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Construction of Simulation Experiment for Coordinated Control of Traffic Signals on Urban Arterial Roads

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ABSTRACT: How to conduct signal control of urban roadway intersections is a practical learning content that must be mastered by undergraduate who major in traffic engineering. In the past, this practical teaching mostly used the field learning mode of “traffic investigation - program design - effect evaluation”. Taking the construction of exemplary simulation project as an opportunity, we have constructed a teaching project of coordinated control of urban arterial traffic signals with intuition and modular step-by-step operation, based on virtual technology. The online teaching practice shows that the application of virtual simulation project can significantly improve the effect of experimental teaching and enhance the level of practical education in college.

KEYWORDS: Traffic engineering; Signal control; Virtual simulation; Engineering program design; Practical instruction.

I. INTRODUCTION

In order to further promote the in-depth integration of information technology and college experimental teaching, continuously strengthen the construction and application of high-quality resources for experimental teaching in universities, and try to enhance the quality of experimental teaching and the level of practical education in higher education, the Ministry of Education began to carry out the construction of exemplary virtual simulation experimental projects in ordinary undergraduate colleges and universities in 2017 [1].

Transportation is a essential demand and prerequisite for the development of national economy, and plays a linking role in the whole social mechanism [2]. As one of the important majors supporting the training of transportation talents, traffic engineering has obvious cross-disciplinary knowledge characteristics [3]. In the teaching process of professional courses of transportation engineering, part of the course content of Traffic Management and Control needs to be demonstrated through experimental practice and engineering cases, while the experimental practice or engineering cases have the characteristics of high cost of experimental analysis, complex process of evolution of traffic patterns, and difficult to be demonstrated and analyzed through physical experiments [4]. In order to solve the contradiction between vivid image and complexity and high cost of physical experiment in the process of experimental teaching of traffic management and control, and to improve the vividness and interest of practical teaching, we use virtual simulation, webpage and multimedia technology [5] to construct the virtual simulation experimental teaching project of urban traffic signal control with intuitive and modular step-by-step operation, which is a supplement and innovation of physical experimental teaching, and it is important theory and innovation for the improvement of the quality of training talents of traffic engineering majors. It is a supplement and innovation of physical experimental teaching, which has important theoretical significance and practical value for improving the quality of talent cultivation of transportation engineering majors.

II. REFORM OF SIMULATION EXPERIMENTAL OF INTERSECTION TRAFFIC SIGNAL CONTROL

Modular step-by-step experiment to realize the comprehensive ability training of traffic signal control. The virtual simulation experiment is divided into four modules: intersection channelization design, signal control scheme design, signal control scheme optimization based on simulation results and scheme verification. Students can step by step to complete the experiment, while each module has a corresponding experimental training purpose, and consistent with the actual engineering design process, can lay the foundation for students' engineering practice

training, and at the same time, can be on the students' traffic control system program design, program control, simulation and analysis of the comprehensive design and application of the ability to cultivate.

Theoretical learning is combined with computer-aided design to enhance the interest of theoretical learning. For the characteristics of road drainage and information control program design, the virtual simulation experimental platform provides intersection lane drainage expert design system, lane saturation flow rate calculation, information control program simulation and analysis of computer-aided design modules. Module function and “traffic management and control” course theory teaching is consistent, so that students in the engineering design at the same time, but also on the course theory to consolidate learning, to achieve the theory and engineering practice combined with the purpose of practical learning.

Apply the constructivism teaching theory to the experimental teaching, realizing the integration of virtual experiment and actual engineering. The experimental project creatively combines theoretical knowledge and engineering cases, constructs the experimental teaching method based on the real situation and comprehensive combat, changes the teacher-led to student autonomy, and changes the mechanical completion of the experimental process to the research, exploration and cooperative experimental process. The experimental project data source of the city's actual road intersections, road sections of real-time traffic information, and provide real-time video information to improve the students to design intersections, road sections of the real problem of the feeling; and can provide students with the possibility of designing engineering programs to prove, thus greatly improving the students' experimental learning initiative and mobility.

III. SIMULATION EXPERIMENT OF COORDINATED CONTROL OF ARTERIAL TRAFFIC SIGNALS

First of all, the video traffic flow detection system was used to count the traffic flow data in the video stored by the traffic video monitoring system in real time as a basis for design. It can also be directly downloaded from the website of the Road Intelligent Transportation System Engineering and Technology Research Center to download the geometric information of the designed road intersection and traffic flow and other basic data. ext, the network virtual experiment platform was applied to complete the design of intersection channelization and signal timing scheme. Then, run TSIS and TRAFVU simulation module to analyze and evaluate the signal control [10]. Finally, the signal control scheme was optimized according to the simulation results. The optimization scheme can be sent to the signal control center of the traffic police detachment, and the optimization effect can be observed through the monitoring video.

Before the experiment, CAD drawings of geometric conditions of intersections along urban arterial roads were downloaded through the website of the simulation experiment program. Observe the intersection traffic flow video in real time through the traffic monitoring system. Participants used the video traffic flow detection system to automatically count the traffic flow characteristics parameters such as flow rate and speed by vehicle type and lane.

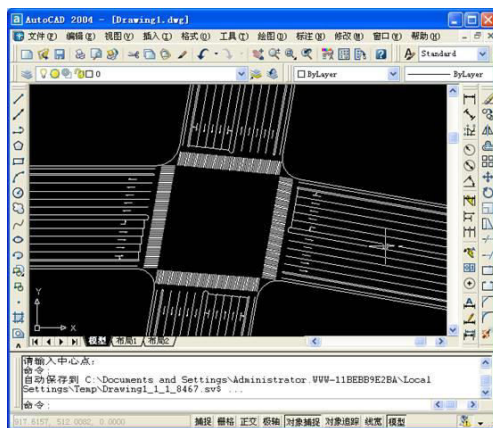


Fig. 1. CAD drawing of junction



Fig. 2. Traffic flow detection system

Click the “Add” button in “Program Design”, enter the name of the experiment in the “Experiment Name” input box, and click the “Submit Now” button to generate a new experiment program. Click the “Submit Now” button to generate a new experiment program, as shown in Figure 3.



Fig. 3. Additional experimental programs

Configure global settings and intersection parameters in “Schematic Design”. Among them, the global settings should be filled in the cycle time, the number of intersections and the scale. When setting intersection parameters, click the “Operation” button, the “Intersection Settings” page will appear, fill in the intersection name, green time, forward speed, reverse speed, intersection length, intersection width, phase difference and so on. After completing all, click “Submit Now” to end the parameter setting of an intersection. Sequentially complete the urban arterial road multiple intersection parameter settings.



Fig. 4. Junction Parameter Setting

According to Webster's signal timing formula, the optimal signal period for a single intersection is calculated as follows:

$$C = \frac{1.5 \times L + 5}{1 - Y} \quad (1)$$

Where C is the signal period, L is the loss time, and Y is the sum of the flow ratios of each phase. Assuming that the loss time of each phase is 5 s, the sum of the loss time of the four phases is 20 s. The signal period of a single intersection is calculated as follows.

$$Y = \sum_{i=1}^n y_i, \quad y_i = \frac{Q_i}{S_i} \quad (2)$$

Where y_i is the flow ratio of each phase; Q_i is the flow rate of the i th phase, and S_i is the capacity of the phase (2100 vehicles/h).

The green light duration of each phase is allocated, and the green light duration of each phase is allocated according to the flow ratio of each phase:

$$G_i = \frac{y_i}{Y} \times C \tag{3}$$

where G_i is the green light duration of the i th phase and C is the signal cycle duration.

The common period was selected for coordinated control of the intersection, and graphical optimization of the time-distance graph can be performed. Graph Optimization includes three optimization modes: Bidirectional Coordination, Forward Coordination and Reverse Coordination, as shown in Figure 5.

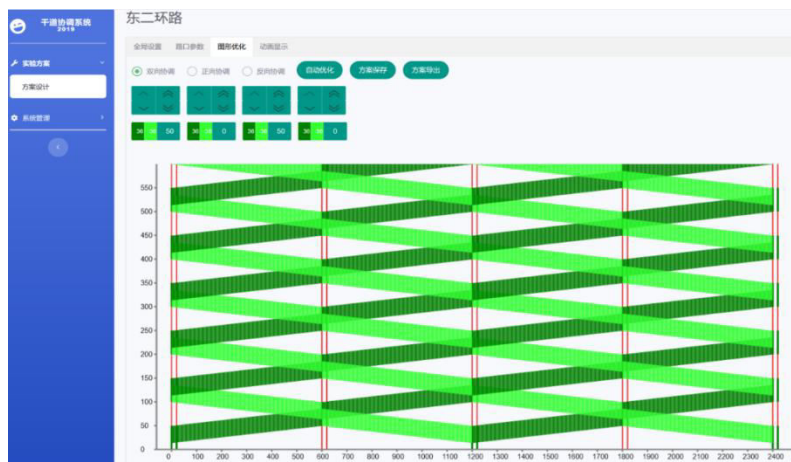


Fig. 5. Graphical optimization of coordinated control schemes

The coordinated scheme adjustment in graphical optimization is realized by clicking the “Auto Optimize” button, and the system automatically calculates the optimized forward/reverse green time and phase difference of each intersection. Manual fine-tuning operation, each group corresponds to an intersection, click once, the intersection green time increased or decreased by 1 second; until the best positive and negative green time and phase difference is found.

Click “Save Scheme” in “Scheme Design” to save the optimized design. Click “Export” in “Programming” to export the saved program. Click the “animation display” of “scheme design”, as in Fig. 8 animation display, to display the optimized and coordinated signal control scheme in animation simulation. Demonstration speed and departure speed can be set, , as shown in Figure 6.

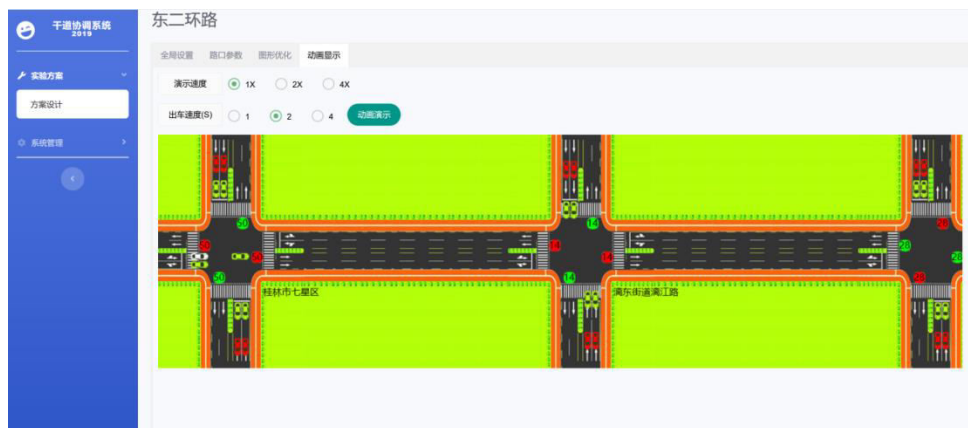


Fig. 6. Graphical optimization of coordinated control schemes

Finally, the optimized signal timing scheme is sent to the signal control center of the traffic police detachment using the network virtual experiment platform. Adjust the actual operation control scheme of the corresponding designed intersection, and observe the optimization effect through the monitoring video of the network virtual experiment platform.

IV. FEATURES OF VIRTUAL SIMULATION EXPERIMENTAL

The combination of virtual and real, can be real and not virtual, realizing the experimental teaching mode of combining virtual experiment and engineering design. For the needs of theoretical and practical teaching of traffic engineering, the construction of traffic signal control virtual network experimental platform and Guilin City, urban traffic intelligent control platform subcontrol center for data and information interface, experimental data from real engineering projects and real-time traffic flow information in Guilin City, and to provide real-time traffic video to improve the design of intersections, road sections of the real problem of the feeling of the students; at the same time also provide students with the possibility of empirical evidence of the design of engineering solutions (virtual network experiment platform can be directly linked to the engineering design) The possibility of evidence for the design of engineering programs (virtual network experimental platform can be directly with the Guilin Traffic Police Detachment Command Center signal control platform to carry out program communication), for students to design programs to provide engineering evidence conditions. Thus, the signal control program design and simulation analysis based on real-time traffic data can be realized in the virtual environment, and the traditional training mode of “traffic survey - program design - program evaluation” can be changed into the experimental process of “information collection - program design - simulation analysis - program optimization - program verification”. The experimental process of “information acquisition - program design - simulation analysis - program optimization - program verification” has realized the experimental teaching mode of “combining virtual experiment and engineering design”.

Based on teaching, science and education synergize and realize the transformation of scientific research results into teaching results. The project is based on the independent research and development of the “traffic signal control integrated experimental platform” scientific research results, transformed into a traffic signal control virtual network experimental platform to provide students with network experimental services. At the same time, also relying on intelligent transportation Guangxi University Key Laboratory, Guangxi Road Intelligent Transportation System Engineering Technology Research Center and other scientific research bases, physical experiments and virtual simulation experiments, so that students can be based on virtual simulation experiments to complete the design, operation, control, verification and other comprehensive experiments and practice sessions, to achieve the organic combination of teaching and research.

Combining theoretical learning with computer-aided design and through modular step-by-step experiments to realize the comprehensive ability training for students in traffic signal control. Aiming at the characteristics of road drainage scheme and signal control scheme design, the network virtual experimental platform provides computer-aided design modules such as intersection lane drainage, lane saturation flow rate calculation, signal control scheme simulation and analysis; at the same time, the experiments are divided into four modules: optimization design of drainage scheme, design of signal control scheme, simulation and optimization of scheme adjustment, and scheme demonstration (optional). The function of the module is consistent with the theoretical teaching of the course “Traffic Management and Control”, and students can complete the experiments step by step; the experimental process is consistent with the actual engineering design process, which achieves the practical learning purpose of combining the theory and engineering practice, and realizes the cultivation of students' ability to design and apply the traffic control system comprehensively.

V. CONCLUSION

This study transforms the traffic signal control scientific research results into a virtual simulation experimental project, collects experimental data through the research center, and gives the conditions for the program engineering evidence, and explores a new mode of teaching combining virtual experiment and engineering design. The virtual simulation project of traffic signal control has been applied in the experimental teaching of traffic management and control courses in our university and achieved good results. Subsequently, the multidisciplinary and cross-disciplinary cooperation and sharing will be further strengthened, and by improving and increasing the experimental projects (inductive signal control, network coordination control, bottleneck control, etc.), we will provide the experimental training projects

related to the comprehensive traffic management and control courses for the traffic engineering students, and comprehensively cultivate the students' comprehensive design of traffic management and control programs, engineering practice and innovation ability.

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REFERENCES

1. http://www.moe.edu.cn/srcsite/A08/s7945/s7946/201707/t20170721_309819.html.
2. Yan Maode, Zhu Liya, Lou Jingmei, Wang Guiping, "Construction of Virtual Simulation Experimental Teaching Center for Traffic Information and Control", Journal of EEE, vol. 39, no.29, pp. 131-135, 2017.
3. Zhang Guoqiang, Chen Jun, Wang Hao, "Teaching Reform of the Practical Part of the Course Traffic Control and Management", Journal of Southeast University (Philosophy and Social Science), vol. 13, pp. 134-136, 2011.
4. Han Yongguang, Niu Le, Fan Xiang, Chang Wei, Lu Baoping, "Construction and Development of Virtual Simulation Experiment Teaching Center and Project", China Education Technology Equipment, vol. 4, pp.8-11, 2023.
5. Chang Liang, Liu Huijun, Sun Xuejun, Zhang Xiaoyu, Chen Xuezheng, "Reflection on construction of virtual simulation experiment teaching projects in colleges and universities: Taking Hebei University as example", Experimental Technology and Management, Vol.37 No.12, pp. 29-32, 2020.



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