The Key Technologies and Challenges of Intelligent Transportation Systems

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Keywords: Intelligent Transportation Systems, Road Perception and Recognition, Big Data Fusion Processing.

Abstract: Intelligent transportation system is the key to improving transportation system efficiency, service quality, safety level, environmental protection and energy conservation. In the future, the focus of intelligent transportation development will use new technologies s to realize the sharing and integration of traffic big data, high-level road coordination and traffic information perception and recognition, improve the intelligent level and decision analysis capability of road transportation services, and realize integrated transportation, improve safety level and achieve green traffic.

1. Introduction

With the advancement of urbanization and the rapid development of society, Transportation System facing a series of serious challenges such as congestion and pollution. The imbalance between traffic supply and demand is becoming increasingly acute. However, due to the limitation of road infrastructure and urban space resources, it is difficult to solve the current serious traffic problems by relying solely on the new transport infrastructure to improve the supply capacity. The application of intelligent transportation technology can improve the efficiency and service of existing infrastructure, and plays an indispensable role in solving urban traffic problems.

The development of ITS can be traced back to the 20th century, and its early development is restricted by the level of communication. From 1995 to 2000, with the development of data transmission system and the breakthrough of location service and communication technology, the development speed of ITS is obviously accelerated. Communication technology is no longer a limiting factor. At this time, the development of ITS is mainly limited by Calculate ability. From 2000 to 2010, Intelligent Transportation technology such as HD video and intelligent analysis technology have been applied in the field of urban transportation. Since 2010, with the continuous development of big data, machine learning, cloud computing and 5G communication technology, road collaboration, automatic driving and intelligent travel based on artificial intelligence will become the key direction of the next phase of technology development of ITS. Integration of new technologies with existing transportation systems will promote the development of intelligent transportation systems and solve many outstanding traffic problems.[2]

H. Abid et al. proposed a new V-cloud architecture, including Vehicle-Vehicle Network (V2V) layer and Vehicle-Infrastructure Network (V2I) layer. Vehicle-based systems are designated as cloud computing entities that support physical layer of network. Van Lint et al. made a short-term prediction of the driving time on the expressway. Lin et al. improved the existing optimal dynamic traffic assignment model of linear programming-based analysis system to enhance the authenticity of intersection modeling. D. Bernstein and others have studied PaaS-level extensions that support a large collection of mobile vehicles to enrich the functions required by the cloud and simulated millions of vehicles. Z. Alazawi has developed an intelligent emergency management system, focusing on transportation systems through ICT development. The aim is to collect data from multiple sources, including accidents. In addition, it also transmits the necessary information to the vehicle in real time. By simulating the impact of disasters on the actual urban traffic environment. Zhao et al. used a linear program to achieve fast signal time allocation at a single supersaturated intersection. Mulder et al. studied the car following kinematics and designed a tactile feedback algorithm to assist the driver's patrol driving system.

However, the use of intelligent vehicle-road collaboration and other technologies has just begun. The basic theories of Human-Vehicle-Road interaction and collaborative control mechanism, the optimal allocation of vehicle-borne and roadside information resources are still insufficient. The technology of road perception and recognition still lacks effective means, especially the perception of long-distance environment in high-speed state and the perception of environmental information under the condition of sensor network. Vehicle information can not achieve optimization and interactive management, and the use of real-time traffic data or information is insufficient.[1]

2. Background

The U.S. government attaches great importance to the development of Intelligent Transportation and Intelligent Network automotive industry, they are defined as the two core strategies. A series of policies and regulations have been issued to promote the establishment of relevant industrial systems. The European Commission promotes the deployment of vehicle networks in EU countries through the establishment of a cooperative intelligent transportation system platform (C-ITS platform), and promotes the integration of investment and regulatory frameworks throughout the EU to facilitate the deployment of C-ITS business from 2019. In order to coordinate deployment and testing activities, EU countries and road operation management agencies have established C-Road Platform, formulated and shared technical specifications, and conducted cross-site interoperability testing and verification. In Asia, the Japanese government attached importance to the development of the automatic driving vehicle and vehicle networking. In 2016, it issued the highway automatic driving implementation report. It clearly hoped to realize the automatic driving function in some areas in 2020. South Korea has formulated a long-term ICV development plan up to 2040. Its goal is to achieve intelligent road traffic system nationwide, to achieve high automation and maximize the use of traffic resources by connecting vehicles, roads and people. Its goal is to achieve zero traffic accidents by 2040. Singapore has formulated the 2022 New City Plan, which plans to deploy autonomous driving nationwide in 2022, become the first country in the world to achieve autonomous driving.

3. Key Technologies of Intelligent Transportation System

Recent technological developments, especially the development of wireless communication, cloud computing, artificial intelligence and remote sensing technology, are pushing intelligent transportation system towards a major leap. Vehicles, as an important part of ITS, are complex computing systems now. There are many computers and sensors on the vehicle, which collect data from part of the vehicle. Vehicles not only collect information about themselves and their environment, but also exchange such information with other nearby vehicles in real time. At the same time, road infrastructure can also establish links with mobile vehicles, realize high-speed information exchange, and form the ability of vehicle-road coordination.

3.1 Road Perception and Recognition Technology

Environmental awareness in complex urban road environment has become a hot topic in the field of modern intelligent transportation. The perception layer of ITS undertakes the overall perception and collection of vehicle and road traffic information, which is the nerve endings of ITS. Through sensors, RFID, vehicle positioning and other technologies, to realize real-time perception of transport condition and control system of road environment, vehicles and vehicles, vehicles and people, vehicles and road infrastructure, etc. At present, there are two main ways to perceive the road environment. One is active way. It collects and analyses the information of the road by its own sensors, such as machine vision, laser radar, millimeter wave radar, infrared, ultrasonic and so on.

The other is passive way, which acquires road information by exchanging information with road infrastructure or other vehicles.

The development of sensor technology makes the description of vehicle status and its surrounding environment clearer and more complete, especially the application of image recognition technology and radar technology. Machine vision achieves the extraction and analysis of human, vehicle, object and other related feature information through image recognition, image comparison and pattern matching. Such as license plate recognition, vehicle color recognition, vehicle type recognition and so on. Machine vision has a good ability to analyze the color and texture of objects, but it is weak in depth information and vulnerable to special environmental impact.[4] Millimeter-wave radar and LIDAR have great advantages in detecting objects, distances and speeds, which enable vehicles to recognize vehicles, pedestrians and obstacles in front and side of vehicles in high-speed complex condition. Radar has a good sense of depth information, but it is easy to be interfered by other objects to produce misjudgment.

Single sensor cannot meet the reliability and integrity requirements of environmental information perception. Multi-sensor information fusion can effectively overcome the shortcomings of single sensor, such as small detection range and low reliability. Therefore, information fusion using multi-sensor is the trend of environmental awareness. The common multi-sensor fusion methods include the fusion of laser radar sensor and machine vision, the fusion of millimeter-wave radar sensor and machine vision, and other sensor fusion methods. It has become a hotspot in the research of vehicle safety environment perception technology.Road perception and recognition technology, combined with positioning technology and safety assistant driving technology, can greatly improve the safety of vehicles, it also avoids collision with pedestrians. At the same time, it also provides support for the development of the automatic driving system. [9]

Current applications include road management: such as intersection, section perception, integrated signal control, traffic detection systems, which provide reliable basis for the optimal timing of intersection, road condition analysis, traffic data, traffic planning, etc. The perception and snapshot of illegal parking on the roadside and the management of parking spaces on the roadside based on image recognition can effectively reduce costs and improve the reliability of the system. Automatic Driving and Vehicle Guidance: Based on the video parking guidance system, fast guidance can be realized. By adding additional equipment, intelligent parking guidance can be upgraded. [7]

3.2 Big Data Fusion Processing of Multi-source Heterogeneous

Traffic big data has the characteristics of multi-source heterogeneity, large space-time span, dynamic variation, heterogeneity, high randomness, locality and short life cycle. How to effectively collect and utilize traffic big data to meet the application needs of high timeliness is an opportunity and challenge faced by ITS. The most important direction is the improvement of data processing ability. In the collection, transmission, processing and application of multi-source large data, a large number of structured, semi-structured and unstructured heterogeneous data are processed to obtain data to support the discovery of rules, mechanism analysis and automatic generation of countermeasures.[5] There are many sources of data, such as detectors, LIDAR and GPS. Data generated by different sensors are often interrelated or complementary, and they are adapted to different environments. Visual and radar systems are susceptible to the effects of light and visibility, such as rain, snow, static or dynamic shadows, and glare. GPS can provide reliable positioning in most open areas, but in urban areas where satellite signals are easily blocked, which result in potential errors or omissions in vehicle positioning data.[10]

Because of the great differences, wide data sources, low value density and real-time updating in the structure of traffic data, it brings great challenges to fusion processing. Researchers have proposed fusion algorithms based on D-S theory, fuzzy set theory, topic maps and semantic rules. Due to the incompetence of traditional data analysis methods, multi-source data fusion using neural networks has been further studied. On the one hand, the neural network has a strong ability of feature extraction and abstraction. It can integrate multi-source information, process heterogeneous data and capture dynamic changes. It is a bridge to realize value transformation of large data. On the other hand, the huge volume of multi-source data provides sufficient training samples for the neural network, making it possible to train large-scale neural network, as shown in Fig.1.[6]

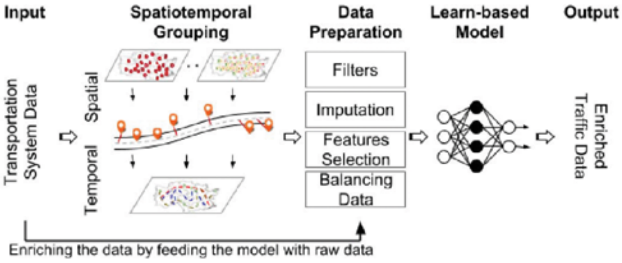

Figure 1. A Design of Heterogeneous Data Fusion Using Neural Network

3.3 Traffic Cloud Technology

Because data processing is limited by a series of conditions, such as high cost and high timeliness, data analysis platform based on cloud computing technology, Hadoop and Spark platform, which can realize distributed computing, will play an increasingly important role in the future. Cloud computing is a computing model that uses computers to process huge data. It provides data acquisition, storage, fast processing, analysis and information publishing services according to users 'needs. With trong traffic data processing ability, multi-user personalized service ability, dynamic load balancing ability, good expansion ability and software redundancy mechanism, it can solve the bottleneck problem of the development of intelligent transportation. Cloud computing and intelligent transportation system is highly fit. In the process of intelligent transportation development, it is of great significance to fully integrate cloud computing technology to realize the organization and mining of traffic big data, the fast processing and analysis of traffic information, and the real-time release and sharing of traffic information in cloud architecture.

Intelligent traffic cloud service integrates traffic information collection, processing, analysis and application, and provides intelligent services for urban traffic management departments and people's daily travel. The basic framework of intelligent traffic cloud computing includes three layers: infrastructure layer, platform layer and application layer. Infrastructure layer integrates all traffic information resources, constructs traffic big data resource pool, and stores and preprocesses traffic big data at the same time. The platform layer is based on the infrastructure layer, providing services such as large data management, distributed parallel computing, traffic software operation and development. The main service objects of application layer are traffic management departments, enterprises, scientific research institutions and travelers. Provide cloud services with fast computing power, high confidentiality and flexibility for urban traffic management departments, and provide traffic information sharing, travel choice guidance for enterprises, scientific research institutions and travelers.[8]

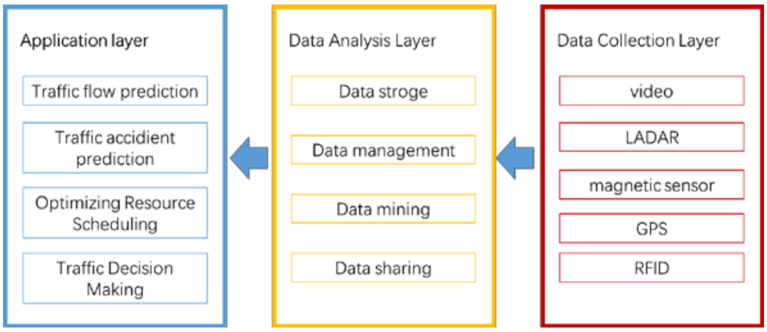

Figure 2. Cloud Architecture of Data Processing in ITS

3.4 Transportation network deduction and decision analysis technology

The traffic data provide unprecedented information support for the comprehensive analysis and evaluation of the system. The application of big data and cloud computing technology in feature recognition, data mining analysis, modeling and simulation, data visualization and so on, to carry out traffic depth analysis and judgment, is expected to achieve more comprehensive demand forecasting, more accurate situation analysis, more accurate forecasting and early warning, more efficient rule discovery, more scientific decision support.[3]

Through the intelligent algorithm of iteration optimization, the traffic connection among intersections, related sections and functional groups is optimized. Based on the real-time perception system of traffic incidents and road traffic flow and the analysis ability of the traffic big data integration platform, the optimization scheme of traffic organization, management and control is formed to improve the road traffic efficiency. Combing the real-time traffic data of the whole region, intersection, section and so on, and developing the algorithm model of accurately describing the road traffic evolution, including traffic video analysis and processing algorithm, data integration algorithm, signal optimization algorithm, traffic evaluation algorithm, situation evaluation algorithm, etc., to support traffic signal control optimization and realize intersection.

4. Challenges and conclusion

In general, the future research of intelligent transportation faces the following challenges: Traffic information collection technology, vehicle identification system, traffic information transmission mode and standard, information storage and processing platform integrated with cloud computing, information fusion processing and analysis, traffic information release and service platform research. Ultimately, the integration and sharing of high-density information in multiple systems will provide powerful technical support for automation and information technology. Intelligent transportation system is the key to improving transportation system efficiency, service quality, safety level, environmental protection and energy conservation. In the future, the focus of intelligent transportation development will use new technologies s to realize the sharing and integration of traffic big data, high-level road coordination and traffic information perception and recognition, improve the intelligent level and decision analysis capability of road transportation services, and realize integrated transportation. Break traffic congestion, improve safety level and achieve green traffic.

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