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Traffic Light Optimization using Fuzzy Logic and Genetic Algorithim

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Abstract
Traffic congestion in the major issue in smart city,as it causes a lot of environmental pollution and difficulty in transportation, which leads to difficult daily life for the human beings in addition to material losses. In this work a smart traffic congestion time estimated model was designed using fuzzy logic and image processing with MATLAB, to control movement in two ways, aided by a camera and auto sensors. The Fuzzy logic has two inputs and one outputs designed, the console input is the number of cars on each road and the estimated time of the congestion on road. Our system can be employed in solving the problem of traffic congestion in the all smart cities.

Keywords: Traffic congestion; smart city; traffic light; fuzzy logic; vehicle; inference engine

Introduction

traffic congestion is a big issue in current time in development countries, there different real time management system are used to manage traffic .in this researcher paper we purposed a model based on fuzzy logic and other parameters. Traffic system is more dependent on various parameters such as time, day, season, weather and unpredictable situations in road. A fuzzy logic controller system gives a better most favorable solution for the fluctuating traffic system. Controlling the traffic flow system using fuzzy technology has the ability to convert human thinking process into an algorithm using some mathematical models. Various concept are used for control the traffic. Implementation of real rules which are similar to the way that traffic policemen would think to manage traffic signal lights can be done by fuzzy if-then rules.

Literature review

Today's traffic is one of the major global issues, and an urban traffic system is essential for managing daily movement. Developing an urban street network between the network and related traffic flow can improve the preparation capabilities of urban systems. This study [1] proposes a new model of urban transport in megacities using a multiagent system and pertinent method. This used to be used for complex urban traffic, based on interconnectivity, i.e., a traffic signal with Petri Nets to show a natural behavior. The process of urban systems can assist in the comprehension of the urban street network. This article studies the impact of

the character proportion of a square urban network on the dynamics of traffic systems. The application of road networks was observed using the Macroscopic Fundamental Diagram (MFD) [2]. Due to the significant increase in vehicles in modern decades, urban traffic congestion became increasingly severe. Furthermore, urban overcrowding creates noise pollution. There are collected dynamical models of city-scale traffic that can help to develop model-based perimeter control methods. Controlling traffic in urban road networks remains challenging. As such, it was suggested a nonlinear model with a predictive perimeter control system for ordinance and commercial optimization goals, with closed-loop stability during development, which is for the effective and reliable control of city-scale traffic [3–6].

Traffic light control and the flow of urban traffic are essential elements for city traffic management. This paper proposes a genetic scheduling model for traffic light control, which has a status update feature that was developed to customize road signs. Also, this model can improve the cycle of road signals at different intersections dynamically [7]. It is very flexible. The fuzzy logic controller get inputs from the images taken from cameras fixed at unique location on the road.

A well described by a random probability distribution in the flexibility of fuzzy logic give good result in simulations.[21]This controller model gives a suitable green flexible timing that depends on the number of vehicle in each road, which can ensure vehicles are not allowed to wait too long on the road. While in the case of fixed time controller green time cannot be changed automatically, our system will give the green time according to the traffic congestion. So, arriving cars must activate the traffic signal time. The performance of the FLSC is affected by traffic congestion. The fuzzy logic control system has proven better in terms of improving the flow of traffic lights in the cities of different cities. In the future, this system will be proven on datasets from multiple city and location, and to provide better results it will include a tracking stage to determine the traffic situation on the road before arriving at the traffic light is reached .Here, we countered the problem during obtaining the data on the speed and driving direction of vehicles based on the video stream from street surveillance cameras. The difficulty during this measures is caused by the given factors: different viewing angle, remoteness from the intersection, overlapping of objects. [22] it add an additional mask branch in the YOLO v3 neural set-up architecture and optimized the shapes of anchors to improve the precision of detection and categorization of objects of different sizes to recover the quality of object tracking. To determine the speed in real time, countered a method based on the application of a perspective transformation of the coordinates of vehicles in the image to geographic coordinates.

In various study find fuzzy logic, KNN and image processing to identify vehicular congestion. Using this technique categorization of vehicles according to its area is possible with ease. there, three main vehicles (bus, cars and bike) were used as a subject as it is the main proponent of public roadways. MATLAB algorithm was used on processing both image and classification of the vehicles from external camera unit. Image processing serves as the tool for feature extraction such as area and the data was used in fuzzy logic. All vehicle samples were given rules set such as few, moderate, and heavy and the outcome is the degree of congestion (light congestion, moderate congestion and heavy congestion) rated as

percentage. Consequently, the study shows that incorporation of KNN, fuzzy logic and image processing is a great way for determining vehicular congestion.[23]

FWFA is a method that combines the concept of water flow algorithm and fuzzy-logic method. It was used to build up the optimization model that is a element of the constructed DSS. The superlative decision was proposed as a road traffic engineering to reduce the level of traffic congestion; where it is related to the road traffic velocity. In accumulation, the concept of fuzzy-logic was practically used to improvement the value of expert decision in determining the urgency value of decision alternatives. It was technically embedded to WFA based optimization model to expand the model. And, the extended model was operated to develop the constructed DSS.[24]

The continuous evolution of the economy and the growth of the population are increasing the mobility issue. It is hoped that the movement between two locations can be achieved as safely and quickly as possible. Studies shown that by modeling real traffic situations, solutions for transport optimization can be found. Various traffic patterns have been developed on various levels of abstraction to give the information of interest as clear as possible. Agent-based modeling is a modeling style that manages to capture individuals and how they interact. The application of this method has been done in this using the Any Logic simulation tool. Through the library dedicated to road transport modeling, Any Logic offers extensive study opportunities on traffic. The most relevant point of study within a network are intersections. Traffic mode configuration is decisive in traffic flow.[25]

Improving transportation efficiency is still an active and challenging research area due to the criticality of the transportation infrastructure being monitored by such systems. This article has provided a comprehensive study of the TMSs, emphasizing the main challenges and shortcomings of the existing systems and suggesting some directions to improve the TMS efficiency. First, we have presented a comprehensive over view of the state of the art in TMS, where the three main TMS phases were described: information gathering, information process, and service delivery. We have also proposed an in-depth classification and review of TMS services organized by their architecture and goals. Furthermore, a qualitative analysis was done based on TMS described. Finally, we presented our vision on improving TMS efficiency and robustness to achieve the desired level of accuracy and traffic control, where this improvement relies on targeting the open challenges. In addition, we have identified and discussed some potential efforts to solve it.

Table 1. Related Study of Urban Traffic

S.No.	Model	Objective	Limit	Author
1.	IoT-based trafficprediction[10]	Optimization	Smart city	M.; Tripathi, S.; Devi, V.B.; Bhardwaj
2.	Effective hybrid-heuristic	Optimization speed of the	Urban traffic	Teng, T.C.; Liao, J.T.; Chiang, M.C

	algorithm[11]	searchalgorithm	light	
3.	Reduce congestion and improve the safety[12]	Reduce congestion and improve	Urban traffic	Khelafa, I.; Ballouk, A.; Baghdad
4.	Machine learning techniques[14]	Optimization	Traffic signal control	Devi, G.L.; Neelapu, R.
5.	Long short-term memory neural network[16]	Real-time signal queue length prediction	Urban traffic	Rahman, R.; Hasan, S.
6.	Deep learning[18]	Forecasting urban traffic	Urban traffic	Vázquez, J.J.; Arjona, J.; Linares, M.; Casanovas-Garcia,

Purposed model –

An Optimal traffic management system consists the major characteristics of flexibility in environmental changes and also focus on intelligence of the system. The output of the fuzzy system based on the knowledge and previous experience of expert operating system. In the fuzzy system experience consider as non linear function in the model. In fuzzy logic method, the linguistic variable gives the score that are used to convert the fuzzy set .In this model input consider and convert in to linguistics variable and then use this variable in membership function and determine the best result. Fuzzy mathematics includes fuzzy sets and include various mathematical operations. In classical set the collected data are defined as member of the set or not, and the related boundaries are used to determine the best result and degree of membership function which is a between zero and one.

Purposed Model use following -

- **Input classified in two categories –**

1.Arrival of vehicle

2.Number of Vehicle in queue

- **Output are-**

1. Prediction time of delay

Table 2. show input and their corresponding output

Input				Output	
Arrival of vehicle		Number of Vehicle in queue		Prediction time of delay	
Range	Linguist Variable	Range	Linguist Variable	Range	Linguist Variable
0-5	Very Small (VS)	0-7	Very Small (VS)	0-5	Very Small (VS)
0-15	Small (S)	0-15	Small (S)	4-10	Small (S)
12-30	Medium (M)	10-30	Medium (M)	8-20	Medium (M)
25-45	Large(L)	26-50	Large(L)	15-25	Large(L)
40-65	Very Large(VL)	30-65	Very Large(VL)	25-50	Very Large(VL)

Fuzzy Rules-

S.No.	Arrival of vehicle	Number of Vehicle in queue	Prediction time of delay
1.	VS	VS	VS
2.	VS	S	S
3.	VS	M	S
4.	VS	L	M
5.	VS	VL	L
6.	S	S	VS
7.	S	M	S
8.	S	L	M
9.	M	S	S
10.	M	M	M
11.	M	L	L
12.	L	S	M
13.	L	M	L
14.	L	L	VL
15.	VL	VS	S
16.	VL	S	M
17.	VL	M	L
18.	VL	L	L
19.	VL	VL	VL

- Data collection methods - Kaggle

Surveys. Surveys are physical or digital questionnaires that gather both qualitative and quantitative data from subjects. Transactional Tracking. Interviews and Focus Groups. Observation. Online Tracking. Forms.Social Media Monitoring.

Primary data is collected from the first-hand experience and is not used in the past. The data gathered by primary data collection methods are specific to the research's motive and highly accurate. Primary data collection methods can be divided into two categories: quantitative methods and qualitative methods.

❖ Membership function and their screen shots

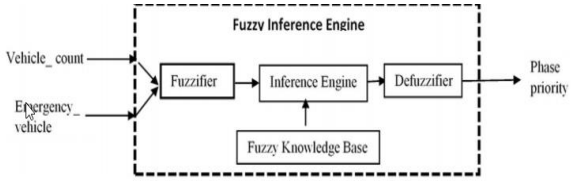


Fig. 7 Fuzzy expert system for phase priority determination

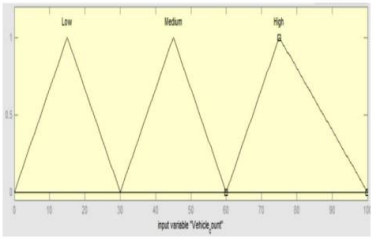


Fig. 8 Membership function plot for Vehicle_count

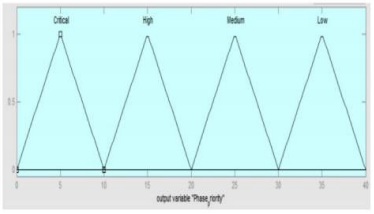
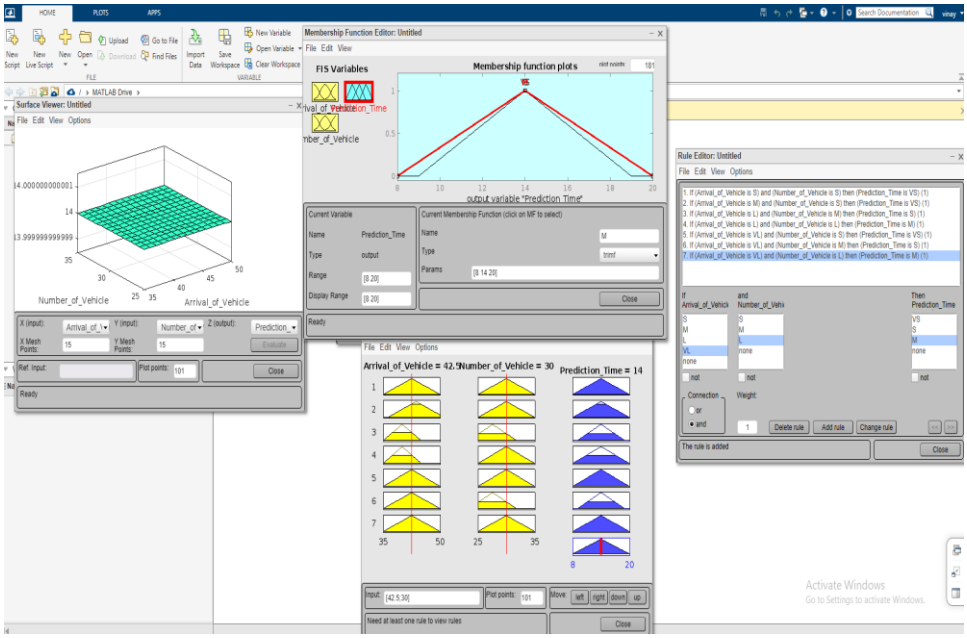
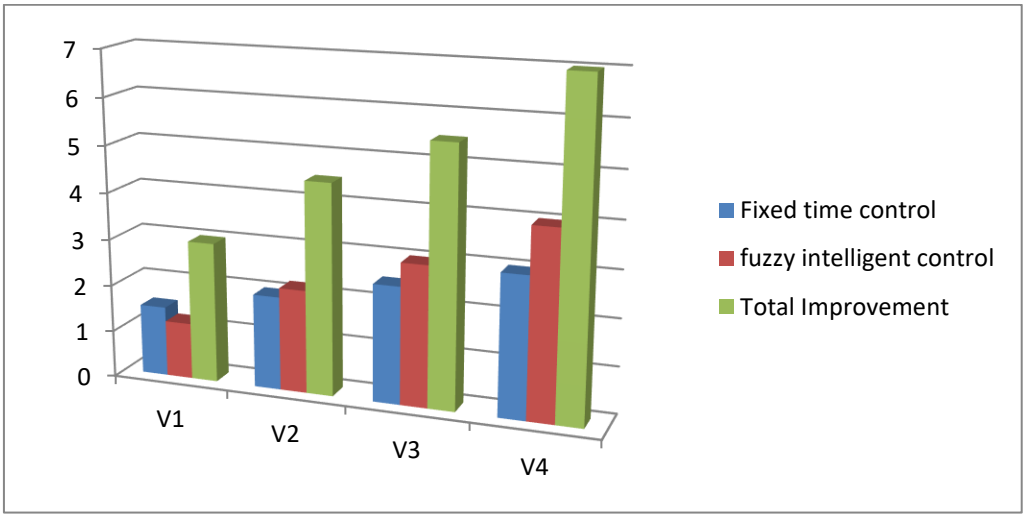


Fig. 10 Membership function plot for Phase_priority

A membership function (MF) is a curve that explain every point in the input space is mapped to a membership value between 0 and 1, the membership function of a fuzzy set is a generalization of the indicator function for classical sets. In fuzzy logic membership function the value of input by linguistics variable and corresponding output values are combine the graph and give the proper classification of the range with parameters.



- Conclusion –In this research paper we use linguists variable approach in fuzzy logic to reduce the traffic consumption time and assessment the best route with minimum travel time and also rectified the traffic light timing as compare the general model. In future this model enhance the best of special vehicles travel time in traffic consumption also combine to approach fuzzy logic and various genetic algorithm approaches.



References

1. Geronimo, M.F.; Martinez, E.G.H.; Vazquez, E.D.F.; Godoy, J.J.F.; Anaya, G.F. A multiagent systems with Petri Net approach for simulation of urban traffic networks. Comput. Environ. Urban Syst. 2021, 89, 101662.
2. Wu, C.Y.; Hu, M.B.; Jiang, R.; Hao, Q.Y. Effects of road network structure on the performance of urban traffic systems. Phys. A Stat. Mech. Its Appl. 2021, 563, 125361.
3. Sirmatel, I.I.; Geroliminis, N. Stabilization of city-scale road traffic networks via macroscopic fundamental diagram-based model predictive perimeter control. Control Eng. Pract. 2021, 109, 104750.
4. Jamil, F.; Kim, D. Payment mechanism for electronic charging using blockchain in smart vehicle. Korea 2019, 30, 31.
5. Ahmad, S.; Jamil, F.; Khudoyberdiev, A.; Kim, D. Accident risk prediction and avoidance in intelligent semi-autonomous vehicles based on road safety data and driver biological behaviours. J. Intell. Fuzzy Syst. 2020, 38, 4591–4601.
6. Ahmad, S.; Jamil, F.; Iqbal, N.; Kim, D. Optimal route recommendation for waste carrier vehicles for efficient waste collection: A step forward towards sustainable cities. IEEE Access 2020, 8, 77875–77887.
7. Wang, H.; Hu, P.; Wang, H. A genetic timing scheduling model for urban traffic signal control. Inf. Sci. 2021, 576, 475–483.
8. Vázquez, J.J.; Arjona, J.; Linares, M.; Casanovas-Garcia, J. A comparison of deep learning methods for urban traffic forecasting using floating car data. Transp. Res. Procedia 2020, 47, 195–202.
9. Chu, T.; Wang, J.; Codecà, L.; Li, Z. Multi-agent deep reinforcement learning for large-scale traffic signal control. IEEE Trans. Intell. Transp. Syst. 2019, 21, 1086–1095.
10. Neelakandan, S.; Berlin, M.; Tripathi, S.; Devi, V.B.; Bhardwaj, I.; Arulkumar, N. IoT-based traffic prediction and traffic signal control system for smart city. Soft Comput. 2021, 25, 12241–12248.
11. Tsai, C.W.; Teng, T.C.; Liao, J.T.; Chiang, M.C. An effective hybrid-heuristic algorithm for urban traffic light scheduling. Neural Comput. Appl. 2021, 33, 17535–17549.

12. Joo, H.; Ahmed, S.H.; Lim, Y. Traffic signal control for smart cities using reinforcement learning. Comput. Commun. 2020, 154, 324–330.
13. Rahman, R.; Hasan, S. Real-time signal queue length prediction using long short-term memory neural network. Neural Comput. Appl. 2021, 33, 3311–3324.
14. Wang, J.; Lv, W.; Jiang, Y.; Qin, S.; Li, J. A multi-agent based cellular automata model for intersection traffic control simulation. Phys. A Stat. Mech. Its Appl. 2021, 584, 126356.
15. Zhao, H.; Han, G.; Niu, X. The signal control optimization of road intersections with slow traffic based on improved PSO. Mob. Netw. Appl. 2020, 25, 623–631.
16. Mao, T.; Mihˇaitˇa, A.S.; Chen, F.; Vu, H.L. Boosted Genetic Algorithm using Machine Learning for traffic control optimization. IEEE Trans. Intell. Transp. Syst. 2021.
17. Khelafa, I.; Ballouk, A.; Baghdad, A. Control algorithm for the urban traffic using a realtime simulation. Int. J. Electr. Comput. Eng. 2021, 11, 3934–3942.
18. Mou, J. Intersection traffic control based on multi-objective optimization. IEEE Access 2020, 8, 61615–61620.
19. Ali, M.; Devi, G.L.; Neelapu, R. Intelligent Traffic Signal Control System Using Machine Learning Techniques. In Microelectronics, Electromagnetics and Telecommunications; Springer: Berlin, Germany, 2021; pp. 611–619.
20.Park, I.S.; Park, C.e.; Kwon, N.K.; Park, P. Dynamic output-feedback control for singular interval-valued fuzzy systems: Linear matrix inequality approach. Inf. Sci. 2021, 576, 393–406.
21. Intelligent Traffic Light Controller using Fuzzy Logic and Image Processing Abdelkader Chabchoub1 , Ali Hamouda , Saleh Al-Ahmadi , Adnen Cherif(IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 12, No. 4, 2021
22.Real-time monitoring of trafc parameters Kirill Khazukov, Vladimir Shepelev , Tatiana Karpeta, Salavat Shabiev, Ivan Slobodin, Irakli Charbadze, https://doi.org/10.1186/s40537-020-00358-x
23. Fuzzy Logic Based Vehicular Congestion Estimation Monitoring System Using Image Processing and KNN Classifier Kent Edve Neil T. Rabe, Edwin R. Arboleda, Adonis A. Andilab, Rhowel M. Dellosa, International Journal Of Scientific & Technology Research Volume 8, Issue 08, August 2019 Issn 2277-8616
24. FWFA Optimization based Decision Support System for Road Traffic Engineering D N Utama, F A Zaki, I J Munjeri, N U Putri, IOP Conf. Series: Journal of Physics: Conf. Series 801 (2017) 012016 doi:10.1088/1742-6596/801/1/012016
25.TrafficLightsManagementUsingOptimizationToolMădălin-DorinPop, doi: 10.1016/j.sbspro.2018.04.008