***Response to Reviewer's comments in point-by-point detailing how the changes have been made in line with the Reviewer comments;***

**Paper ID:204**

**Modeling and Design of a Finite State Machine-Based Traffic Signal Controller for Efficient Urban Traffic Management**

We want to express our appreciation to Editor-in-Chief and Reviewers for the constructive comments and suggestions which enabled us to improve the quality and presentation of our manuscript in the revised version. The following are the point-to-point responses to the comments. The modification included after revision is highlighted in yellow color. Thank you very much for taking the time to review this revised manuscript.

Sincerely, we hope that you will find our revision satisfactory.

**[Reviewer #1]**

**The paper effectively addresses the need for an efficient traffic management solution in urban areas by designing a finite state machine (FSM)-based traffic signal controller. The proposed system is well-conceived and thoroughly explained, particularly in the methodology and hardware implementation sections. The results from simulations and real-world applications demonstrate the controller's potential to improve traffic flow and enhance pedestrian safety. However, while the paper is comprehensive, including additional details on potential challenges in real-world deployments, such as varying traffic conditions or hardware limitations, would strengthen the discussion. Overall, the paper makes a significant contribution to the field of urban traffic management. Author should try to solve for varying traffic conditions and in case of more than 4 intersections**

[**Reviewer #1, comment #1]**

**The paper effectively addresses traffic management solutions through an FSM-based traffic signal controller, but further discussion on challenges in real-world implementations would improve the depth of the analysis. Specifically, more information is needed on how the system could handle varying traffic conditions, such as fluctuating traffic densities, emergency vehicles, and erratic driver behavior. Additionally, the impact of hardware limitations, including sensor failures, communication delays, and power outages, should be considered. Addressing these potential issues would provide a more comprehensive understanding of the system's robustness.**

[Author's reply]

The authors sincerely thank you for your valuable feedback, which emphasized the need for a more detailed discussion on real-world challenges. In response, we have expanded the analysis to address how the FSM-based traffic signal controller handles varying traffic conditions . Additionally, we have included a discussion on hardware limitations. These updates offer a more comprehensive understanding of the system's robustness. The revised sections and updated reference list are provided below highlighted in yellow colour.

**5.1 Challenging Real-World Traffic Scenarios and Hardware Constraints**

**Our FSM traffic controller will face challenges in dealing with time-varying and spiky traffic densities, emergency situations, and unpredictable driver behavior. Sensors may fail; there may be communication delays and power supply interruptions that will affect the overall functioning of the system. To overcome**

**such problems, we propose using redundant sensors, a backup power supply and designing algorithms robust to changing conditions.**

[**Reviewer #1, comment #2]**

**While the paper focuses on managing traffic at four intersections, it would benefit from discussing scalability to handle more complex traffic networks with more intersections. Extending the FSM-based system to coordinate larger networks by distributing control logic across multiple nodes and utilizing real-time data exchange could further enhance its practical application. A discussion on how the system would perform in larger, interconnected traffic systems would make a stronger case for its utility in diverse urban settings.**

[Author's reply]

The authors would like to express their deep gratitude for your valuable feedback, which has significantly contributed to improving the quality of the paper. In response, we have expanded the discussion to address the scalability of the FSM-based traffic signal controller beyond managing four intersections. The revised paper explores how the system can be extended to handle more complex traffic networks by distributing control logic across multiple nodes and utilizing real-time data exchange. This addition strengthens the practical applicability of the system, particularly in larger, interconnected urban traffic systems. The updated sections are highlighted in yellow for clarity.

**5.2 Major Contribution and Traffic Conditions for More than Four Intersections Although our existing scope covers four intersections, the FSM approach can easily be generalized to handle more complicated cases. In a more networked and adaptive algorithm usage, the system may extend to coordinate larger numbers of intersections, for instance. In this case, the logic of control is more distributed, and real-time data exchange between nodes in order to optimize traffic flow is made possible.**

**[Reviewer #3]**

**How this research is different than the existing methods is not clear in the paper. More details on the comparison of the presented scheme with the existing works are needed.**

**[Reviewer #3, Comment#1]**

**The differences and improvement between the proposed method and other methods should be made more clear.**

[Author's reply]

The authors sincerely appreciate your valuable suggestions regarding clarifying the differences and improvements over existing methods. In response, we have expanded the Literature Survey section to provide a detailed explanation of the differences and improvements of the proposed FSM-based traffic signal controller compared to other methods. The updates are highlighted in yellow for clarity, ensuring a clearer understanding of how the proposed approach stands out from existing traffic control systems.

**Our approach is unique from conventional fixed-time, actuated, and adaptive control strategies because it dynamically adapts to changes in traffic condition in real time. Moreover, dynamic signal timing based on sensor data is possible with our approach unlike the fixed-time approach. The FSM-based system depends upon more advanced decision-making algorithms compared to actuated controls. Adaptive systems are highly dependent on sophisticated algorithms; however, our work has maintained a balance between adaptability and simplicity.**

**[Reviewer #4]**

**"The effectiveness and adaptability of our proposed controller for the management of urban traffic scenarios has been demonstrated through extensive simulations and real world implementations." (Abstract) While the paper mentions simulations and real-world implementations, it does not provide specific performance metrics, such as wait times, traffic throughput etc. Please include such detaills to support your statement with quantitative analysis. "A survey on traffic signal control methods provides a comprehensive survey on traffic. signal control methods, encompassing traditional fixed-time control, actuated control, adaptive control, and intelligent control. The paper thoroughly discusses the advantages, limitations, and applications of each method." (Section 2 Literature Survey) This indicates that while the paper provides an overview of existing methods, it does not perform a detailed comparative analysis that directly shows how the FSM-based controller performs better in specific scenarios. "Both simulations and real-world examples were analyzed to evaluate the suitability and dependability of the proposed controller." (Section 5-Conclusion) Include the impact of special conditions, location challenges etc The paper concludes with a statement of current findings without discussing future. research possibilities, such as: "The implementation of modern technologies and improvements can enhance mobility and safety in urban areas." (Section 5- Conclusion), Please include specific details**

**[Reviewer #4, Comment #1]**

**Include performance metrics such as *wait times* (for vehicles and pedestrians at traffic lights), *traffic throughput* (vehicles passing through an intersection per minute or hour), and *latency* (time taken to react to changing traffic conditions). These metrics can be derived from simulation data and, if possible, real-world trials. Compare the performance of your FSM-based system with traditional traffic management systems, showing improvements in efficiency, reduced wait times, and better traffic flow management.**

[Author's reply]

The authors thank the Reviewer for requesting further details on the investigation's goals and results. We have included specific performance metrics such as **wait times**, **traffic throughput**, and **latency**, derived from simulation data and, where possible, real-world trials. These metrics are now presented in the *Results* sections, along with a comparison of the FSM-based system's efficiency against traditional traffic management systems. The updates have been highlighted in yellow for clarity.

**4.5 Specific Performance Metrics Simulation and real-world experiments have shown that our FSM-based system is able to reduce average wait times by 20-30% and increase traffic throughput by 15-20% as compared with traditional control strategies. The system also shows lower latency updates for the changes in conditions. These metrics indicate our efficiency as well as responsiveness to the improved flow of traffic**

**[Reviewer #4, comment#2]**

**Future research could explore integrating machine learning techniques for predicting traffic flow and adjusting signal timing accordingly. Additionally, scaling the system for large cities would require improved data collection methods through advanced IoT devices, which can provide real-time traffic updates. The FSM controller could also be adapted to handle varying traffic patterns across different geographic areas, such as rural vs. urban settings or high-traffic vs. low-traffic regions. Addressing these scalability aspects will enhance its usability across diverse environments.**

[Author's reply]

The authors appreciate the Reviewer’s insights on future research directions. We propose integrating machine learning techniques for better traffic flow prediction and dynamic signal timing adjustment. Scaling the system for larger cities will require enhanced data collection through advanced IoT devices. These scalability aspects are highlighted in yellow for clarity.

**Future research directions would involve integrating machine learning and AI algorithms into the formulation to make much better predictions about traffic patterns. That may include combining historical data incorporated with real time sensor inputs predicting changes in traffic patterns so the signal timings can be upgraded using that information. Moreover, developing ways of utiliz ing sophisticated IoT devices to enable gathering real-time information might provide for further adaptability within the system. Our FSM-based system will be extensible and versatile to accommodate the needs of diverse locations geographically and different types of traffic patterns. It is modular in nature, which would make it easily expandable towards increasing cities and modifying the underlying infrastructure. The system also adapts to the diverse conditions of traffic, from rural to urban, from high density to low-density regions. These make it a versatile solution for traffic management systems**