Implementation of Artificial Intelligence in Traffic Engineering Management; A Short Review

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Abstract— **Several technologies, including fuzzy logic, Q-learning, neural networks, the internet of things, and evolutionary algorithms, are commonly used to solve this topic in an effort to find answers to traffic problems in metropolitan areas. Furthermore, these techniques highlight the optimization function, resulting in a traffic signal control design that may optimize the number of cars in a system, with implications for minimizing waiting times and the volume of vehicles in waiting situations. The likelihood of obtaining a reduction in the amount of noise and pollution created by motorized vehicles is the next impact of this. Based on these considerations, a number of previously described ways may be classed as one strategy in producing a design or design that is directed to the built environment and in accordance with sustainable development goals. This research is an approach to reviewing the processes that may be established artificially in the traffic system so that it can adapt to the situations around it in real time.**

Keywords— **Put your keywords here, keywords are separated by semi colon.**

I. INTRODUCTION

Increased urban traffic has a significant influence on road traffic congestion, and hence on the time it takes road users to reach their destination. Expanding the road and expanding its capacity will not enough since the intersection will become congested. Congestion is unavoidable, yet by regulating the intersection, there is still space for improvement.

The primary goal of traffic regulation in metropolitan settings is to ensure the safety of road users. Furthermore, for the convenience aspect, various factors such as delays, traffic jams, pollution, noise, and the effect of enhancing service delivery to traffic are taken into account. The major criteria of the designed control system are that the signal not enable unclear traffic movement and that it be open about how and when the displayed signal is updated. Furthermore, two additional aspects of regulating the control system are addressed: judgments concerning the order of signal indications so that the system may be successfully optimized and the construction of control logic for signal production.

Fixed time and traffic-response are the two most popular techniques to dealing with traffic control signals. Fixed-time, on the other hand, lacks the adaptability to traffic demands. As a result, the goal of this work is to conduct a literature review on artificial intelligence techniques to operating traffic light systems.

II. METHODOLOGY

This study employs a literature review to examine past studies on the advancement of artificial intelligence in traffic control. Furthermore, conclusions may be taken about the procedures that can be put in place to create the quantity of traffic volume.

III. RESULT AND DISCUSSION

A. Approaches Related to Artificial Intelligence

Artificial intelligence and machine learning have shown to be excellent methods for improving the effectiveness of traffic control systems [1]. In terms of enhancing traffic system performance, three trustworthy methodologies are Q-Learning, Neural Networks, and Fuzzy Logic Systems [2].

B. Q-Learning

The concept behind this strategy is to observe movement at each junction so that the environment may interact with it in order to develop the best control mechanisms for lowering the duration of waiting lineups for both automobiles and pedestrians [3].

Furthermore, the outcomes of these observations are transmitted with other intersections via a distributed network in order to produce a global optimal timetable for the whole system [4]. Furthermore, the current traffic management regulations are included into the learning algorithm in order to give solutions while testing in the actual condition stage [5].

Furthermore, Zeng and Zhang [6] published a work in 2018 that built a form of a deep reinforcement learning agent that uses real-time GPS data to learn how to regulate traffic lights at isolated crossroads [7]. They constructed it using a mix of Recurrent Neural Network and Deep Q-Network, dubbed DRQN [8], and compared its performance on the partially observed traffic scope to that of the Deep Q-Network (DQN) standard [9].

Another effective transportation system has evolved by combining deep learning techniques with an approach function to train an adaptive traffic signal controller [10]. The n-step asynchronous Q-Learning algorithm is utilized in the learning stage, together with two hidden layers of the artificial neural network [11]. This method can minimize the average overall delay by 40% [12].

Based on these considerations, the optimization method based on Q-Learning is a type of adaptive artificial intelligence used to improve traffic system performance [13].

C. Neural Network

This technique is used to address the situation of growing vehicle traffic in metropolitan areas, which causes substantial traffic congestion [14]. The goal of this strategy is to forecast traffic [15], which is a critical component of effective traffic management [16]. Furthermore, the modeling developed by this artificial neural network can solve difficult issues and non-linear scenarios [17].

The model is then utilized to compare against a traffic data set collected during a monitoring operation [18]. Furthermore, because of the intricacy of the challenge in optimizing traffic management systems, Cellular Neural Networks (CNN) are being used as a solution to this problem [19]. The key benefit of this mechanism is that it is very quick at solving complicated and even non-linear problems. CNN, too, is hardware platform agnostic [20].

Another benefit is that the modeler may create a full-scale model that takes non-linear elements and complexity into consideration. Finally, the CNN strategy in this context is a coordinated area traffic control with several junctions, both urban and highway [21].

Castro et al. have offered a fictitious conditional network with adaptive biological behavior in accepting system circumstances and the ability to adjust control behavior [22].

D. Fuzzy Logic

This method can overcome language and traffic data challenges that are difficult to forecast in order to regulate traffic [23]. Time, day, season, weather, and unusual conditions are some of the characteristics considered in estimating traffic behavior. If these issues are not thoroughly explored, they might cause delays [24].

Furthermore, another technique to reduce traffic delays is to use fuzzy control to dynamically determine the maximum green time. The fundamental benefit of this method is its ability to respond to real-time traffic conditions at isolated junctions, resulting in the construction of an efficient traffic management system [25].

The application of fuzzy logic is also considered to be an effective solution to traffic congestion problems, as well as a means of determining the reasons of traffic bottlenecks [26].

E. Internet of Things (IoT)

This technique tries to minimize travel time, pollutant emissions, traffic, and driving stress [27]. This notion may be implemented by installing a number of sensors at each junction to monitor the movement of cars on the road trajectory in real time [28].

Each lane has sensors fitted to identify things 200 meters away from the light signal. To support traffic signals in conjunction with an IoT strategy [29], RFID (Radio-Frequency Identification) devices such as RFID tags and RFID sticker readers, parking area sensors, and video systems are employed [30]. As a result, it is envisaged that the sensor object observes the vehicle in both tiny and large-scale movement intensities, as well as while it is halted or waiting for a traffic light [31].

The studied position or entity is then sent to a local smart server (LSS), which has more processors and storage capacity than the sensor [32]. The procedure is carried out through the closest node. In order to achieve this aim, LSS-based sensors provide real-time context aware computing and flow processing over Wi-Fi [33].

F. Genetic Algorithm

The Genetic Algorithm is commonly used to solve traffic signal system difficulties [34]. The method that is often employed in traffic has various issues, such as extended wait periods, which have an influence on the number of cars accumulated [35].

Furthermore, one type of algorithm that can be used for optimization is the Genetic Algorithm [36]. This system employs a strategy based on evolutionary natural and biological selection theory, which is accomplished in multiple stages, namely:

1. Initial population
2. Calculating the suitability function for each solution
3. Selection through crossing and mutation Of these three variables will affect the increase in the number of vehicles that pass through the system [37].

IV. Conclusions

Finally, Fuzzy Logic, Q-learning, Neural Network, Internet of Things, and Genetic Algorithm are mechanisms that may be employed in traffic signal optimization to generate the number of cars in an intersection in order to decrease waiting times and vehicle volume build-up. This research examines the approaches that have been employed to improve the function of traffic signals in combating vehicle volume buildup.

References

[1] M. Šelmić, D. Teodorović, and K. Vukadinovic, “Locating inspection facilities in traffic networks: An artificial intelligence approach,” *Transp. Plan. Technol.*, vol. 33, no. 6, pp. 481–493, 2010, doi: 10.1080/03081060.2010.505047.

[2] N. V. Findler and R. Lo, “Distributed artificial intelligence approach to air traffic control,” *IEE Proc. D Control Theory Appl.*, vol. 138, no. 6, pp. 515–524, 1991, doi: 10.1049/IP-D.1991.0072.

[3] W. Genders and S. Razavi, “Asynchronous n-step Q-learning adaptive traffic signal control,” *J. Intell. Transp. Syst. Technol. Planning, Oper.*, vol. 23, no. 4, pp. 319–331, Jul. 2019, doi: 10.1080/15472450.2018.1491003.

[4] M. Abdoos, N. Mozayani, and A. L. C. Bazzan, “Hierarchical control of traffic signals using Q-learning with tile coding,” *Appl. Intell.*, vol. 40, no. 2, pp. 201–213, Mar. 2014, doi: 10.1007/S10489-013-0455-3.

[5] M. Abdoos, … N. M.-2011 14th I., and undefined 2011, "Traffic light control in non-stationary environments based on multi agent Q-learning," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/6083114/

[6] J. Zeng, J. Hu, Y. Z.-2018 I. I. Vehicles, and undefined 2018, "Adaptive traffic signal control with deep recurrent Q-learning," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8500414/

[7] Y. Chin, W. Kow, W. Khong, … M. T.-2012 S. Uks., and undefined 2012, "Q-learning traffic signal optimization within multiple intersections traffic network," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/6410175/

[8] Y. Chin, N. Bolong, A. Kiring, … S. Y.-I. J. of, and undefined 2011, "Q-learning based traffic optimization in management of signal timing plan," *researchgate.net*, Accessed: May 05, 2022. [Online]. Available: https://www.researchgate.net/profile/Soo-Yang-3/publication/264889551_Q-Learning_Based_Traffic_Optimization_in_Management_of_Signal_Timing_Plan/links/552fa3fd0cf22d437171100d/Q-Learning-Based-Traffic-Optimization-in-Management-of-Signal-Timing-Plan.pdf

[9] Y. Liu, L. Liu, W. C.-2017 I. 20th international, and undefined 2017, "Intelligent traffic light control using distributed multi-agent Q learning," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8317730/

[10] S. Lu, X. Liu, S. D.-2008 7th W. C. on Intelligent, and undefined 2008, "Incremental multistep Q-learning for adaptive traffic signal control based on delay minimization strategy," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/4593378/

[11] W. Genders, S. R.-J. of I. Transportation, and undefined 2019, "Asynchronous n-step Q-learning adaptive traffic signal control," *Taylor Fr.*, Accessed: May 05, 2022. [Online]. Available: https://www.tandfonline.com/doi/abs/10.1080/15472450.2018.1491003

[12] M. Abdoos, N. Mozayani, A. B.-A. intelligence, and undefined 2014, "Hierarchical control of traffic signals using Q-learning with tile coding," *Springer*, Accessed: May 05, 2022. [Online]. Available: https://link.springer.com/article/10.1007/s10489-013-0455-3

[13] L. Bello, P. Mitchell, D. G.-E. W. 2014; 20th, and undefined 2014, "Application of Q-learning for RACH access to support M2M traffic over a cellular network," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/6843101/

[14] T. P. Oliveira, J. S. Barbar, and A. S. Soares, "Computer network traffic prediction: a comparison between traditional and deep learning neural networks," *Int. J. Big Data Intell.*, vol. 3, no. 1, p. 28, 2016, doi: 10.1504/IJBDI.2016.073903.

[15] W. Wang, M. Zhu, X. Zeng, … X. Y.-2017 I., and undefined 2017, "Malware traffic classification using convolutional neural network for representation learning," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/7899588/

[16] T. Oliveira, … J. B.-I. J. of, and undefined 2016, "Computer network traffic prediction: a comparison between traditional and deep learning neural networks," *inderscienceonline.com*, Accessed: May 05, 2022. [Online]. Available: https://www.inderscienceonline.com/doi/abs/10.1504/IJBDI.2016.073903

[17] C. L.-T. R. P. C. Emerging and undefined 1997, "An urban traffic flow model integrating neural networks," *Elsevier*, Accessed: May 05, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0968090X97000156

[18] M. Saharkhizan, A. Azmoodeh, A. Dehghantanha, S. Member, K.-K. Raymond Choo, and R. M. Parizi, "An ensemble of deep recurrent neural networks for detecting IoT cyber attacks using network traffic," *ieeexplore.ieee.org*, vol. 7, no. 9, 2020, doi: 10.1109/JIOT.2020.2996425.

[19] D. Srinivasan, M. Choy, R. C.-I. T. on, and undefined 2006, "Neural networks for real-time traffic signal control," *ieeexplore.ieee.org*, vol. 7, no. 3, 2006, doi: 10.1109/TITS.2006.874716.

[20] A. Abdellah, … O. M.-… C. on U., and undefined 2019, "IoT traffic prediction using multi-step ahead prediction with neural network," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8970675/

[21] R. Li, X. Xiao, S. Ni, H. Zheng, S. X.-2018 I. 26th, and undefined 2018, "Byte segment neural network for network traffic classification," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8624128/

[22] Z. Cui, K. Henrickson, … R. K.-I. T. on, and undefined 2019, "Traffic graph convolutional recurrent neural network: A deep learning framework for network-scale traffic learning and forecasting," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/8917706/

[23] K. Khiang Tan, M. Khalid, and R. Yusof, "Intelligent traffic lights control by fuzzy logic," *jati.um.edu.my*, vol. 9, no. 2, pp. 29–35, 1996, Accessed: May 05, 2022. [Online]. Available: https://jati.um.edu.my/index.php/MJCS/article/view/2995

[24] G. Kulkarni, P. W.-2007 I. Conference, and undefined 2007, "Fuzzy logic based traffic light controller," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/4579157/

[25] D. Hartanti, R. Aziza, … P. S.-C. E. and, and undefined 2019, "Optimization of smart traffic lights to prevent traffic congestion using fuzzy logic," *academia.edu*, Accessed: May 05, 2022. [Online]. Available: https://www.academia.edu/download/64081156/40 10129.pdf

[26] M. McDonald, J. Wu, M. B.-P. of Conference, and undefined 1997, "Development of a fuzzy logic based microscopic motorway simulation model," *ieeexplore.ieee.org*, 1997, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/660454/

[27] F. Metzger, T. Hossfeld, A. Bauer, S. Kounev, T. Hoßfeld, and P. E. Heegaard, "Modeling of aggregated IoT traffic and its application to an IoT cloud," *ieeexplore.ieee.org*, 2019, doi: 10.1109/JPROC.2019.2901578.

[28] M. Trabia, M. Kaseko, M. A.-T. R. P. C, and undefined 1999, "A two-stage fuzzy logic controller for traffic signals," *Elsevier*, Accessed: May 05, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0968090X99000261

[29] A. Abdellah, A. K.-I. of Things, S. Spaces, and Next, and undefined 2020, "Deep learning with long short-term memory for iot traffic prediction," *Springer*, Accessed: May 05, 2022. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-030-65726-0_24

[30] S. Soomro, M. Miraz, A. Prasanth, and M. Abdullah, "Artificial intelligence enabled IoT: traffic congestion reduction in smart cities," 2018, Accessed: May 05, 2022. [Online]. Available: https://digital-library.theiet.org/content/conferences/10.1049/cp.2018.1381

[31] J. Favilla, A. Machion, … F. G.-C. on F., and undefined 1993, "Fuzzy traffic control: adaptive strategies," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/327519/

[32] A. Abdellah, … O. M.-2020 12th I., and undefined 2020, "Delay prediction in IoT using machine learning approach," *ieeexplore.ieee.org*, Accessed: May 05, 2022. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9222245/

[33] S. Soomro, M. H. Miraz, A. Prasanth, and M. Abdullah, "Artificial Intelligence enabled IoT: Traffic congestion reduction in smart cities," *IET Conf. Publ.*, vol. 2018, no. CP747, 2018, doi: 10.1049/CP.2018.1381.

[34] B. Park, C. J. Messer, and T. Urbanik, "Traffic signal optimization program for oversaturated conditions: genetic algorithm approach," *Transp. Res. Rec.*, no. 1683, pp. 133–142, 1999, doi: 10.3141/1683-17.

[35] F. Teklu, A. Sumalee, D. W.-C. C. and, and undefined 2007, "A genetic algorithm approach for optimizing traffic control signals considering routing," *Wiley Online Libr.*, vol. 22, no. 1, pp. 31–43, Jan. 2007, doi: 10.1111/j.1467-8667.2006.00468.x.

[36] R. Putha, … L. Q.-C. C. and, and undefined 2012, "Comparing ant colony optimization and genetic algorithm approaches for solving traffic signal coordination under oversaturation conditions," *Wiley Online Libr.*, vol. 27, no. 1, pp. 14–28, Jan. 2012, doi: 10.1111/j.1467-8667.2010.00715.x.

[37] K. B. Kesur, “Advances in genetic algorithm optimization of traffic signals,” *J. Transp. Eng.*, vol. 135, no. 4, pp. 160–173, 2009, doi: 10.1061/(ASCE)0733-947X(2009)135:4(160).