Scholar Publishing Group
International Journal of Big Data Intelligent Technology
https://doi.org/10.38007/IJBDIT.2023.040102
ISSN 2790-0932 Vol. 4, Issue 1: 10-16

Intelligent Traffic System Based on PLC Fuzzy Control

Gongxing Yan[1,2,a*] and Xie Hui[1,b]

[1]School of Intelligent Construction, Luzhou Vocational and Technical College, Luzhou 646000, Sichuan, China
[2]Luzhou Key Laboratory of Intelligent Construction and Low-carbon Technology, Luzhou 646000, Sichuan, China
[a]yaaangx@126.com, [b]xh225001@163.com
[*]corresponding author

Keywords: Intelligent Transportation System, Fuzzy Control, Plc, Phase Sequence Optimization, MCGS

Abstract: This study designed an intelligent transportation system based on PLC fuzzy control for alleviating urban traffic jams and complex vehicles. The system includes two parts. The first part is a three-level fuzzy controller. Through monitoring the traffic of vehicles in each phase, the fuzzy control rules are used to optimize the phase sequence and adjust the green time length of the corresponding phase. Experimental results show that the traffic efficiency of the three-stage fuzzy controller is 11% higher than that of the traditional fuzzy controller. The second part is the emergency passage module, which dredges special vehicles. The MCGS configuration software is used to test the system, and results show that the system meets the control requirements and is suitable for various traffic conditions.

1. Introduction

With the development of the urban economy and industry, the number of private cars grows rapidly, accompanied by increasing traffic problems. Research on the control of traffic systems thus has been a hot topic for a long period. The time-varying, stochastic and uncertain nature of traffic flow makes implementing the traditional model-based control theory difficult [1]. In contrast, fuzzy control does not require a definitive mathematical model to describe complex systems, which makes the application of fuzzy control on traffic signal indicates an important research direction in traffic signal control [2]. Implementing fuzzy control to traffic signal indication has become an important research direction. With the aim of solving complex traffic issues, this paper proposed a method for phase optimization and green light delay and constructed an emergency access module[15].

2. The Design of the Control System

2.1 The Design of the Control Strategy

This study divides the traffic flow into the east-west main phase and north-south main phase according to the direction of traffic flow [3]. Moreover, this research divides the east-west (north-south) main phases and the east-west (north-south) main phase into two sub-phases, namely east-west (north-south) straight ahead sub-phase and east-west (north-south) left-turn sub-phases, as shown in Figure 1.

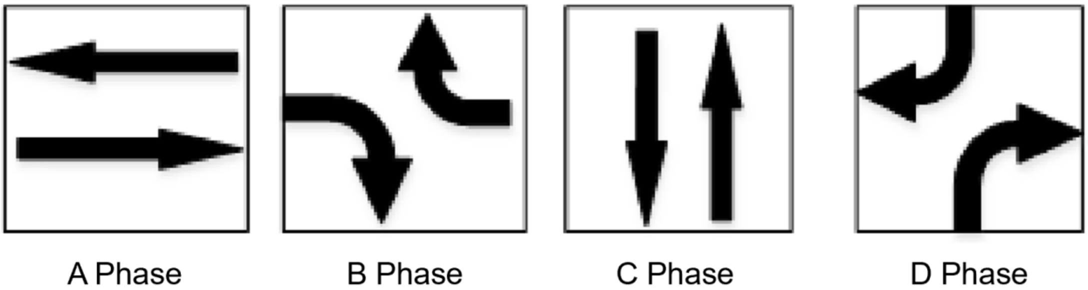


Figure 1. Phase Diagram

The system consists of two modules, including a fuzzy controller and an emergency access module[17]. The fuzzy controller module mainly detects the traffic flow in each phase to manipulate the corresponding fuzzy rule table and obtain the tension of each phase and the corresponding green light delay time. In this way, the module can realize the optimization of the phase sequence and can adjust the light traffic time timely [5].

This study adopts the emergency access module to detect the presence of special vehicles through a DSP device for image recognition installed at the road junction. This facility detects whether special vehicles are entering a specific road section. When the device detects special vehicles, the corresponding algorithm module can be invoked to mediate the corresponding phase, thus easing traffic [6].

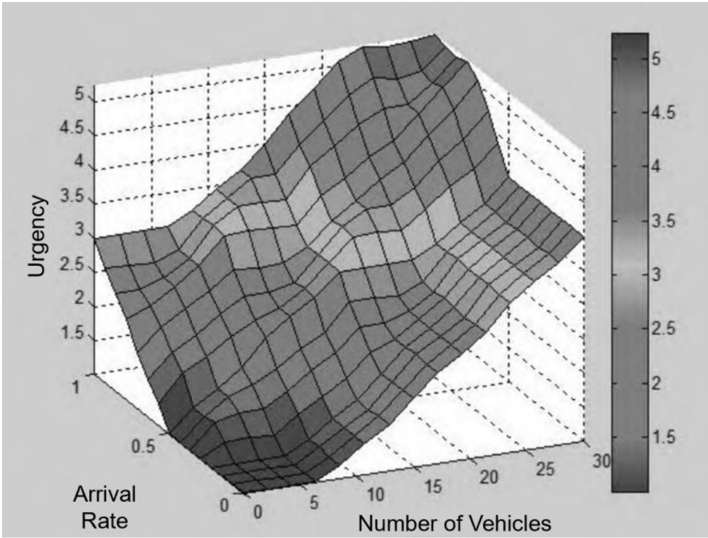
When the detection module of a special vehicle detects that a special vehicle entered into a specific phase, the corresponding algorithm can invoke[16]. Based on the speed of the special vehicle and the current traffic flow of the phase, the special vehicle will pass through the traffic light at the end of the and the current traffic flow of the phase, phase can be passed in advance before the special vehicle passes through the traffic light. In this way, the algorithm module can help ease the traffic for the special vehicle when it passes through the traffic light [7-8].

When the detection module detects the traffic situation of each phase, it calculates the tension of each phase through the fuzzy rule table. The tension of the main phase is the maximum tension of sub-phases. The main phase of the next candidate's green light can be decided by comparing the tension of the two main phases [9]. Then, the tension of the two sub-phases under the main phase would be compared to optimize the phase sequence.

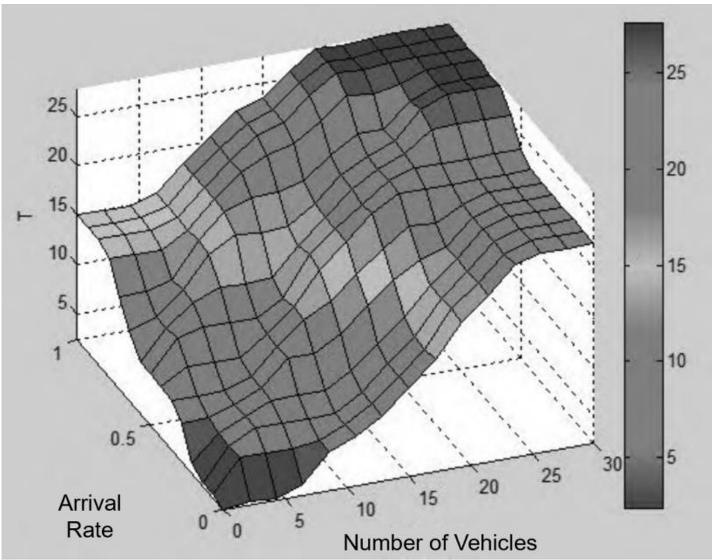
2.2 Design of the Fuzzy Controller

This system mainly uses two fuzzy controllers: the Tightness Fuzzy Controller and Green Light Delay Fuzzy Controller. They take the number of vehicles in the queue (PD) and the arrival rate of vehicles (DD) as the number of fuzzy input variables[18]. The fuzzy output variables are urgency (U) and delay time (T). Among them, the basic domain of the fuzzy input variable PD is {0, 1, 2, ..., 30}, and that of DD is (0, 1). If taking the fuzzy factor as 1, the fuzzy theoretical domains of the fuzzy input variables PD and DD would be {0, 1, 2, ..., 30}, and {0, 0.1, 0.2, ..., 1}. The fundamental domain of the fuzzy output variables (U) tension is (0, 6). If we also take the fuzzy factor as 1, the basic theoretical domain of U would also be (0, 6). In addition, if the fundamental domain of the fuzzy output variable T is (0, 30), taking the fuzzy factor as 1, its fuzzy theoretical domain would be (0, 30).

This study defines he fuzzy language of the fuzzy input variables (PD and DD) and the fuzzy output variables (U and T) as {vs, s, m, d, vd} in this study. The relationship curve charts of the input and output variables are generated as shown in Figure 2, which is formed based on the Fuzzy toolbox.



(a) Surface plot of the input-output variable relationship for U



(b) The input-output variable relationship surface plot of T

Figure 2. Fuzzy Controller Input-Output Relationship Surface Diagram

2.3 Simulation Test of the Fuzzy Control System

The number of vehicles arriving at the intersection set in this paper conforms to the Poisson distribution. The simulation diagram of the fuzzy control system is built according to the control strategy and the fuzzy control principle [9].

We compared ten different sets of traffic situations with those resulting from the traditional fuzzy control method to verify the superiority of the control system. When other parameters are the same, the passing efficiency of the three-levels fuzzy control system is compared with conventional fuzzy control[19,20].

The comparison results show that the efficiency of the three-level fuzzy control system is higher than that of the traditional fuzzy control system. In the case of high traffic flow, the efficiency of the three-level fuzzy control system is 11% higher than that of the traditional fuzzy control system [10].

3. The Design of PLC and MCGS Based on the Intelligent Traffic Control System

The fuzzy controller adopts the number of vehicles in the queue and their arrival rate as input. We adopted the number of vehicles passing through the i^{th} cycle phase detected by the front detector in this system as n_1. Also, this paper adopts the number of vehicles detected by the rear detector in the i^{th} cycle and the current phase before the $i+1^{th}$ cycle as n_2. We suppose there are Ni cars waiting to pass before the i^{th} cycle, the number of vehicles in the queue is $N_i + 1 = N_i + n_2 - n_1$, and the arrival rate of vehicles $p = n_1 / N_i$. The installation of the rear and front detectors for each phase is shown in Figure 3. The front detector is installed on the stop line, and the rear detector is mounted at 150m from the stop line.

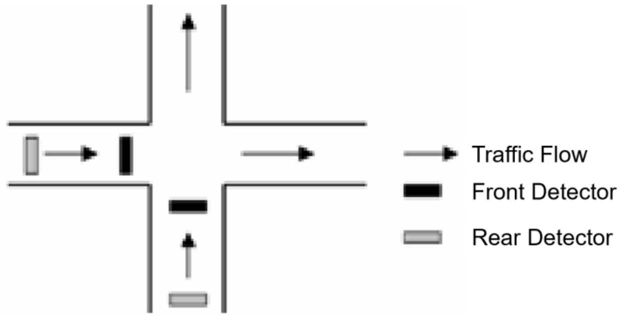


Figure 3. Detector Installation Diagram

The emergency access module opens and closes based on whether it detects special vehicles entering this road section. Thus, its detection device is a DSP device for image recognition and other peripheral devices such as cameras [11]. The installation is shown in Figure 4. It is installed at entrance B of the AB section to detect if a special vehicle enters the AB section. When it is detected that a special vehicle is about to enter the road section, the normally open contact connected to the detection device for calling the emergency access module would close, and the emergency access module would operate.

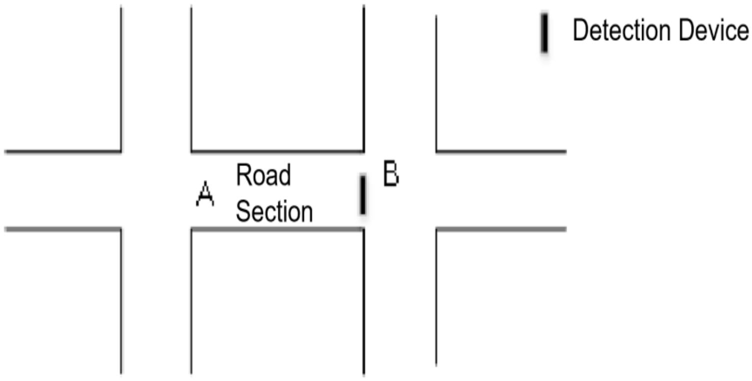


Figure 4. DSP device installation diagram

Once the PLC has been programmed and wired, it can be commissioned with MCGS. Designing an intelligent transport system with the help of the MCGS configuration system, the operating system is then operated according to the configuration system design [12-13].

This study defines several actions of the traffic system as variables to make the system meet the requirements. Examples are the four phases of the traffic lights, the movements of the vehicles in the relevant phases, and the signal changes of traffic jams, etc.

This study designed A simple and intelligent traffic system simulation platform based on a real-time database. The base time of the system is 15 seconds. The total green time of the current passing phase is the sum of the base time and the extended time output by the fuzzy controller. The input of the fuzzy controller is the detected traffic flow of each phase and its corresponding arrival rate[14].

The PLC controller was connected and the platform function was tested with four traffic conditions. The experimental results are shown in Table 1.

Table 1. Experimental results of each phase sequence and green light delay

Trial Order	Phase	Delay Time of Green Light
1	A→B→C→D	30→22.5→26.3→22.3
2	B→A→C→D	30→22→25.2→22
3	C→D→A→B	31.9→22.1→25.2→22.4
4	D→C→A→B	30→21.5→22.5→21.5

Through the experiment, each phase sequence and the green light delay time align with the requirement and can help regulate traffic.

4. Conclusion

The intelligent traffic system based on PLC fuzzy control designed by this study can make phase optimization according to the number of vehicles in different phases and their passing rate. So, the system can direct the smooth passage of special vehicles and alleviate traffic congestion to a certain extent[21].

The three-stage fuzzy algorithm used in this study has been simulated. Via trial and comparison with the traditional fuzzy algorithm, the results show that the system is more effective in solving traffic congestion problems and applies to many traffic conditions. It meets our expectations.

Funding

This work was supported by Sichuan Province Luzhou city of Stars science and technology planning project (2021-JYJ-97).

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Liu J.J., Zuo X.Q. Research on fuzzy control and optimization of traffic lights at intersections. Journal of System Simulation, 2020, 32(12):2401-2408.

[2] Tang M.A. Optimal control strategy of traffic signal combination under unbalanced road network. Control Engineering, 2019, 26(01):144-149.

[3] Deng L.Y., He W.T. Research on Fuzzy Control Method of Traffic Signal Light at Single Intersection. Foreign Electronic Measurement Technology, 2018, 37(04):83-86.

[4] He P.L. Research on Intelligent Transportation Based on Fuzzy Control. Xi'an: Xi'an University of Science and Technology, 2017.

[5] Li X.R. Traffic Signal Timing Optimization Based on Fuzzy Control. Xi'an: Xi'an University of Science and Technology, 2016.

[6] Wu S.J. Application of PLC in Intelligent Traffic Light Control System. Journal of Changzhou Institute of Technology, 2014, 27(06):29-33+41.

[7] Gongxing Yan, Hongzhi Wang. Autonomous Coordinated Control Strategy for Complex Process of Traffic Information Physical Fusion System Based on Big Data. IEEE Access, 2020(7):148370- 148377.

[8] Gongxing Yan, Qi Qin. The Application of Edge Computing Technology in the Collaborative Optimization of Intelligent Transportation System Based on Information Physical Fusion. IEEE Access, 2020(8):153264-153272.

[9] Gongxing Yan, Yanping Chen. The application of virtual Reality technology on intelligent traffic construction and Decision support in smart cities. wireless Communications and Mobile Computing. 2021, 579(10): 176-188.

[10] C. Li and P. Xu, "Application on traffic flow prediction of machine learning in intelligent transportation," Neural Computing and Applications, vol. 33, no. 2, pp. 613–624, 2021.

[11] M. Saki, M. Abolhasan, and J. Lipman, "A novel approach for big data classification and transportation in rail networks," IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 3, pp. 1239-1249, 2020.

[12] C. An and C. Wu, "Traffic big data assisted V2X communications toward smart transportation," Wireless Networks, vol. 26,no. 3, pp. 1601–1610, 2020.

[13] S. K. Roy, S. Midya, and G. W. Weber, "Multi-objective multiitem fixed-charge solid transportation problem under twofold uncertainty," Neural Computing and Applications, vol. 31,no. 12, pp. 8593–8613, 2019.

[14] A. Sukoco, A. S. Prihatmanto, R. Wijaya, I. Sadad, and R. Darmakusuma, “SEMUT: next generation public transportation architecture in the era IoT and big data,” Journal of Engineering and Applied Sciences, vol. 14, no. 12, pp. 4052–4059, 2019.

[15] T. B. A. Isabel, D. S. Javier, L. Ibai, M. Ilardia, M. N. Bilbao, and S. Campos-Cordobés, “Big data for transportation and mobility: recent advances, trends and challenges,” IET Intelligent Transport Systems, vol. 12, no. 8, pp. 742–755, 2018.

[16] D. Chen, M. Hu, H. Zhang, and J. Yin, “Forecast method for medium-long term air traffic flow considering periodic fluctuation factors,” Xinan Jiaotong Daxue Xuebao/Journal of South-west Jiaotong University, vol. 50, no. 3, pp. 562–568, 2015.

[17] L. Zhao, D. Wei, Y. Dong-Mei, G. Chai, and J.-h. Guo, “Short term traffic flow forecast based on combination of K nearest neighbor algorithm and support vector regression,” Journal of Highway and Transportation Research and Development,vol. 12, no. 1, pp. 89–96, 2018.

[18] T. Xie and J. C. Grossman, “Crystal graph convolutional neural networks for an accurate and interpretable prediction of material properties,” Physical Review Letters, vol. 120, no. 14,pp. 145301.1–145301.6, 2018.

[19] V. Korolev, A. Mitrofanov, A. Korotcov, and V. Tkachenko, “Graph convolutional neural networks as "general-purpose" property predictors: the universality and limits of applicability,” Journal of Chemical Information and Modeling, vol. 60,no. 1, pp. 22–28, 2020.

[20] D. Bone, C.-C. Lee, and T. Chaspari, “Signal processing and machine learning for mental health research and clinical applications [perspectives],” IEEE Signal Processing Magazine, vol. 34, no. 5, p. 196, 2017.

[21] A. Deleforge, D. Di Carlo, M. Strauss, R. Serizel, and L. Marcenaro, “Audio-based search and rescue with a drone: highlights from the IEEE signal processing cup 2019 student competition [SP competitions],” IEEE Signal Processing Magazine, vol. 36, no. 5, pp. 138–144, 2019.