Coordination and Optimization of Urban Traffic Control and Path Guidance Based on Multi-Agent

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Abstract: With the development of society, the urbanization process is accelerating, the urban population is growing rapidly, and the traffic problems are becoming more and more prominent, which seriously affects the normal operation of the city. Transportation is the lifeblood of the city. Scientific management and control is an important way to improve the efficiency of urban traffic operation, and it is also an important symbol of urban transportation modernization, informationization and intelligence. This paper aims to study the new coordinated control method of traffic signals. Different from the traditional coordinated control method of centralized control and hierarchical control, a multi-agent distributed traffic signal coordination control system is established, which distributes the main functions of signal control to Signal control agents at various intersections reduce to the complexity of the control algorithm and improve the reliability and intelligence of the system.

1. Introduction
With the development of social economy, the city has expanded rapidly, traffic volume has increased sharply, traffic congestion has intensified, and traffic accidents have occurred frequently. Especially in some big cities, traffic problems have become a bottleneck restricting urban economic development. With the rise of artificial intelligence research, artificial intelligence methods provide a solid theoretical basis for the study of intelligent transportation systems. Intelligent control has the superiority that traditional control methods are difficult to compare. It achieves the purpose of control by simulating human intelligent decision-making methods, and shows powerful control effects when dealing with complexity and uncertainty. The biggest feature of the intelligent control method is that its control algorithm has the ability to strongly approximate nonlinear functions, and does not depend on accurate mathematical models. Intelligent control methods such as fuzzy control, artificial neural network and genetic algorithm can achieve better results than timing control and induction control. Therefore, the combination of multiple intelligent control methods is a feasible strategy to solve urban traffic control.

Based on the theory of agent and the characteristics of the transportation system itself, based on the analysis of the current lack of traffic control structure, a distributed urban traffic signal control system structure based on multi-agent is proposed. The system puts the right to formulate the control strategy of the transportation system at each intersection agent. The agents at each intersection control the transportation system according to their own knowledge and cooperate with each other, which improves the intelligent decision-making ability of the intersection agent, thus making the control system more flexible. Adapt to the complex and varied characteristics of the transportation system.

In order to effectively alleviate traffic congestion, UTCS (Urban Traffic Control System) and UTFGS (Urban Traffic Flow Guidance System) must be coordinated to rationally distribute road network traffic flow in space and time, so that road network traffic flow can be properly allocated. And
optimize to achieve good traffic management results. Therefore, studying the synergy between UTCS and UTFGS has important practical significance for effectively alleviating urban traffic congestion in China.

2. Research purposes and significance
Urban traffic problems, represented by traffic congestion and other problems brought about by them, have become a serious problem facing the world. The solution to the traffic problem must adopt the ideas and methods of system engineering, through scientific and systematic comprehensive management. Traffic control and traffic guidance must work together to ensure the realization of their respective functions. The significance of the synergy between the urban traffic control system and the traffic flow guidance system is reflected in:

(1) Achieve common traffic management goals
The cooperation between UTCS and UTFGS can optimize the traffic management objectives, make the induction information more accurate, and thus greatly improve the efficiency of road transportation, and truly achieve the smooth and effective operation target of the road network.

(2) Realizing resource integration of traffic management system
The control system and the inductive system can be built on a common subsystem. Traffic flow detection system, road information collection system, traffic information release system, data communication system traffic flow real-time information processing system, controlled network geographic information system and all other data and information about the network environment can be controlled and induced. The system is jointly owned and utilized.

(3) Realizing the time and space complementarity of traffic management means
Traffic control is mandatory passive management. Vehicles on the road network must be observed. Induction is the active management of flexibility. Travelers can choose to obey or choose to disobey.

In short, in the urban traffic management, the control system and the inductive system are interconnected, independent, complementary, and each have their own characteristics. Control-induced synergy can achieve synergy between overall and local management, dynamics, and stability. Coexistence of coercion and flexibility is a necessary means to achieve safe, efficient and smooth operation of traffic.

3. Research content
Aiming at the problem of the combination of the existing traffic control system and the traffic guidance system, this paper uses the inductive information as one of the means of traffic management, combined with the distributed characteristics of traffic control, and adopts multi-agent technology in traffic control and induction. Hierarchical hierarchy theory and intelligent decision-making technology, which influences the path selection of travellers, establishes a user-optimized and system-optimized traffic control system and traffic guidance system integration model to solve the formulation of traffic control and induction synergy strategy. Achieve system optimization in an achievable sense.

(1) Structure of multi-agent control system
The multi-agent control system is formed by the coordination of multiple agents to realize the control of complex systems. Each agent in a multi-agent system is a physical or abstract entity that acts on itself and the environment, manipulates partial representations of the environment, and communicates with other agents. Multi-agent control system structure, see Fig 1.
A multi-agent system differs from a simple combination of individual agents, with interactions between agents. The purpose of collaboration is to achieve (or avoid) the state that one or several agents need (or evade). The two basic modes of collaboration are cooperation and competition. In the process of cooperation, several agents work together and share knowledge and skills to achieve common goals. During the competition, several agents compete against each other due to conflicts of goals. Can be balanced by negotiation. The problems solved by multi-agent technology are distributed and complex. The former is characterized by spatial, temporal and functional distribution; the latter shows that the system is too large and difficult to solve with a single centralized system. Moreover, expanding a centralized large system is time-consuming, labor-intensive, and costly. Moreover, this extension is usually quite fragile and often becomes an invalid system due to small changes in environmental factors.

Multi-agent systems provide a new way to understand, manage, and use distributed, large-scale, dynamic, open, heterogeneous computing and information systems. The multi-agent system is not only to make the original scattered system form a coordinated whole through interaction, but also to transform the existing large system to make its internal structure more reasonable and more efficient. Systems with intrinsic distribution characteristics and complexity are often difficult to solve with centralized computing technology. Multi-agent systems are abstract reflections of real-world intelligent systems, and have obvious advantages in solving large-scale distributed complex problems. Increase speed and efficiency, stability and reliability, flexibility, and reduce costs. In general, agents in a multi-agent system will contact owners who represent different goals and motivations. For successful interaction, these agents need to have the ability to cooperate, coordinate and negotiate with other agents.

(2) Research on collaborative framework based on traffic control and induction

Traffic control and traffic guidance are two important components of traffic management. Therefore, in the process of establishing the intelligent decision support system in traffic management, it is necessary to fully consider the realization of traffic control and induction and the joint work of the two. Based on the transportation system is a complex large system, the hierarchical hierarchical intelligent control mode is considered when constructing the model. The hierarchical intelligent traffic control system proposed by Saridis consists of three levels: organization level, coordination level and control level. It can reduce the dimension of the problem, obtain real-time control scheme with less computing resources, and can make rapid traffic events reaction. The traffic control and induced collaborative system model constructed by combining multi-agent technology and hierarchical hierarchical structure, the road segment agent, intersection agent, regional agent and central agent are established in the system.

In the transportation system, the intersection is the central nervous system of traffic, a well-designed intersection, which can effectively realize the merger and diversion of traffic flow, which is the key to the normal operation of the traffic system. Therefore, the intersection agent model is the urban microscopic traffic simulation. An agent that is very important to the system, the structure...
The diagram of the intersection agent, and the structure of the single-route agent model are shown in Figure 2.

![Diagram of the intersection agent and single-route agent model](image)

**Fig 2** The agent structure Model of crossing agent

The intersection agent mainly consists of the basic attributes of the intersection, the knowledge base, the sensing unit, the decision unit, the detector and the communication unit. The attributes of the intersection agent mainly include: the central coordinates of the intersection, the section connected by the intersection, the type of the intersection, the route that all the vehicles can travel, and the distance between the center point of the intersection and the parking line of each section.

The communication unit establishes communication with each intersection agent and performs mutual coordination. In this way, real-time traffic state information can be received within a given time interval; reasoning and predicting the trend of increase or decrease in the next cycle of the traffic flow; communicating with the agent at the upper layer of the same layer or the region; obtaining the adjacent intersection Traffic status information; important information transmitted to other agents about the intersection; local targets and tasks are to optimize the control of the intersection.

![Control and Guidance System Integration System Framework](image)

**Fig 3** Control and Guidance System Integration System Framework Based on Multi-Intelligent System

(3) **Information processing of traffic control and traffic guidance synergy**

In traffic management, timely and accurate traffic information is directly related to the correct and reasonable formulation of traffic management strategies. Traffic information can characterize the parameters of traffic flow characteristics and reflect traffic conditions. It is the basis for the development of coordinated strategies for traffic control and traffic management. Only based on real-time, high-precision basic traffic parameter information and road network traffic flow state information can the corresponding traffic control and induction strategies be developed. Only the corresponding control strategy, induction strategy and coordination strategy can be developed to manage the traffic flow to the optimal operation state reasonably and effectively. The collection and processing of traffic basic information is the guarantee for the realization of traffic control and traffic induced coordination.

After the traffic information is collected and processed, it is provided to the traffic control and
traffic guidance collaborative application. The formulation of the traffic coordination strategy requires not only the current data, but also historical data to predict the future state. Therefore, the traffic information must be accurate and reliable.

(4) Research on traffic control and induced collaborative optimization based on

Traffic control and traffic induced collaborative information fusion technology. Data fusion, also known as information fusion, refers to the information processing process in which multi-sensor data is automatically analyzed and integrated under certain criteria to complete the required decision-making and evaluation. The biggest advantage of data fusion technology is that it can reasonably coordinate multi-source data, fully integrate useful information, and improve the ability to make correct decisions in a changing environment.

Data fusion technology is a comprehensive information processing technology that utilizes multi-source information to obtain a more objective and more fundamental understanding of the same thing or target. Because the traffic parameters, average speed, instantaneous speed, headway distance, vehicle classification, and lane occupancy rate of the traffic parameters that can be detected are different, the accuracy of the collected data is different, so different data needs to be performed Fusion.

The communication control and induction synergy has always been the research focus of traffic workers in various countries. It refers to the advantages of complementary traffic between the intersections under the macro-control of the traffic center, and the advantages of complementarity between the intersections are maximized. Traffic flow, thereby improving the capacity of the road.

4. Research and innovation
(1) Distributed coordinated control system based on multi-agent

Multi-agent system is a collection of agents. It is the frontier discipline of artificial intelligence
today. It is an important branch in the research of distributed artificial intelligence. Combining agent technology with urban control is the solution to urban traffic intelligent control and The direction of traffic management research. As a large and complex system, the urban transportation system can be constructed into a small, easy-to-manage system that communicates and coordinates with each other using multi-agent system theory.

(2) Traffic control and traffic induced collaborative information processing technology

Traffic information collected directly through the detector may cause errors, abnormalities or missing phenomena for various reasons. In order to ensure accurate traffic control and induced traffic information, traffic information is pre-processed and fused before being provided to decision makers. Combined with the characteristics of traffic information, this paper designs a traffic control and traffic-induced dynamic traffic information processing process, as shown in the figure.

The process mainly includes traffic information collection, data extraction, conversion and loading, and multi-source traffic information processing. Data extraction refers to the extraction of data from different networks, different operating platforms, different databases and data formats, and different subsystems. The conversion of data refers to the consolidation, aggregation, filtering, conversion, etc. Loaded into the database of the information processing flow. Traffic information processing mainly includes data preprocessing, data fusion and data mining, and finally forms useful information and knowledge.

(3) Agent modeling in traffic control and induced coordination

Based on the requirements of traffic management and traffic control, the MAS-based intelligent decision support system establishes the road segment agent, intersection agent, traffic control and induction coordination agent, regional agent and central agent. The general structure model of each agent is shown in the figure: The information transfer between the agents is achieved through a dialogue mechanism.
5. The conclusion
In summary, aiming at the importance of global strategy formulation in traffic control and induced coordination, a multi-agent based intelligent decision support system technology is adopted, and the application model framework is given. Starting from the practical application, starting from the collaborative mode and the collaborative algorithm, the multi-agent technology and intelligent decision-making technology are applied to the formulation and implementation of the inductive control collaborative management strategy. Traffic flow guidance system and traffic control system are the main means to realize urban traffic management intelligence, modernization, informationization and network. UTCS and UTFGS must be coordinated to make the road network traffic flow properly distributed and optimized, thus achieving good results. Traffic management effects.

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References
[1] China Transportation Technology Network. The future direction of intelligent transportation [EB/OL] (2017.01)
[2] Wang Yunpeng. Internet of Vehicles and Roads Collaboration [EB/OL]. (2016.11)
[3] Luo Lianghong. Research on Key Technologies of Vehicle Road Cooperation Based on ZIGBEE[D]. Guangzhou: South China University of Technology, 2016(7)
[4] Hewer TD, Nekovee M.Congestion Reduction Using Ad-Hoc Message Dissemination in Vehicular Networks[c]. The First International ICST Conference on Communications Infrastructure, Systems and Applications in Europe. 2017.8
[5] Xu Q. Mark T, Ko J. etal. Vehicleto-Vehicle Safety Messaging in DSRC [C] . Proceedings of the 1st ACM International Workshop on Vehicular Ad Hoc Networks, Philadelphia: ACM, 2014.9
[6] Wang Feiyue. Vehicle road coordination is a concrete example of intelligent transportation [EB/OL]. (2018. 10)
[7] Wang Yunpeng. Collaboration between Vehicle Networking and Vehicle Roads [ EB/OL]. (2016.11).
[8] Shi Jianjun, Li Xiaoli. Traffic information cloud computing and its application research [J]. Transportation Systems Engineering and Information, 2017.11(1)

[9] Jmeng. Key technologies and development trends of the Internet of Vehicles [EB/OL] (2017.10) http://www.Enet.Com.cn/networks/.

[10] Baidu Encyclopedia. Data Fusion Technology [EB/OL]. Http: /baike.baidu.com/view/1112169.html.