



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 7, July 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Fuzzy Logic and Deep Learning for Traffic Control

Shireesha K B ¹

Department of Master of Computer Application, RV College of Engineering Bangalore, India¹

ABSTRACT: Fuzzy logic and deep learning present exciting opportunities to enhance traffic control systems. Fuzzy logic controllers have the ability to adjust signal timings in real-time by considering various factors like traffic volume, pedestrian presence, and environmental conditions, leading to improved traffic flow and reduced congestion. On the other hand, deep learning, in combination with attention mechanisms, allows for effective analysis of human actions and driving behaviors, enabling better prediction of traffic patterns. By integrating fuzzy logic and deep learning, traffic control systems can become intelligent and adaptive, dynamically responding to changing traffic conditions and optimizing signal timings and management strategies. This integration has the potential to significantly improve traffic efficiency, safety, and overall mobility in urban areas.

KEYWORDS: fuzzy logic, deep learning, urban mobility, congestion mitigation, signal timings.

I. INTRODUCTION

In today's rapidly evolving urban environments, effective traffic control plays a crucial role in ensuring smooth mobility, reducing congestion, and enhancing overall transportation systems. Recent advancements in artificial intelligence and machine learning, particularly in the domains of fuzzy logic and deep learning, offer promising opportunities to revolutionize traffic management strategies. Fuzzy logic allows for adaptive decision-making based on imprecise and uncertain inputs, making it well-suited for handling the complexities of real-world traffic conditions. On the other hand, deep learning techniques, such as attention-based Long Short-Term Memory (LSTM), excel at analyzing vast amounts of data, enabling accurate predictions of traffic flow patterns in real-time. By integrating fuzzy logic and deep learning, we can significantly improve traffic control by optimizing signal timings, predicting traffic flow patterns in real-time, and ultimately contributing to more efficient and sustainable urban mobility.

II. LITERATURE SURVEY

[1]The paper proposes a new method for controlling traffic signals at urban intersections. The approach utilizes time-space resource scheduling to optimize traffic flow and reduce congestion. By carefully managing the allocation of time and space for vehicles at intersections, the goal is to improve overall traffic efficiency, reduce delays, and ensure smoother traffic operations in urban areas.[2]In their research propose an innovative traffic management system for intersections. The system utilizes multilayer fuzzy control and Type-2 fuzzy logic for community-based traffic forecasting. By integrating these techniques, the approach aims to optimize traffic flow and enhance overall management at intersections. Type-2 fuzzy logic enables handling uncertainties in traffic forecasts, while the multilayer fuzzy control ensures efficient traffic flow. This promising framework has the potential to revolutionize traffic control strategies, leading to smoother mobility and reduced congestion in urban areas. The research showcases the benefits of using advanced fuzzy logic techniques to improve transportation systems.[3] The study investigates how fuzzy logic can effectively analyze environmental data to optimize traffic control strategies. By utilizing fuzzy logic techniques, the aim is to improve traffic management by making well-informed decisions based on imprecise environmental inputs. The research provides valuable insights into the potential of fuzzy logic in enhancing traffic control systems through the analysis of environmental data.[4]The research paper study investigates the integration of fuzzy logic and neural networks to optimize traffic control and accurately predict traffic



patterns. By combining these techniques, the approach aims to enhance traffic management by effectively adapting to changing conditions and making precise traffic forecasts. The research sheds light on the promising potential of fuzzy neural systems in revolutionizing traffic control and forecasting strategies.[5] This paper introduces a real-time analysis system for smart manufacturing that leverages the capabilities of blockchain and machine learning. By continuously analyzing manufacturing data in real-time, the system can identify potential issues or inefficiencies and make proactive adjustments to improve production processes. This approach enables industries to achieve higher productivity, reduce downtime, and optimize resource utilization, leading to increased overall operational efficiency.[6] The paper explores the application of blockchain and machine learning in the context of intelligent ride-hailing services. By considering multiple factors, such as traffic conditions, demand, and driver availability, this approach aims to provide optimized and personalized ride-hailing services to passengers. The integration of blockchain ensures transparent and secure transactions, enhancing trust and accountability in the ride-hailing ecosystem.[7]The research explores how fuzzy logic can be employed to create an adaptive system for controlling traffic signals. By utilizing fuzzy logic techniques, the approach aims to optimize traffic flow by dynamically adjusting signal timings based on real-time traffic conditions. The study offers valuable insights into using fuzzy logic for enhancing traffic signal control systems.[8]The paper introduces a fuzzy time logic-based traffic control system. The research utilizes a hyper dynamic scheduling graph theory approach to optimize traffic management. By employing fuzzy time logic, the system dynamically adapts traffic control strategies based on real-time conditions. The study highlights the potential of this approach in improving traffic flow and efficiency, offering valuable insights for the development of advanced traffic control systems.[9] This paper focuses on the development of a sophisticated fuzzy logic-based traffic light control system. By incorporating fuzzy logic principles, the system can adapt signal timings in response to real-time traffic conditions, optimizing traffic flow and reducing congestion. The approach also considers factors such as pedestrian safety and emergency vehicle prioritization, resulting in a more efficient and responsive traffic control system.[10] The paper investigates different fuzzy logic control strategies for traffic signal timing, taking into account state inputs. By analyzing different control approaches, the study aims to identify the most suitable fuzzy logic strategy for optimizing traffic signal timings under various traffic conditions. The findings can contribute to better traffic management and improved urban mobility.[11] This paper introduces a multiagent system with Petri Net approach for simulating urban traffic networks. The proposed approach combines the multiagent system with Petri Net modeling to accurately represent and simulate traffic dynamics in urban areas. The simulation provides valuable insights into traffic patterns and enables the evaluation of traffic management strategies, contributing to more efficient traffic planning and control.[12] In their paper propose an innovative method for designing and implementing an intelligent traffic control system using fuzzy logic and FPGA (Field Programmable Gate Array) technology. The research focuses on creating an adaptive traffic control system that can efficiently manage traffic in real-time. By leveraging the power of fuzzy logic and FPGA, the study aims to enhance traffic management and contribute valuable insights into the field of intelligent traffic control systems.[13] This paper presents a model predictive perimeter control approach to stabilize city-scale road traffic networks using the macroscopic fundamental diagram. The proposed method optimizes traffic flow and reduces congestion by implementing model predictive control based on macroscopic traffic dynamics. The approach is applicable to large-scale urban networks and contributes to the improvement of overall traffic performance in complex road systems.[14]The research focuses on designing and implementing an intelligent traffic control system using fuzzy logic techniques. By leveraging fuzzy logic, the system aims to optimize traffic flow and improve overall traffic management in the region. The study offers valuable insights into the application of fuzzy logic in developing effective traffic control systems.[15] This paper presents accident risk prediction and avoidance in intelligent semi-autonomous vehicles based on road safety data and driver behavior. By leveraging machine learning and road safety data, the proposed system predicts potential accident risk and assists drivers in making safer decisions. This technology has significant implications for improving road safety and promoting the adoption of semi-autonomous vehicle systems.[16] The paper proposes a genetic timing scheduling model for urban traffic signal control. By applying genetic algorithms to optimize signal timings, the proposed approach aims to reduce traffic congestion and improve overall traffic flow in urban areas. The genetic timing scheduling model considers various factors, such as traffic demand and road conditions, to ensure adaptive and efficient traffic signal control.[17]The paper focuses on designing and implementing an intelligent traffic control system using fuzzy logic techniques. By leveraging fuzzy logic, the system aims to optimize traffic flow and improve overall traffic management in the region. The study offers valuable insights into the application of fuzzy logic in developing effective traffic control systems.[18] The paper explores fuzzy control under time-varying universes and phase optimization for traffic lights. By incorporating fuzzy logic principles with a time-varying universe, the approach optimizes the timing of traffic signals to accommodate fluctuations in traffic demand. This ensures efficient traffic flow and reduced congestion during varying traffic conditions, making it suitable for real-

world traffic management applications.[19]The paper presents an adaptive method for traffic signal control using fuzzy logic and the Webster and Modified Webster formulas. The study utilizes the SUMO Traffic Simulator for implementation. By integrating fuzzy logic with these traffic formulas, the approach aims to optimize traffic signal control for better efficiency and reduced congestion. The research offers valuable insights into developing adaptive traffic control systems using fuzzy logic techniques and traffic simulation..[20] The paper presents a traffic flow prediction model for urban road networks using license plate recognition data. The model combines attention-LSTM and genetic algorithms to accurately forecast traffic conditions. The approach holds potential for improving traffic management, enabling authorities to implement proactive measures to mitigate congestion.

III. PROPOSED METHODOLOGY

Fuzzy logic is a powerful and versatile computational approach that deals with uncertainty and imprecise information. It enables decision-making and reasoning in complex and ambiguous situations. Unlike traditional binary logic with only true or false statements, fuzzy logic introduces degrees of truth, allowing for gradual membership between the two extremes. It uses linguistic variables and membership functions to represent uncertainty and vagueness. The key strength of fuzzy logic lies in its ability to handle approximate reasoning, creating a connection between human reasoning and machine computation. As a result, fuzzy logic finds applications in various fields, including control systems, pattern recognition, artificial intelligence, and decision-making processes.

Fuzzy logic Architecture:The block diagram would show the flow of data and processes as blocks connected by arrows, representing the sequence of steps for implementing fuzzy logic in deep learning.

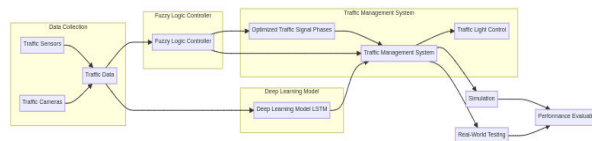


Figure: Architecture of proposed methodology

To achieve this methodology, the following steps can be followed:

The architecture diagram of fuzzy logic represents the flow of information and processes involved in a fuzzy logic-based system. Fuzzy logic is a computational approach that actually deals with uncertainty and imprecision by using linguistic variables and rules to make decisions. The architecture diagram consists of several things that work together to achieve the desired control.

i. Data Collection:The traffic flow control system initiates comprehensive data collection from sensors and cameras installed at various intersections. Traffic sensors gather real-time information, including traffic density and vehicle speed, while cameras capture visual data about road conditions. This rich dataset provides crucial insights into the current state at each intersection.

ii. Fuzzy Logic Controller:The collected traffic data is then fed into a sophisticated Fuzzy Logic Controller (FLC). The FLC utilizes linguistic variables and membership functions to process the incoming data effectively. By considering multiple factors, such as traffic density, vehicle speed, and road conditions, the FLC makes intelligent decisions on optimizing traffic signal phases. These decisions are based on predefined fuzzy rules, which have been established using expert knowledge and historical traffic data.

iii. Deep Learning Model (LSTM):The traffic flow control system further incorporates a state-of-the-art Deep Learning Model based on Long Short-Term Memory (LSTM) neural network architecture. The LSTM model is well-suited for capturing temporal dependencies in sequential data, making it ideal for predicting traffic patterns. It leverages historical traffic data to train the model and enable it to make accurate traffic forecasts for future time intervals.



iv Optimized Traffic Signal Phases:The outputs from both the Fuzzy Logic Controller and the Deep Learning Model are seamlessly integrated to determine the optimized traffic signal phases. By combining the knowledge-based decisions from the FLC with the data-driven predictions from the LSTM model, the system achieves a holistic approach to traffic signal optimization. This integration allows the system to adapt dynamically to changing traffic conditions, leading to more efficient traffic flow and reduced congestion at intersections.

v. Traffic Management System:The central decision-making unit, orchestrating the entire traffic control process. It integrates the Fuzzy Logic Controller, Deep Learning Model, and the optimized signal phases to create a unified traffic control strategy. This centralized approach ensures seamless coordination between different components of the system and enables real-time adjustments based on the present traffic situation.

vi. Simulation and Performance Evaluation:To evaluate the system's performance and validate its effectiveness, it undergoes rigorous simulation tests. These tests involve various traffic scenarios, helping to analyze how the system responds to different traffic patterns and conditions. Performance evaluation metrics, such as traffic flow efficiency and waiting times, are carefully measured and compared with conventional traffic controls of different methods. The simulation results play a vital role in fine-tuning the system and identifying areas for improvement.

vii. Real-World TestingAfter successful simulations, the system progresses to real-world testing in live traffic conditions. This critical phase aims to validate the system's practical applicability and effectiveness in real-world urban transportation settings. The system is deployed in selected intersections or road networks to observe its performance in real-time traffic situations. Any issues or challenges which arise during this testing phase are addressed, and further refinements are made to enhance the system's robustness.

By leveraging the power of both fuzzy logic and deep learning, this smarter traffic flow control system significantly improves urban traffic management. The integration of data-driven predictions from the LSTM model with knowledge-based decisions from the Fuzzy Logic Controller leads to optimized traffic signal timings, smoother traffic flow, and enhanced safety on the roads. The real-time adaptability of the system, combined with its simulation-based fine-tuning, ensures that it can handle complex traffic scenarios and effectively contribute to a more efficient and sustainable urban transportation network.

IV. CONCLUSIONS

In conclusion, the combination of fuzzy logic and deep learning techniques presents an exciting opportunity to revolutionize the systems. By harnessing the adaptability of fuzzy logic to handle uncertain inputs and the analytical capabilities of deep learning to process complex data, traffic management strategies can be optimized for real-world conditions. The utilization of attention-based LSTM for real-time traffic flow prediction empowers authorities to take proactive measures in alleviating congestion and enhancing transportation efficiency. Integrating these powerful technologies has more potential to create more sustainable and efficient urban mobility, resulting in smoother traffic flow, reduced delays, and overall improved transportation systems. Embracing these advancements will pave more smarter, more responsive, and safer cities in the future.

V. FUTURE ENHANCEMENTS

The integration of fuzzy logic and deep learning promises to revolutionize the way we manage urban mobility. By combining the adaptive capabilities of fuzzy logic with the predictive power of deep learning, intelligent traffic systems can be created. These systems can accurately forecast traffic flow, optimize signal timings, and dynamically adapt to changing conditions in real-time. To enhance future implementations, attention-based LSTM models can be improved by utilizing larger datasets and integrating up-to-date traffic information. Additionally, incorporating reinforcement learning algorithms can enable the system to continuously learn and optimize its decision-making process. The future of traffic control lies in creating smart, responsive, and sustainable systems that effectively manage urban mobility challenges.

REFERENCES

- [1] L. Zhang, Q. Zhao, L. Wang and L. Zhang, "Urban Intersection Signal Control Based on Time-Space Resource Scheduling," in *IEEE Access*, vol. 9, pp. 49281-49291, 2021 10.1109/ACCESS.2021.3059496.
- [2] Z. Weibin and L. Wenjiang, "Multilayer Fuzzy Control of Intersections Community Based Traffic Forecast of Type-2 Fuzzy Logic," 2007 Chinese Control Conference, Zhangjiajie, China, 2007, pp. 309-313, 10.1109/CHICC.2006.4347009.
- [3] B. Krause, C. von Altrock and M. Pozybill, "Fuzzy logic data analysis of environmental data for traffic control," *Proceedings of 6th International Fuzzy Systems Conference*, Barcelona, Spain, 1997, pp. 835-838 vol.2. 10.1109/FUZZY.1997.622818.
- [4] H. Hellendoorn and R. Baudrexl, "Fuzzy neural traffic control and forecasting," *Proceedings of 1995 IEEE International Conference on Fuzzy Systems*, Yokohama, Japan, 1995, pp. 2187-2194 vol.4. 10.1109/FUZZY.1995.409983.
- [5] Shahbazi, Z.; Byun, Y.-C. Smart Manufacturing Real-Time Analysis Based on Blockchain and Machine Learning Approaches. *Appl. Sci.* 2021, *11*, 3535. <https://doi.org/10.3390/app11083535>
- [6] Z. Shahbazi and Y. Byun, "Blockchain and machine learning for intelligent multiple factor-based ride-hailing services," *Computers, Materials & Continua*, vol. 70, no.3, pp. 4429–4446, 2022.
- [7] S. Chiu and S. Chand, "Adaptive traffic signal control using fuzzy logic," [Proceedings 1993] *Second IEEE International Conference on Fuzzy Systems*, San Francisco, CA, USA, 1993, pp. 1371-1376 vol.2. 10.1109/FUZZY.1993.327593.
- [8] A. Rathour, "Fuzzy Time Logic-Based Traffic Control System Using Hyper Dynamic Scheduling Graph Theory Approach for Traffic Environment," 2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2023, pp. 2392-2397, 10.1109/ICACCS57279.2023.10113083.
- [9] A. Vogel, I. Oremović, R. Šimić and E. Ivanjko, "Improving Traffic Light Control by Means of Fuzzy Logic," 2018 International Symposium ELMAR, Zadar, Croatia, 2018, pp. 51-56. 10.23919/ELMAR.2018.8534692.
- [10] Tunc, Ilhan, Atakan Yasin Yesilyurt, and Mehmet Turan Soylemez. "Different fuzzy logic control strategies for traffic signal timing control with state inputs." *IFAC-PapersOnLine* 54.2 (2021): 265-270.
- [11] Geronimo, Mauricio Flores, et al. "A multiagent systems with Petri Net approach for simulation of urban traffic networks." *Computers, Environment and Urban Systems* 89 (2021): 101662.
- [12] M. Ramzanzad and H. Rashidy Kanan, "A new method for design and implementation of intelligent traffic control system based on fuzzy logic using FPGA," 2013 13th Iranian Conference on Fuzzy Systems (IFSC), Qazvin, Iran, 2013, pp. 1-4. 10.1109/IFSC.2013.6675630.
- [13] Sirmatel, Isik Ilber, and Nikolas Geroliminis. "Stabilization of city-scale road traffic networks via macroscopic fundamental diagram-based model predictive perimeter control." *Control Engineering Practice* 109 (2021): 104750.
- [14] C. Karakuzu and E. Topal, "Fuzzy Logic Based Traffic Control System in Bilecik Province," 2019 4th International Conference on Computer Science and Engineering (UBMK), Samsun, Turkey, 2019, pp. 255-260. 10.1109/UBMK.2019.8907180.
- [15] Ahmad, Shabir et al. 'Accident Risk Prediction and Avoidance in Intelligent Semi-autonomous Vehicles Based on Road Safety Data and Driver Biological Behaviours'. 1 Jan. 2020 : 4591 – 4601.
- [16] Wang, Huan, Po Hu, and Hao Wang. "A genetic timing scheduling model for urban traffic signal control." *Information Sciences* 576 (2021): 475-483.
- [17] J. L. L. Tiberio, M. Gelian Ante, E. Dadios and J. A. C. Jose, "Density Based Fuzzy Logic Control Scheme for a Multi-Stoplight Road Network Implemented on a Simplified Traffic Model," 2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication, Environment, and Management (HNICEM), Boracay Island, Philippines, 2022, pp. 1-6. 10.1109/HNICEM57413.2022.10109454.
- [18] Zhou, C., Mo, H., Chen, X. et al. Fuzzy Control Under Time-Varying Universe and Phase Optimization in Traffic Lights (ICSSE 2020). *Int. J. Fuzzy Syst.* 23, 692–703 (2021). <https://doi.org/10.1007/s40815-020-00995-7>
- [19] M. E. M. Ali, A. Durdu, S. A. Celtek and A. Yilmaz, "An Adaptive Method for Traffic Signal Control Based on Fuzzy Logic With Webster and Modified Webster Formula Using SUMO Traffic Simulator," in *IEEE Access*, vol. 9, pp. 102985-102997, 2021, 10.1109/ACCESS.2021.3094270.
- [20] Tang, Jinjun, et al. "Traffic flow prediction on urban road network based on license plate recognition data: combining attention-LSTM with genetic algorithm." *Transportmetrica A: Transport Science* 17.4 (2021): 1217-1243.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.423



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

9940 572 462 6381 907 438 ijirset@gmail.com



www.ijirset.com

Scan to save the contact details