SMART CONTROL OF TRAFFIC LIGHT USING ARTIFICIAL INTELLIGENCE

Mood Srikanth Chowhan :: srikanth14483@gmail.com

Abstract: *With the rapid increase in the number of vehicles on roads, efficient traffic management has become a growing challenge. Traditional traffic systems, including manual and static timers or sensor-based approaches, often fail to adapt to real-time traffic conditions or require expensive infrastructure. This paper presents an intelligent, camera-based traffic control system that eliminates the need for physical sensors by using computer vision and artificial intelligence. The proposed model utilizes the YOLOv8 object detection algorithm to estimate traffic density from real-time video input and adjusts signal durations accordingly. A graphical user interface (GUI) integrates two key modules: a Pygame-based traffic simulation environment and a real-time video analysis system for vehicle detection. By capturing traffic flow and dynamically adjusting signal timing per lane, the system aims to reduce congestion, improve fuel efficiency, and enhance road safety. The experimental results demonstrate the effectiveness of this approach in both simulated and real environments, highlighting the potential of AI-driven methods in future smart city traffic management solutions.*

Keywords: *YOLOv8, Real-time Traffic Detection, Intelligent Traffic Management, Pygame Simulation, Smart Traffic Lights, Lane-wise Density Estimation, Computer Vision, Artificial Intelligence, Traffic Signal Optimization, Smart City Infrastructure*

1. INTRODUCTION

Traffic conjection is among the most urgent problems of the city development and particularly at peak hours. The conventional signals systems work on a pre-determined time system; thus failing to adjust to real-time traffic situations that create frustrating delays, burning of fuel, and other sources of pollution. As the road vehicles keep increasing, it is evident that intelligent traffic solutions should be applied as there is a need to have dynamic intelligent solutions to the traffic. The following paper discusses how Artificial Intelligence (AI) in the form of computer vision and machine learning could be used to develop an intelligent traffic light control system. The system uses monitoring of live video feeds and identification of vehicle density to automatically adjust signal timing patterns to alleviate congestion and improve the efficiency of road use as well as improve commuter travel.

The explosion in human populations in cities, as well as the high concentration of traffic in cities, has considerably burdened the classic city management systems, particularly megacities. The static nature of fixed-timer signal systems cannot be used anymore to cope with the dynamic and usually unpredictable way that traffic flows in urban areas. Such obsolete structures tend to lead to more use of fuel, anger among the commuters, and high air pollution [1]. Therefore, in response, there is an increasing demand on smart, versatile, and economical traffic control systems to adapt in real time to the real-world traffic duties.

Fig1.1. A Simple Picture of Busy Traffic Signal at A City Intersection

ISSN: 2278-4632
Vol-15, Issue-09, No.02, September: 2025

Innovations in Artificial Intelligence (AI) and computer vision have turned out to be strong technologies to transform the process of traffic control. One set of studies has suggested that deep learning models such as object detection algorithms based on YOLO can be used to sense vehicle density at the intersection and dynamically signal the various traffic lights [2], [3]. There is no longer an expensive physical infrastructure such as sensors these AI-based systems use solely video surveillance and image analysis. Lane-wise density estimation and adaptive supply of the green time are among the means used to mitigate the problems of congestion and enhance the efficiency of the flows [4], [5].

The most recent studies also address the partnership of Reinforcement Learning (RL), Multi-Agent Systems and Edge-AI, in formulating an optimal adjustment of the traffic signal signal timings in single junction and multi-junction set ups. An example is that reinforcement learning-based mechanisms are able to adjust to past and real-time patterns of traffic and learn over time to shorten queue lengths and averting times [6]. Moreover, Edge-AI models are currently put into use at intersections to process video locally in order to minimize latency and optimize real-time responsiveness [8].

This paper suggests an intelligent traffic light control mechanism built on AI that employs the YOLOv8 algorithm through GPU to create realtime vehicle detection and estimation of the density without physical sensors. The system has two interactive components namely a simulation environment that is based on the pygame and a video analysis unit that has a real-time operation. The simulation mode permits the users to observe the behavior of traffic signals on the road, whereas the video mode allows optimizing the traffic in the lanes in real-time. This technology is affordable, expandable, and it has the capacity to manage the smart cities infrastructures via intelligent traffic operations.

2. LITERATURE SURVEY

In their paper, the authors study the current problem of traffic jam in the urban cities as populations and cars rise. They point at the role of traffic jams that cause delays, frustration of the drivers, as well as environmental pollution. The recommended approach presents the utilization of real-time images provided by traffic cameras on intersections that estimate the vehicle density on each of the lanes based on their processing and artificial intelligence. According to this density, the system dynamically switches traffic lights and this allows the smooth movement to occur at the busier lanes. The technique is also meant to alleviate congestion, decrease pollution and enhance the efficiency of travel by substituting intelligent control, based on data, instead of replacing old static signal systems. [1]

The impact of rapid urbanization on the situation with traffic congestion, as well as a traffic light control system based on AI, is discussed in this paper. The authors criticize the traditional fixed-timer signal systems because they do not respond to the real-time traffic variations resulting in acquired delays and fuel wastage. The autonomous algorithm can be described as their intelligent model that utilizes machine learning and computer vision technology to study the behavior of traffic patterns based on the data received by the cameras or sensors. The cross signal timing of the system can be dynamically optimized and the system learns based on past trends to consistently get better at it. The study shows that AI has the power to develop innovative, efficient, and smart traffic control programs in contemporary days. [2]

As people move towards urban centers and the number of vehicles in the cities rise, traffic jam is also becoming a big issue particularly in the megacities. As a result, this causes increased travel time, fuel usage and air pollution. Traffic control is indispensable to control this rising challenge. This paper outlines a smart traffic light control system that applies intelligent artificial intelligence and real-time processing of images to check vehicle density through intersections. The system optimises the duration of the traffic lights according to real-time traffic based on camera footage. The model suggested in the paper would allow improving the quality of management of road traffic, namely, improving the control of the signals and minimize the traffic jams based on the data. [3]

As urbanization accelerates and the number of vehicles increases, traffic congestion has become a significant challenge, especially in megacities. This leads to longer travel times, higher fuel consumption, and increased air pollution. Effective traffic control is essential to address these growing concerns. This paper proposes a smart traffic signal control system that leverages artificial intelligence and real-time image processing to monitor vehicle density at intersections. Based on live camera footage, the system dynamically adjusts traffic signal timings to match actual traffic conditions. The proposed model aims to enhance traffic management by optimizing signal control and reducing congestion through data-driven decisions. [4]

The classical traffic light control is well established and has been used to regulate traffic, however, the ever-increasing populations and the rising levels of motor vehicles and citizens have aggravated the situation in terms of congestion and pollution. With the introduction of smart cities, this paper proposes centralized traffic signal control based on exclusive wireless communications network. Several different types of urban intersections are supported by the system, and control routines are provided both in the normal traffic conditions and also in special cases: road closures caused by traffic accidents or events. Moreover, the safety precautions check the functional condition of signal lamps and send an alert to the central management centre. The functionality of the system was tested using logic analyzer and timing diagram which revealed that it offered reliable functionalities both in theory and in lab.[5]

Traffic has been considered as a major concern in a city, where congestions occur and may be found to cause delay and the risk of accidents. To solve this problem, this research has developed the concept of a smart control system of traffic signals based on the use of Artificial Intelligence (AI) and the Internet of Things (IoT). Taking an example of Shiraz City, which still uses the traditional fixed-time traffic signals, the given system would use Multi-Agent Reinforcement Learning(MARL) along with real-time data collected by sensors and cameras to adjust traffic conditions dynamically. The simulation models run on both artificial and real-world data show an extensive decrease in the waiting times and queues of vehicles as compared to the current one. The outcomes underline the usefulness of adaptive signal control based on MARLs to enhance traffic in cities.[6]

Traffic lights to control the movement of vehicles has been in existence but with the influx of cars, bus, and motorcycle movement in urban areas the traffic become very busy causing air pollution, noise and traffic jam. To address these, it has become the theme of smart cities to adopt smarter traffic systems that utilise technology to control traffic better. A centralized traffic light control wirelessly communicating network is proposed in this work. It is able to control normal intersections and special cases including accidents or road closures in addition to verifying the working status of its lights and reporting faults to a central unit. Timing diagrams tests indicated the system is dependable enough to be considered a useful step towards smarter, safer traffic regulation. [8]

3. PROPOSED METHOD

3.1 Overview of the Method

The proposed system will develop the intelligent traffic control system when there will be no physical sensors to control traffic but instead artificial intelligence and computer vision will be used. It uses live video as input to track traffic volume of the lanes on a road with the YOLOv8 object detection model. The system dynamically resets the time of traffic signals based on the number of vehicles identified within each of the lanes. The entire process is simulated by means of the Pygame-based simulation which reproduces the traffic behavior and switching of lights in real-time. This two-module system offers both a simulation (interactive) and the actual video based analysis and offers a convenient, lower cost alternative to conventional sensor-reliant systems.

3.2 Implementation Flow

The entire methodology is applied in two significant parts. To begin with, a GUI application lets the user decide to either run the Pygame simulation or to upload a real traffic video. When the simulation mode is used, the system estimates artificial counts of vehicles on a lane and changes signal timing on that basis. In case the actual video mode is chosen, frames of the uploaded video are taken at a frequency of several seconds, fed into the YOLOv8 model, and the volume of vehicles in each lane is identified. Simple logic then sets in where the denser lanes are allocated a longer green and the lighter the lanes shorter. The GUI expresses results once processed and the process also stores those results as an output video in order to be checked. This is a methodology that will support the implementation of intelligent and flexible traffic control with a minimum of infrastructure and possessing the greatest flexibility.

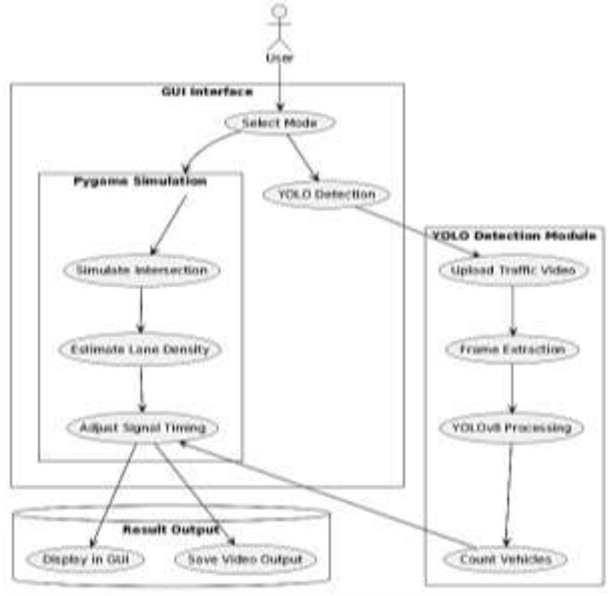

Fig. 3.1: Block Diagram of Smart Traffic Signal Control Using YOLOv8 and Pygame Simulation

As per shown in above block diagram there are two different modes of the proposed application are as below,

a) Pygame simulation
b) YOLO based traffic detection

Pygame library has advance features of virtual environment for traffic simulation while YOLO v8 is applied for real time surveillance-based traffic detection. Both methods demonstrate that how simulation traffic is a key for handling huge traffic efficiently at signals. Proposed method introduces GUI for easy understanding of the users.

YOLOv8 represents the newest state of the art in a series of object detection models named You Only Look Once, which detect and track objects in real-time. YOLOv8 is faster, accurate, and versatile in a variety of uses as compared to the older ones. It is capable of counting vehicles and spotting them within live video streams with a high level of accuracy as regards to traffic management. This aids in approximating traffic lane density without using the prohibitively costly hardware such as sensors. With the adaptation of signals timings according to the number of cars passing through the road, traffic lights in YOLOv8 can operate dynamically, lessening the load, waste of fuel, and time spent waiting in traffic.

Pygame is a Python add-on module that allows building graphical applications and games easily. In this paper, it is used to develop a virtual traffic scene in which roads, cars and traffic lights can be modelled on the screen. The simulation is able to visualize the way traffic lights would act in various conditions and enables the researcher to experiment with their AI-based traffic models prior to their application in reality. As a convenient method to visualize the traffic flows and signal change, Pygame serves as a useful system to illustrate how the system reacts to the volume of vehicles on the road and allows an effective vehicular movement process

ISSN: 2278-4632
Vol-15, Issue-09, No.02, September: 2025

4. RESULTS

To run project double click on 'run.bat' file to get below output

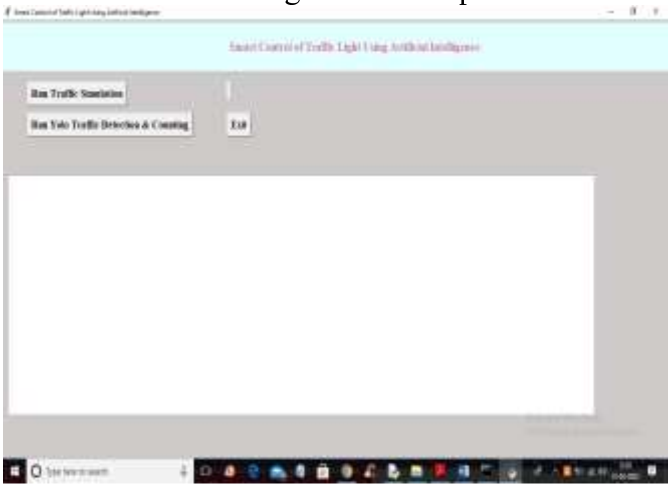

Fig. 4.1: Home Screen of the Smart Traffic Control GUI with Action Buttons

In above screen click on 'Run Traffic Simulation' button to start PYGAME simulation and get below output

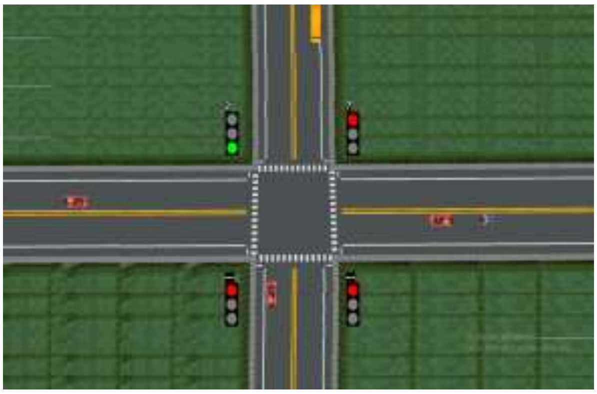

Fig. 4.2: Pygame Simulation Initiated Showing Vehicle Density at Each Lane

Fig. 4.3: Pygame Output Displaying Dynamic Signal Timings Based on Simulated Lane Density

In above screen you can see PYGAME simulation output and at each lane traffic density is calculated and then adjusts green and red line. This simulation run in INFINITE loop so you press 'windows' key from keyboard and then close application and then restart and run second YOLO module

ISSN: 2278-4632
Vol-15, Issue-09, No.02, September: 2025

Fig. 4.4: YOLOv8 Module Interface for Uploading Real-Time Traffic Video

Now in above screen click on 'Run Yolo Traffic Detection & Counting' button to upload traffic video and then estimate traffic density

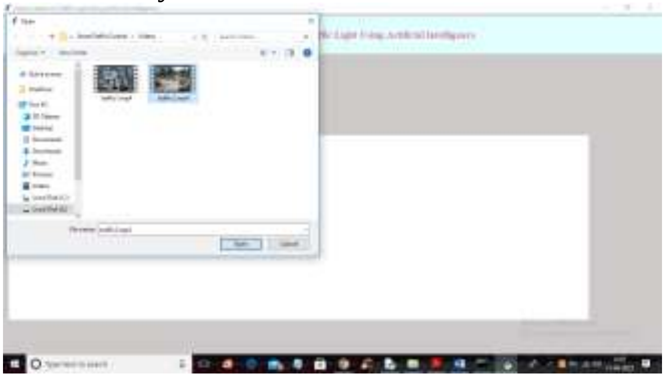

Fig. 4.5: Video Selection Dialog for Real-Time Vehicle Detection via YOLOv8

In above screen selecting and uploading 'traffic2.mp4' video and then click on 'Open' button to get below output

Fig. 4.6: YOLOv8 in Action: Detecting and Counting Vehicles from Uploaded Traffic Video

In above screen detecting traffic and then estimating its count and based on that traffic time will be adjusted. YOLO runs very slowly in normal laptop so let it finish all frame processing then u will get output.mp4 file which you can play as normal video with traffic density.

Fig. 4.7: YOLOv8 Estimating Lane-Wise Vehicle Count for Signal Time Adjustment

In YOLO family YOLO v8 model is used which is very faster and advance model for object detection. In our case objects are taken as vehicles. Different vehicles are with different colour bonding box.

Fig. 4.8: Final Output Video Generation Post YOLO Processing with Optimized Traffic Signals

YOLO model helps in finding the total vehicles by using detection with bounding box. In above picture it is observed that there are 29 vehicles which are affecting the road traffic.

Fig. 4.9: Playback of Output Video Showing Traffic Signal Optimization Based on Density

Total number of vehicles are detected in the video frame and different objects are detected with different colour bounding box. The car and motorbike are causing traffic so those are counted and we got total count as 45 vehicles which are affecting traffic.

5. CONCLSUION

In this paper we introduce a smart and efficient traffic control system that incorporates the artificial intelligence and computer vision to deploy instead of the conventional sensor-based methods. With the help of the object detection model Yolo v8, the system can detect real-time lane-wise vehicle density in RAW video and thus dynamically adapt the timing of multiple traffic signals. The simulation module realized using Pygame graphically illustrates the possibility of optimization of the traffic by effectively switching the traffic lights but the real-time detection module uses real traffic videos to prove the viability of the model. Both modules together deal with interactive, low-cost, and scalable solution that fits in the modern urban setting. The experimental findings speak of the possibility of reducing the waiting time and congestion by a great extent as the system prioritized its high-density lanes. It is less expensive to implement since the cost of deployment reduces due to the removal of physical sensors, thus making the method more flexible when pertaining to smart city infrastructure. Future work can be performed by adding en inputs of live CCTV footage to show when to open and integrate reinforcement learning so it can optimise around an ideal timing and execute the actions on embedded devices such as Raspberry Pi to test it in the real world. On the whole, the outlined AI-driven traffic management system shows good findings and can be a basis of intelligent, adaptable systems of traffic control.

This system in the future can be advanced whereby it is directly linked to direct CCTV monitoring cameras that it can be used in real-time on the real roads. Additional improvement can be achieved by adding such machine learning methods as reinforcement learning to make the system learn over time about the traffic pattern and make smarter choices. The system can work without a heavy machinery like the installation of the whole system on small machines such as Raspberry Pi to make it cheaper and easy to carry around. Finally, we can relate this system to other traffic signals in the city via the use of IoT such that as a combination act in harmony with each other to alleviate traffic and streamline the city.

REFERENCES

1. Gandhi, Mihir M., Devansh S. Solanki, Rutwij S. Daptardar, and Nirmala Shinde Baloorkar. "Smart control of traffic light using artificial intelligence." In 2020 5th IEEE international conference on recent advances and innovations in engineering (ICRAIE), pp. 1-6. IEEE, 2020.
2. Vardhan, Dunna Nandi, and B. S. Murthy. "Smart Control of Traffic Light Using Artificial Intelligence." International Journal of Management Research and Reviews 15, no. 2s (2025): 425-431.
3. Shazly, Khadija, and M. Marwa. "Utilizing Artificial Intelligence to Provide Intelligent Control of Traffic Lights." Journal of Artificial Intelligence and Metaheuristics (JAIM) 4, no. 02 (2023): 18-27.
4. Jin, Qi. "Automatic Control of Traffic Lights at Multiple Intersections Based on Artificial Intelligence and ABST Light." IEEE Access (2024).
5. Sharma, Moolchand, Ananya Bansal, Vaibhav Kashyap, Pramod Goyal, and Tariq Hussain Sheikh. "Intelligent traffic light control system based on traffic environment using deep learning." In IOP conference series: Materials science and engineering, vol. 1022, no. 1, p. 012122. IOP
6. Damadam, Shima, Mojtaba Zourbakhsh, Reza Javidan, and Azadeh Faroughi. "An intelligent IoT based traffic light management system: Deep reinforcement learning." Smart Cities 5, no. 4 (2022): 1293-1311.
7. Mahmood, S. Malik, M. Khan, and H. Mahmood, "Smart Traffic Management System Using AI-Based Decision Making," IEEE Access, vol. 9, pp. 10432–10444, 2021.
8. De Oliveira, Luiz Fernando Pinto, Leandro Tiago Manera, and Paulo Denis Garcez Da Luz. "Development of a smart traffic light control system with real-time monitoring." IEEE Internet of Things Journal 8, no. 5 (2020): 3384-3393.
9. M. Z. Ali and A. Raza, "Deep Reinforcement Learning-Based Adaptive Traffic Signal Control for Smart Cities," IEEE Internet of Things Journal, vol. 8, no. 6, pp. 4855–4863, 2021.
10. Y. Chen, K. Wang, and T. Zhang, "Edge-AI Enabled Traffic Signal Optimization," IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 4, pp. 3564–3572, 2022.
11. S. Lee and H. Kim, "YOLO-Based Real-Time Lane Density Estimation for Traffic Control," IEEE Sensors Journal, vol. 22, no. 12, pp. 11933–11941, 2022.
12. C. Zhang, M. Zhang, and J. Liu, "Multi-Agent Traffic Signal Control with MARL," IEEE Access, vol. 10, pp. 54312–54323, 2023.
13. T. Nguyen, J. Ly, and B. Tran, "Computer Vision Driven Smart Traffic Lights," IEEE Transactions on Circuits and Systems II: Express Briefs, vol. 70, no. 7, pp. 1124–1128, 2023.
14. P. Reddy and N. Sharma, "IoT and AI Enabled Traffic Light Coordination," 2024 IEEE International Smart Cities Conference (ISC2), pp. 320–325, 2024.
15. F. Khan, A. Rehman, and S. Baloch, "AI-Driven Traffic Congestion Control System for Smart Urban Areas," IEEE International Conference on Artificial Intelligence (ICAI), pp. 101–106, 2021.

