergency vehicle alerts. This increased situational awareness enabled the operators to action rapidly and decisively, while the automation processes were supported. Still, there were occasional bursts of challenges under unfavourable weather conditions (heavy rain, fog) that led to a slight reduction in the accuracy of vehicle detecting. Furthermore, there is a scalability issue in the real-time processing on edge devices due to the computational need, where especially in regions with a lot of intersections and high traffic volumes provided a problem.

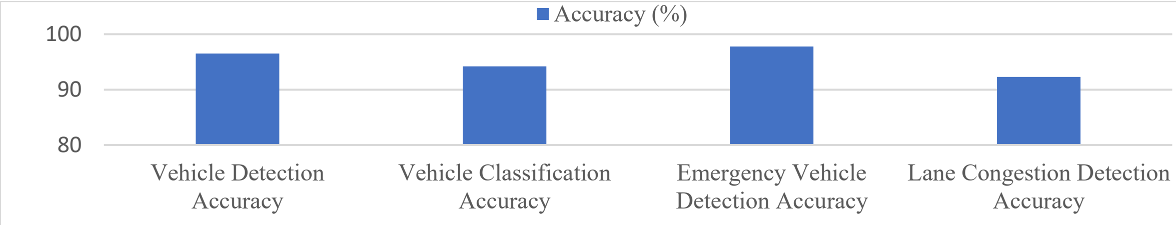

Fig. 4. Accuracy of the result

The findings of the study reiterate the usefulness of melding YOLOv11's precise object detections with the adaptive optimization offered by the DRL in urban traffic management. Although the system produced significant enhancements in traffic flow and emergency response times there is scope for improvement. Future versions may solve issues related with scalability and the environment by adopting other sensors, for example, weather-proof cameras or GPS information from emergency vehicles, and by ensuring that the deployment on large scales occurs efficiently computationally. The DRL agent will also require periodic remitting with updated traffic patterns, which will help in achieving further adaptability and performance.

CONCLUSION AND FUTURE ENHANCEMENT

The traffic monitoring and management system deals with some monumental issues affecting transport in urban spaces such as the issue of congestion, and the use of cutting-edge technology like computer vision and deep learning to prioritize emergency vehicles, deep reinforcement learning (DRL). The system improves real time traffic monitoring, dynamic signal optimization, and emergency response efficiency with an integrated solution for modern cities. The YOLOv11 object detection model is the basis of the system which lets the sensing component to sense high accuracy vehicle detection and classification. A model with an average detection precision of 96%, identifies and categoizes cars, buses, trucks and ambulances (emergency vehicles) effectively. This ability guarantees a correct number of vehicles as well as real time traffic density that is important in traffic control.

FUTURE ENHANCEMENT

Although the proposed traffic monitoring and traffic control system has shown remarkable affluence of traffic in urban areas and improved scenarios regarding emergency response, the improvement can be brought to its present limitations to make its application applicable in other applications. Future work can be directed towards enhancing the robustness, scalability, and functionality to suit the changing needs of the modern cities. Improvement in the system's performance in adverse environmental conditions is also a requirement. Vehicle detection can be influenced by heavy rain, fog or low lights. Caming on board such advanced sensor technologies as LiDAR, infrared cameras, or thermal imaging can enhance detection reliability in difficult environments. It is possible that these sensors, with their combination to the YOLOV11 model, can guarantee steady performance regardless of weather conditions. Scalability is, therefore, another area that needs to be addressed.

REFERENCE

[1]N. Zarei, P. Moallem and M. Shams, "Fast-Yolo-Rec: Incorporating Yolo-Base Detection and Recurrent-Base Prediction Networks for Fast Vehicle Detection in Consecutive Images," in IEEE Access, vol. 10, pp. 120592-120605, 2022, doi: 10.1109/ACCESS.2022.3221942.

[2] Thenmozhi, M., Saravanan, M., Kumar, K.P.M., Suseela, S. and Deepan, S., 2020. Improving the prediction rate of unusual behaviors of animal in a poultry using deep learning technique. Soft Computing, 24, pp.14491-14502.

[3] A. J, V. K and M. K, "Categorization of On Road Automobiles using Deep Learning Approach," 2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS),

Erode, India, 2022, pp. 227-233, doi: 10.1109/ICSCDS53736.2022.9761036.
[4] Ravish, Roopa & Swamy, Shanta. (2021). Intelligent Traffic Management: A Review of Challenges, Solutions, and Future Perspectives. Transport and Telecommunication Journal. 22. 163-182. 10.2478/ttj-2021-0013.
[5] C. -J. Lin and J. -Y. Jhang, "Intelligent Traffic-Monitoring System Based on YOLO and Convolutional Fuzzy Neural Networks," in IEEE Access, vol. 10, pp. 14120-14133, 2022, doi: 10.1109/ACCESS.2022.3147866.
[6] Al-Smadi, Ma'moun & Abdulrahim, Khairi & Abdul Salam, Rosalina. (2016). Traffic surveillance: A review of vision-based vehicle detection, recognition and tracking. 11. 713- 726.
[7] G. Liu et al., "Smart Traffic Monitoring System Using Computer Vision and Edge Computing," in IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 8, pp. 12027-12038, Aug. 2022, doi: 10.1109/TITS.2021.3109481.
[8] S. H. Ahmed, M. Raza, S. S. Mehdi, I. Rehman, M. Kazmi and S. A. Qazi, "Faster RCNN based Vehicle Detection and Counting Framework for Undisciplined Traffic Conditions," 2021 IEEE 18th International Conference on Smart Communities: Improving Quality of Life Using ICT, IoT and AI (HONET), 2021, pp.173-178, doi:10.1109/HONET53078.2021.9615466
[9] Peiyuan Jiang, Daji Ergu, Fangyao Liu, Ying Cai, Bo Ma, A Review of Yolo Algorithm Developments, Procedia Computer Science, Volume 199, 2022, Pages 1066-1073, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2022.01.135
[10] Dr. Prabakaran Selvaraja, M Santhanalakshmi, A Sampath Dakshina Murthy, Mohit Ranjan Panda, G Sambasiva Rao, MS Nidhya, " Enhanced Security Model For Heterogeneous Wireless Sensor Networks", IEEE 2024 15th International Conference on Computing Communication and Networking Technologies (ICCCNT) DOI: 10.1109/ICCCNT61001.2024.10724810 Kamand, India
[11] Lakshmanan, Lalit & Vora, Yash & Ghate, Raj. (2020). Deep Learning Based Vehicle Tracking System Using License Plate Detection And Recognition.
[12] F. A. Nazira, M. I. Uddin, M. H. Raju, S. Hossain, M. N. Rahman and M. F. Mridha, "Face Recognition Based Driver Detection System," 2021 International Conference on Data Analytics for Business and Industry (ICDABI), Sakheer, Bahrain, 2021, pp. 572-577, doi: 10.1109/ICDABI53623.2021.9655889.
[13] Gienapp, Lukas & Kircheis, Wolfgang & Sievers, Bjarne & Stein, Benno & Potthast, Martin. (2023). A large dataset of scientific text reuse in Open-Access publications. Scientific Data. 10. 10.1038/s41597-022-01908-z.
[14] Lanke, Ninad & Koul, Sheetal. (2013). Smart Traffic Management System. International Journal of Computer Applications. 75. 19-22. 10.5120/13123-0473.
[15] Alomari, Ahmad & Lebdeh, Enas & Awad, Bashar & Hawamdeh, Mohammed & Karasneh, Mohammad & Al-Qudah, Sara & Ajjawi, Yara. (2021). Autonomous Real-Time Multiple Vehicles Detection and Tracking System.
[16] Prasad B.V.V.S.; Ali S.S., "Software - defined networking based secure routing in mobile ad hoc network", International Journal of Engineering and Technology(UAE), 7:1.2, 229