ISSN 2616-5767 Vol.7, Issue 3: 1-6, DOI: 10.25236/AJETS.2024.070301

Research on Coordinated Control of Arterial Green Wave on Intelligent Traffic—Taking Dongfeng Street in Weifang City, Shandong Province as an Example

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Abstract: *In response to the requirements of the Traffic Management Bureau of the Ministry of Public Security of China to promote the "two modernizations" (the intelligentization of road traffic signals and the standardization of traffic signs and markings), and in light of the current status of road traffic control in the central urban area of Weifang City, Shandong Province, relying on the implementation project of urban traffic optimization in Weifang, a segmented green wave coordinated control scheme design is carried out and implemented for 11 intersections on the main trunk road of Dongfeng Street in the city. The aim is to optimize the traffic organization design for 11 of the 26 intersections included in the traffic optimization implementation project, standardize road traffic facilities, improve traffic order, increase the efficiency of road resource utilization, and provide a good foundation for the application of advanced traffic signal control technology.*

Keywords: *Green wave control, trunk line optimization, two modernizations*

1. Introduction

As urban traffic volume continues to grow, traditional traffic signal control methods have become increasingly unable to meet the demands for efficient and safe traffic flow. Green wave control technology, as an advanced traffic signal management strategy, aims to significantly improve road traffic efficiency and reduce vehicle delays and stops by rationally designing the signal phase differences between intersections, enabling vehicles to continuously pass through multiple intersections at a specific speed. In recent years, green wave control technology has gradually become a research hotspot for scholars both domestically and internationally, and has been widely applied in practical traffic management.

Liu Xiaoming et.al [1] conducted a thorough exploration of the impact of continuous traffic volume on the effectiveness of green wave control, and proposed corresponding optimization methods. Wang Jungang et.al [2] studied the collaborative optimization of green split and green wave control, providing theoretical support for enhancing road traffic capacity. Jing Binbin et.al [3] improved the traditional model, enhancing the flexibility and adaptability of green wave control. Lu Kai et.al [4] proposed a numerical solution algorithm for bidirectional green wave coordinated control under asymmetric traffic conditions, providing a solution for green wave control in complex traffic environments.

In addition, Chang Yulin et.al [5] studied the optimization of bidirectional green wave control for urban trunk lines. Lu Shunda and Cheng Lin [6] proposed optimization strategies using graphical methods. Tang Keshuang et.al [7] explored improved methods for multi-bandwidth trunk line coordinated control models. Zhang Yan et.al [8] constructed a double-cycle arterial green wave coordinated control model, which was empirically verified. These studies not only enrich the theoretical system of green wave control technology but also provide strong technical support for practical applications.

In summary, green wave control technology plays a crucial role in improving urban traffic management and alleviating traffic congestion. This article presents an empirical study, relying on the implementation project of urban traffic optimization in Weifang City. It designs and implements a segmented green wave coordinated control scheme for 11 intersections on the main arterial road of Dongfeng Street within the city.

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2. Optimized object

According to the requirements of the previous construction, the installation and debugging of the intelligent traffic signal controller and geomagnetic testing equipment have been completed.

The traffic signal control system has been deployed. By borrowing the network of the second and third phases of the electric police project, 6 signal controllers and 8 geomagnetic detectors can be accessed.

Considering the actual problems in communication and the on-site situation, this signal optimization work is mainly aimed at designing a time-sharing segmented green wave coordinated control scheme for 11 intersections of Dongfeng Street trunk line, as shown in figure 1:

Figure 1: Location distribution map of design intersections along Dongfeng Street

3. Design of Green Wave coordinated Control

3.1 Traffic survey methods

Based on the geomagnetic detector in the construction foundation, the cross-sectional flow data at the position of 30-40 meters behind the stop line can be obtained, and the statistical frequency of the data is 5min (through theoretical proof and practical engineering proof, 5min statistical flow data can better reflect the characteristics of lane traffic flow). Considering that the Dongfeng Street involved is the urban trunk road of Weifang City, and there is a large demand for public transport and pedestrian traffic, it should be taken into account in the cross-section flow survey of the intersection. The floating vehicle survey method was used to investigate the motor vehicle travel time, parking times and delay time. A car goes back and forth once in a period of time (sub-peak peace peak).

3.2 Location of traffic survey

Intersection cross-section flow survey is an on-the-spot investigation, traffic timing and light sequence investigation, together with the information provided by the detachment, carried out field investigation and verification, a total of 11 intersections. Using company vehicles and taxis as floating cars, the travel time, parking times and delay time of 11 intersections were investigated.

3.3 Survey methods of travel time and parking times

Floating vehicle: One Mercedes-Benz and one taxi, as shown in figure 2.

Figure 2: Floating car

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4. Design of Green Wave coordinated Control

After years of theoretical research and practical engineering experience, many kinds of trunk line coordinated control design software have been developed. This project mainly uses the following three types of trunk line green wave coordinated control design for Dongfeng Street, and compares the schemes designed by the three software. Fine-tune the actual situation of the traffic survey to meet the requirements of the traffic characteristics of the area, as shown in figure 3 and figure 4 :

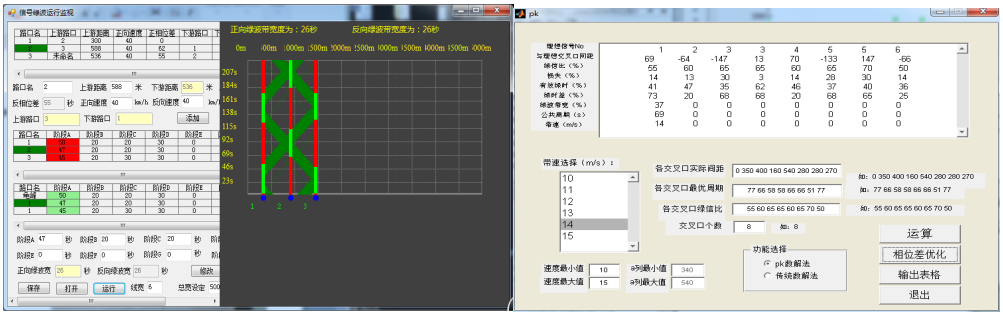


Figure 3: Green wave design software

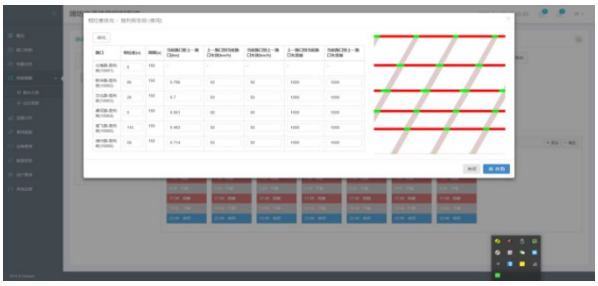
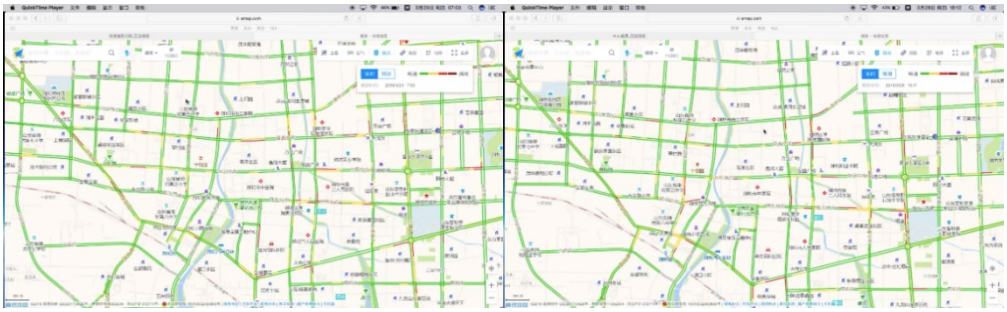


Figure 4: Green wave design module of traffic control system

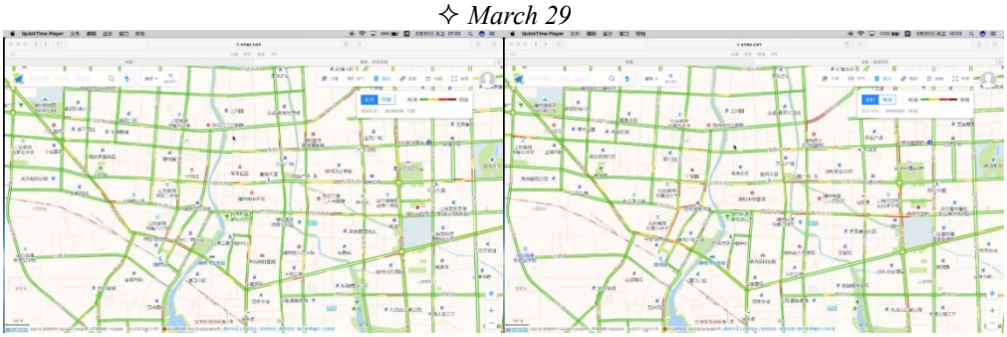
5. Test verification

5.1 Road condition analysis

From March 29, 2023 to April 4, 2023, road conditions are derived from Amap real-time road conditions, with morning peak at 7:00-8:30 and evening peak at 17:00-19:00, as shown in figure 5.



✧ *March 29*



✧ *March 30*

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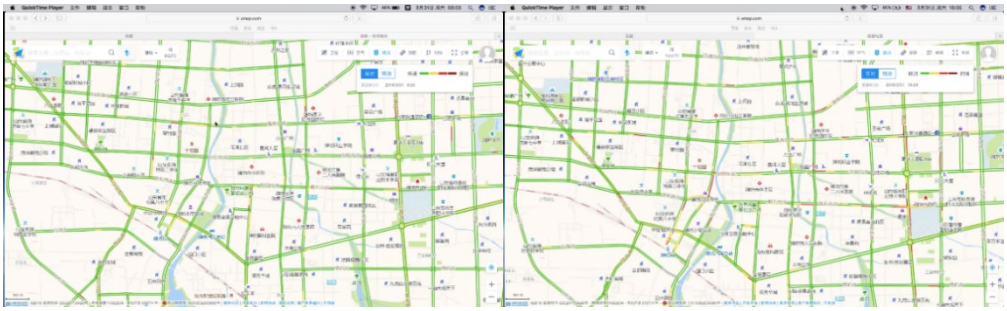
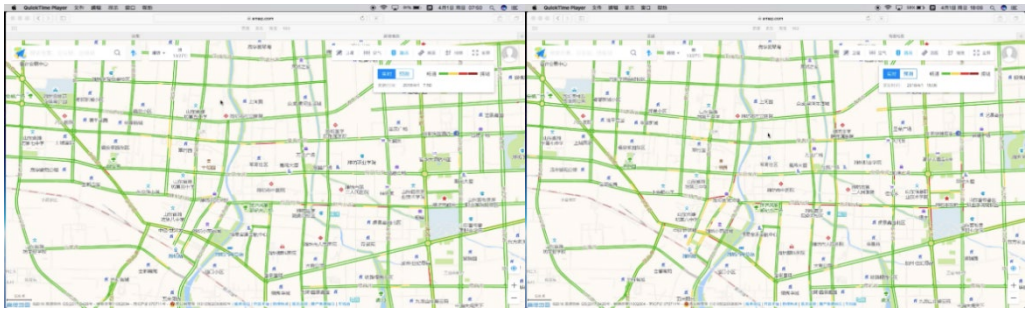
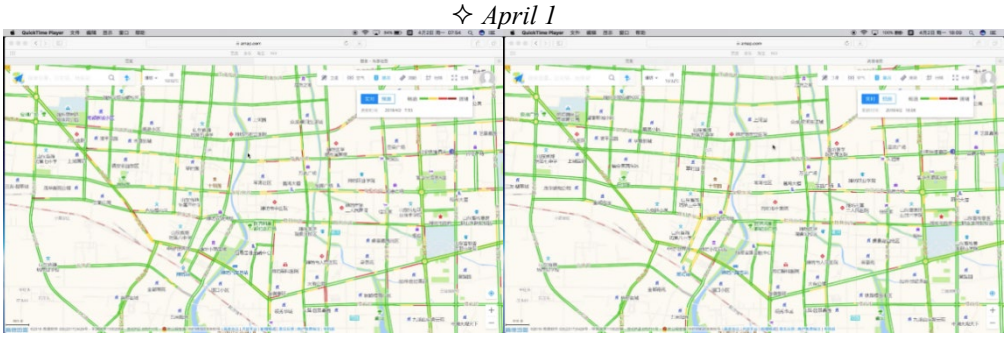


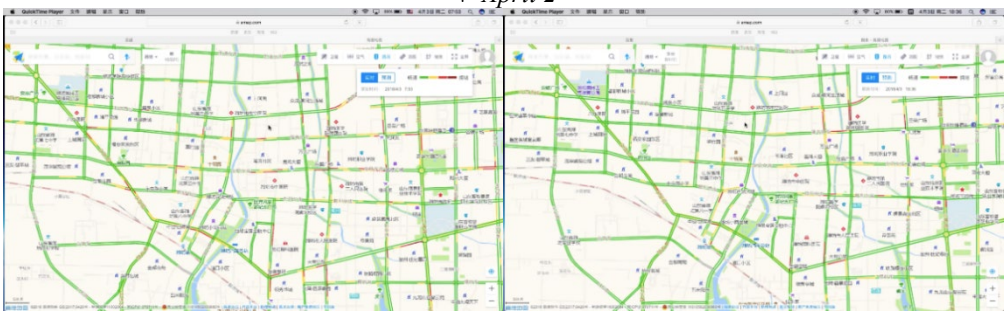
✧ *March 31*



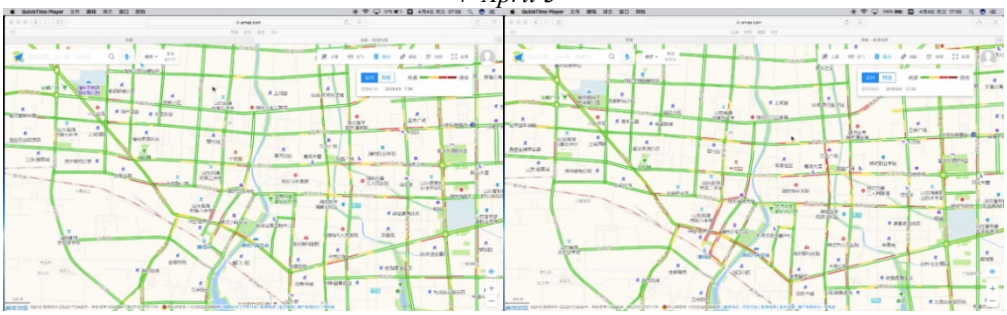
✧ *April 1*



✧ *April 2*



✧ *April 3*



✧ *April 4*

Figure 5: Real-time road condition analysis

5.2 Travel time and number of stop

From March 29 to April 4, 2023, the data source is the floating car test, which takes place from 7:00

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to 8:30 in the morning peak and 17:00 to 19:00 in the evening peak, with two round trips, as shown in table 1.

Table 1: Floating car test

Road	Time	Morning peak		Evening peak	
		Stop	Travel time	Stop	Travel time
Anshun Road-Heping Road	3.29	1.5	7.5min	1.3	7min
	3.30	1.4	7.5min	1.8	8.5min
	3.31	1.2	7min	1.3	7min
	4.1	1.2	7min	1.2	7min
	4.2	1.6	8min	1.4	7.5min
	4.3	1.5	7.5min	1.4	7.5min
	4.4	1.7	8min	2.0	9min
	Average	1.44	7.50min	1.49	7.64min
Siping Road-Xinhua Road	3.29	1.6	8min	1.4	7.5min
	3.30	1.4	7.5min	1.9	8.5min
	3.31	1.3	7min	1.3	7min
	4.1	1.3	7min	1.3	7min
	4.2	1.5	7.5min	1.5	8min
	4.3	1.6	8min	1.5	7.5min
	4.4	1.8	8.5min	1.9	8.5min
	Average	1.5	7.64min	1.54	7.71min

From the test data, the parking times and travel time in the morning and evening peak have decreased. By observing the road condition of Dongfeng Street for a week, it can be found that the road condition is obviously improved after the implementation of segmented green wave.

6. Conclusion

This paper takes into full account the current situation of road traffic control in the central urban area of Weifang City, Shandong Province. Relying on the Weifang Urban Traffic Optimization Organization and Implementation Project, a segmented green wave coordinated control scheme is designed and implemented for 11 intersections on Dongfeng Street, the main arterial road in the city. Through real-time traffic analysis and testing using floating cars, satisfactory results have been achieved, demonstrating the feasibility and effectiveness of the green wave control scheme designed in this paper. However, the following issues have been identified during the implementation process, which can affect green wave control:

An investigation revealed that the main arterial section of Dongfeng Street uses guardrails for physical isolation, with numerous openings in the section primarily used for vehicles to make U-turns and pedestrians to cross the street.

(1) Regarding U-turn vehicles: Due to the close proximity of the openings to intersections, when the east-west straight-through phase is authorized, U-turn vehicles have a significant impact on straight-through vehicles, significantly reducing the speed of the vehicle platoon and causing significant interference with green wave coordination.

(2) Regarding pedestrians crossing the street: Pedestrian crossings are generally located in the middle of the section. Considering the regulations for motor vehicles to yield to pedestrians, this has a significant impact on the green wave vehicle platoon midway through its journey.

In response to the above issues, the following suggestions are made in this paper:

(1) For U-turn vehicles, it is recommended to eliminate U-turns on the section and instead set up designated U-turn lanes or U-turn signals at multiple intersections.

(2) For U-turn vehicles, a microcirculation approach can be adopted, utilizing feeder roads to complete U-turns.

(3) For pedestrians crossing the street, it is recommended to establish consolidated pedestrian crossings on the section, install pedestrian crossing signal lights, and incorporate the signal lights into the overall green wave coordination scheme for the arterial road.

(4) Enhanced supervision of non-motor vehicles (including electric bicycles, tricycles, and bicycles)

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should be implemented. For intersections with larger internal spaces and a higher number of non-motor vehicles, non-motor vehicle waiting areas can be added to ensure the safety of non-motor vehicles and maintain the overall traffic capacity of the intersection.

Acknowledgement

This research was supported by grants from the Beijing Science and Technology Association 2021-2023 Young Talent Promotion Project (BYESS2021164), Beijing Digital Education Research Project (BDEC2022619048), Ningxia Natural Science Foundation General Project (2022AAC03757), Beijing Higher Education Association Project (MS2022144), Ministry of Education Industry-School Cooperative Education Project (220607039172210, 22107153134955). The referees' valuable suggestions are greatly appreciated.

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