Intelligent Traffic Signal Optimization Via Real -Time Density Estimation And Vehicle Counting With Canny Edge Detection And Yolov8

Prof.Shilpa Joshi [1], Basavaraj Malipatil[2]

[1]Professor, Master of Computer Application, VTU's CPGS, Kalaburagi, Karnataka, India
[2]Student, Master of Computer Application, VTU's CPGS, Kalaburagi, Karnataka, India

---***---

Abstract - This article presents an intelligent traffic signal optimization system that aims to improve urban traffic flow through automated perception and real-time decision-making. The system collects video data that includes vehicle detection, tracking, and density estimation, based on a model of deep learning and algorithms for tracking such as YOLOv8. These perception outputs capture traffic in real-time for each approach and are reliant upon a rigorous methodology for data fusion, accounting for varying light conditions and levels of congestion. The data is processed in a manner aligned with the max pressure, where green times are re-allocated based on real-time data collection and the software recognizes and maintains the optimal signal phases to mitigate wait time, congestion, and queue buildup. The system can communicate with existing controllers, and integrates a web-based dashboard for monitoring and supplementary manual controls. Periodic experimental trials illustrate significant improvements with respect to traffic responsiveness, levels of signal delay, and operational effectiveness as compared to fixed-time traffic signal control. This study provides a foundation for additional experimentation with integrating perception based on artificial intelligence with signal optimization based on adaptive planning for intelligent transportation systems.

1.INTRODUCTION

Traffic congestion is an expanding challenge in cities, often resulting in extensive delays and poor vehicle movement. Fixed-time traffic signals, the default for controlling car flow, cannot respond to fluctuating conditions making the traffic signal ineffective at peak hours or unexpected surges. Emerging technologies, specifically in computer vision and machine learning, make it possible to remotely and in real-time analyze traffic flow without on-site inspection using video based detection, tracking, and density estimation. The intelligent signal control system proposed here employs intelligent signal control techniques using computer vision and machine learning to develop simulation models that can assess car flow and dynamically apply signal timing using a max-pressure algorithm. The ultimate goal is to reduce wait times, reduce congestion and increase the efficiency of traffic management.

2.PROBLEM STATEMENT

Conventional traffic light systems utilize fixed timing cycles and are unable to adapt to real-time changes to vehicular flow. Because of this, intersections frequently suffer from high queue lengths, excessive delays and poor traffic flow - particularly occurring during peak hours. Productivity decreases while delays continue to grow without real-time traffic monitoring and adaptive control. Thus, there is a need for an intelligent system capable of estimating traffic density utilising modern computer vision technologies and optimally adjusting signal timings in real-time to enhance traffic flow efficiency and minimize delay.

3.OBJECTIVES

The main goal of this initiative is to create a smart traffic signal control system which will self-adjust according to traffic conditions in real-time. The system will be based on computer vision methods to reliably detect and follow the movement of vehicles, track traffic density, and identify flow patterns at intersection locations. By combining these inputs, we will aim to optimize signal timings dynamically based on a suitable algorithm which will reduce congestion, waiting times, and improve overall traffic flows. Another goal of the initiative would be to present traffic information in an easily understandable dashboard that allows for monitoring and management of the system, while allowing for a straightforward integration into existing traffic control environments.

4.RESEARCH METHODOLOGY

The research method accentuates the creation of an intelligent traffic signal system through an organized and data-oriented procedure. The methodology consists of live video feeds being collected from traffic cameras and preparing the dataset for analysis. The vehicle detection and classification is then achieved using computer vision methodologies such as YOLOv8.. The detection task is followed by tracking algorithms to gauge vehicle movement. Edge detection and density estimation methodologies will be used to gauge congestion levels. The three outputs will then be fused together to provide a more reliable representation of live traffic flow. Upon acquiring a processed output, the max-pressure algorithm will be utilized to determine the optimum times for traffic lights, reduce wait times, and relieve congestion. It will be tested at various traffic conditions and compared to previous fixed-time signals to illustrate improvements in relation to the traditional signals. This methodology validates the proposed system as being accurate, adaptive to new conditions, and releasable in real-world applications.

5. REVIEW OF LITERATURE

The proposed intelligent traffic signal system successfully integrates computer vision, tracking, and density estimation to monitor real-time traffic conditions and optimize signal timings using the max-pressure algorithm. This approach reduces waiting time, minimizes congestion, and improves the overall efficiency of urban intersections compared to fixed-time methods. In the future, the system can be expanded by incorporating additional sensors, predictive machine-learning models, and multi-intersection coordination to further enhance accuracy and scalability. Integrating vehicle-to-infrastructure communication and offering mobile or cloud-based monitoring could also support smarter, city-wide traffic management.

6. SYSTEM DESIGN

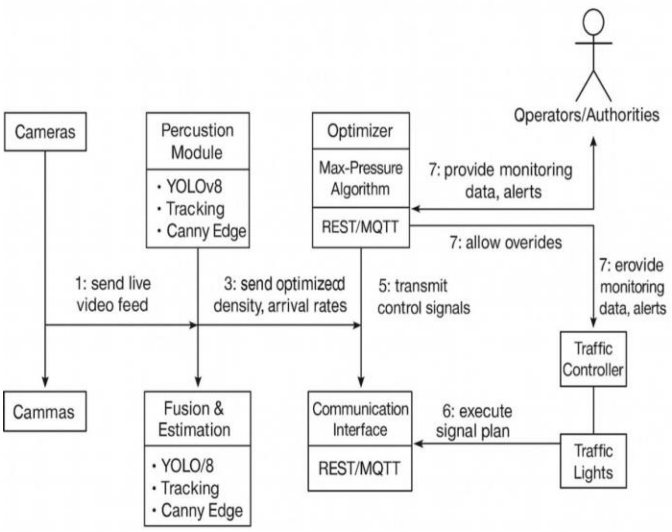

Figure 4 : Collaboration Diagram

7. SCREENSHOT

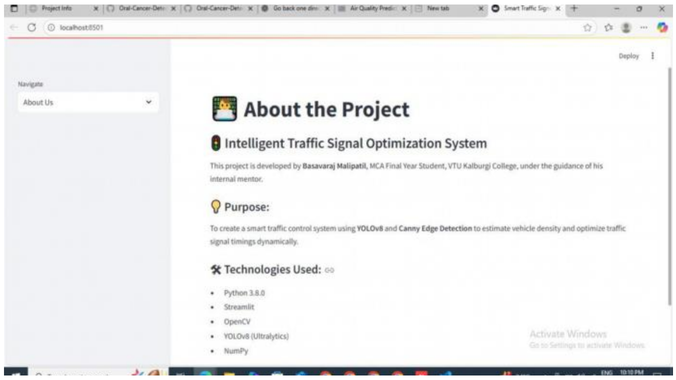

Figure8: About The Project

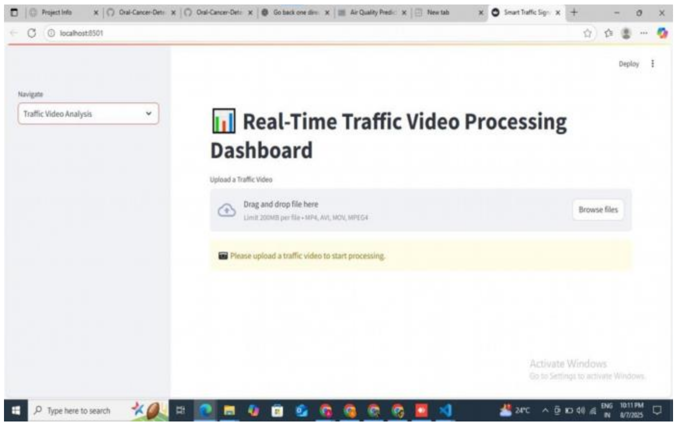

Figure9: Dashboard

Figure10: Prediction Page

8. Conclusion & Future Scope

The intelligent traffic signal system being proposed is designed to combine computer vision, tracking, and density estimation to observe present traffic conditions while controlling signal timings with the max-pressure algorithm, thus improving the waiting time, reducing congestion, and maximizing efficiency at urban intersections over fixed-time methods. The system will allow further expansion by adding other types of sensors, predicting machine learning models, and coordinating multiple intersections to increase accuracy and scalability. The integration of vehicle-to-infrastructure communication and mobile or cloud-based monitoring would also promote smarter, city-wide traffic management.

9. REFERENCES

[1] A. Bochkovskiy, C.-Y. Wang, and H.-Y. M. Liao, "YOLOv4: Optimal Speed and Accuracy of Object Detection," arXiv preprint arXiv:2004.10934, 2020.

[2] G. Jocher et al., "YOLOv5: A Family of Object Detection Models," Ultralytics, 2020.

[3] Z. Chen et al., "YOLOv8: Advanced Real-Time Object Detection and Tracking Framework," Ultralytics, 2023.

[4] A. Bewley et al., "Simple Online and Realtime Tracking," in Proc. IEEE Int. Conf. on Image Processing, 2016.

[5].W. L. Jin, "The Traffic Flow Max-Pressure Control Algorithm," Transportation Research Part C, vol. 100, pp. 44–62, 2019.

[6]. S. A. Boxill and L. Yu, "An Evaluation of Traffic Signal Control Algorithms via Microscopic Simulation," Texas Transportation Institute, 2000.

[7]M. Papageorgiou et al., "Traffic-Responsive Signal Control Methods: A Review," Transportation Research Part A, vol. 33, no. 7–8, pp. 529–548, 1999.