Applications of Big Data technology in Intelligent Transportation System

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Abstract. With the continuous development of Intelligent Transportation System (ITS), amount of data can be collected, generated and used by ITS, and the application of big data technology in Intelligent Transportation System is also applied in different kinds of fields. This paper first explains the definition of big data and intelligent transportation systems. Second, the framework of big data technology in the Intelligent Transport System (ITS) is introduced, which summarizes the data collection methods in specific scenarios of ITS, the application methods of data analysis in ITS, and the application of big data technology in ITS. Furthermore, this paper introduces several case studies on the application of big data technology in ITS, including public transport service planning, road traffic flow prediction, road traffic accident analysis, personal travel route planning, rail traffic management and control, and data analysis and prediction of bridge safety. Finally, this paper discusses some challenges of using big data technology in ITS.

Keywords: Intelligent Transportation System, Big Data, data collection method, data analysis.

1. Introduction

In order to make the life of urban residents more convenient, the Intelligent Transport System (ITS) has become an indispensable part of the digital society. Nowadays, urban mobility is a critical issue in any city or region, where people use the transportation system to go to school, to work, and to travel for any purpose.

Intelligent Transport System aims to achieve traffic efficiency by minimizing traffic problems. It enriches the user's prior information of traffic which is easy to grasp. It helps people travel more conveniently and improves travel safety and comfort [1]. The use of ITS is not limited to traffic congestion control and information, but also includes road safety and efficient use of infrastructure. Due to the intelligence of ITS and the possibility of rapid development in the future ITS has now become a multidisciplinary field of work, and ITS systems are widely recognized and applied in many countries today [2].

Intelligent transportation systems are the application of sensing, analysis, control and communications technologies to ground transportation in order to improve safety, mobility and efficiency. The technical core of intelligent transportation systems (ITS) is the application of information and control technologies to transportation system operations [3]. There are two specific examples to illustrate in detail which are intelligent parking systems and intelligent traffic monitoring system. The working principle of intelligent parking systems included in the field of intelligent transportation systems is as follows: the parking information acquisition equipment is installed in each parking lot or the entrance and exit of the parking lot to detect the vehicles in and out in real time, and collect the parking space change data. Secondly, the change data of parking Spaces is transmitted by the parking guidance system through the wireless public communication network [4]. After processing by the parking guidance control system, the free parking data corresponding to each parking lot is generated, and the corresponding information display board is divided [5]. Finally, the data of free parking Spaces in corresponding parking lots will reach the corresponding information display board through wireless communication network to provide the driver with the effective vacancy information of each parking lot.

The second example of intelligent transportation system to be introduced in this article is intelligent transportation monitoring system. First of all, through the intelligent traffic monitoring system can intuitively capture the vehicle model and color of the hit-and-run accident, to save a lot of human and material resources for the detection of the driving accident. Second, intelligent transportation monitoring system can visually monitor, the characteristics of the hit-and-run driver for some certificates or fake certificates after the traffic accident to escape, escape untraceable under the condition of vehicles, by intelligent monitoring system can master some important bayonet driving people's appearance, characteristics such as gender, hair style and take personnel situation, can provide clues in many aspects for investigating the case [6]. Moreover, the intelligent transportation monitoring system can visually monitor hit-and-run vehicle plate number, through the trunk road traffic lights electronic monitoring system in the process of capturing such traffic violations can directly capture vehicle plate number, and to solve the case, find the breakthrough point, to curb drove away accidents and show an ascendant trend [7].

The following introduces four common data collection methods in Section 2. Section 3 introduces the application methods of big data analysis technology in intelligent transportation systems. Section 4 introduces some common application methods of big data technology in intelligent transportation systems and examples. In section 5, this part illustrates a series of challenges that people face in the application of big data technology in intelligent transportation systems, and finally leads to the expectations of intelligent transportation systems in the summary part of the article. By reading this paper, it can provide a summary of big data technology applied in ITS to let more readers have a clearer full structure of the methods of big data and applications of ITS.

2. Data collection methods applied in specific occasions of intelligent transportation systems

There is a range of information and communications technologies that enables the development of ITS. Smart card, GPS, Video and Sensor equipment. The smart card can be used to see the real-time information of customers. Real time images are provided by traffic sensors including video and GPS to help traffic center operators monitor complex traffic conditions and make appropriate decisions.

2.1. Smart card

With the widespread use of smart card automatic toll collection systems in public transport agencies, smart card data has become the main data source for investigating passenger movement patterns. Their main purpose is to collect revenue data about the toll system, and they also generate a large number of detailed amounts about passengers' transactions on public transport. This data is very useful to transportation planners, enabling them to have a long-term and particular plan from the day-to-day operation of the transportation system to the strategic planning of the network. For example, automatic fare collection (AFC) systems have been widely used in urban rail transit systems, where passengers need to use a smart card when riding a bus or train. The e-reader in the smart card captures passengers' details [8], such as when they boarded the bus, whether and how much they purchased tickets, etc.

2.2. GPS

GPS is the most popular location tracking tool of our time. Location tracking via GPS allows for more efficient and safer collection of traffic data. Through its triangulation technique (a mathematical method of determining location information), we can find the user's precise location on Earth and create a digital map of the surrounding area [9]. Triangulation can also determine data on the time it takes for a signal to travel from the satellite to the receiver, as well as data on the distance between the receiver and the satellite visible in the sky. This data can help the system operator to determine when to find a specific target. Applying the data collected by GPS in intelligent transportation systems can solve many traffic problems, such as travel mode detection, travel delay measurement and real-time traffic monitoring.

2.3. Video

Video cameras are widely deployed in ITS. In order to complete the tasks better such as vehicle identification and traffic flow detection, the video-based traffic data collection system for multiple vehicle types is created. It is important for pavement design, traffic operations and traffic control. By tracking and classifying every passing vehicle under mixed traffic conditions, the type and speed of every passing vehicle are recognized [10]. Finally, the flows and mean speeds of multiple vehicle types are output. A colour image-based adaptive background subtraction is proposed to obtain more accurate and a series of processes like shadow removal and setting road detection region are used to improve the system safety. In order to improve the accuracy of vehicle counting, cross-lane vehicles are detected and repeated counting for one vehicle is avoided. In order to reduce the classification errors, the space ratio and data fusion are used to reduce the classification errors caused by vehicle occlusions.

2.4. Sensor equipment

Sensor equipment installed in ITS is used to collect data such as vehicle speeds, vehicle density, traffic flows, and trip times. Data collection from sensors can be divided into three sources: roadside data, floating car data, and wide area data [11]. Floating car data (FCD) mainly refers to the vehicle mobility data at different locations in ITS, where customized detectors are embedded in vehicles. Some onboard sensors provide confident and efficient information for travel route selection and estimations. Nowadays, popular FCD sensor techniques include: automatic vehicle identification (AVI), license plate recognition (LPR), and transponders such as probe vehicles and electronic toll tags. Wide area data refers to the wide area traffic flow data that is collected by diverse sensor tracking techniques such as photographic processing, sound recording, video processing, and space-based radar.

3. Big data analytic methods in ITS

Machine learning is the most popular modeling and analysis method in big data technology. Its main applications in big data technology and intelligent transportation technology are data labeling, segmentation, data analysis and scenario simulation [12]. It can model traffic scenarios through data analysis technology [13], so it is widely used in big data technology and intelligent transportation systems. The main learning methods of machine learning are supervised learning and unsupervised learning [14].

3.1. Supervised learning

Supervised learning, also known as supervised machine learning, is defined by its use of labeled datasets to train algorithms to classify data or predict outcomes accurately. As input data is fed into the model, the model adjusts its weights until it has been fitted appropriately. This occurs as part of the cross-validation process to ensure that the model avoids over-fitting or under-fitting. Usually in its, the most commonly used techniques are regression, Ann, classification [15]. Regression is mainly divided into linear regression and logistic regression [16]. Linear regression: This algorithm is used to predict numerical values, based on a linear relationship between different values. Logistic regression: This supervised learning algorithm makes predictions for categorical response variables, such as "yes/no" answers to questions. Furthermore, neural networks: Neural networks simulate the way the human brain works, with a huge number of linked processing nodes. Neural networks are good at recognizing patterns and play an important role in applications including natural language translation, image recognition, speech recognition, and image creation. Classification is defined as the process of recognition, understanding, and grouping of objects and ideas into preset categories and known as "sub-populations [17]." With the help of these per-categorized training datasets, classification in machine learning programs leverages a wide range of algorithms to classify future datasets into respective and relevant categories.

3.2. Unsupervised learning

Unsupervised Learning is a data-driven knowledge discovery approach that can infer a function describing the structure from datasets consisting of input data without labeled responses. Unsupervised algorithms can be divided into two different categories: clustering algorithms and dimension reduction algorithms. Clustering is a data mining technique which groups unlabeled data based on their similarities or differences [18]. Clustering algorithms are used to process raw, unclassified data objects into groups represented by structures or patterns in the information [19]. Clustering algorithms can be categorized into a few types, specifically exclusive, overlapping, hierarchical, and probabilistic.

4. Big data application in ITS

Big data technology is widely used in intelligent transportation systems, and it can be applied in different kinds of usages. For instance, traffic planning, traffic management, traffic diversion and safety, etc.

4.1. Application in traffic planning

With the continuous acceleration of the development of transportation cities, the number of urban vehicles is increasing rapidly, and each city presents traffic congestion problems to varying degrees. By analyzing the data presented in the intelligent transportation system through big data technology, we can understand the characteristics of traffic flow distribution in different times and space. By analyzing the traffic index of the road segment, it is possible to predict in advance the time and road segment where traffic congestion may occur in the future [20].

4.2. Application in intelligent traffic management

Big data processing technology can be used in intelligent traffic control. It can quickly transmit information, and uses data analysis technology to quickly process and accurately analyze information [21]. For example, technicians can organize data according to the specific needs of traffic control, so as to extract effective information from a large amount of data, and then apply big data processing technology to discover the rules, so as to achieve more scientific and effective control and guidance [22]. Ultimately, the flow of cars within a specific area is optimally controlled. In addition, the application of big data processing technology can conduct multi-angle, all-round and multi-level analysis for different types of traffic data, so as to provide reliable detection data for vehicles.

4.2.1 Application in traffic diversion

Traffic diversion means that according to the collected data and with reference to the relevant analysis conclusions, a reasonable forecast of the traffic state in the current stage is made, and the diversion plan is formulated in a targeted manner, and make use of radio, television, network platforms, information and intelligence equipment and many more to announce to the outside world [23]. Because of the large volume characteristic of big data technology, it can provide powerful data support for traffic diversion in traffic management [24, 25]. For example, the application of sensing technology can timely understand road condition information, such as construction road sections, water storage, icing, etc., and release such information to the service system in a timely manner, so that travelers can choose the appropriate transportation manners according to the road condition information, which relieves transportation pressure while improving travel safety [26]. In addition, through the data information of alcohol detection, the food detection function can grasp the physical condition and mental state of the driver at any time according to the data information, and judge whether the driver is driving safely.

4.2.2 Supervise bridges to ensure traffic safety

Big data technology can carry out three-dimensional detection of bridge operation status from multiple perspectives. Through data analysis of the external appearance of bridge deck and pier, it can judge the aging degree of bridge and infer the life of bridge [27].

The app which is called 'Self driving' is an intelligent transportation terminal software that can be installed in the car [30]. Use the corresponding hardware equipment to upload the driving status of the car to the data processing center in the form of data. Its applied big data technology includes the following points:

(1) Record all data of the user during driving, including fuel consumption, mileage, time, fuel cost, carbon emission, etc. Analyze the driving habits of users by collecting the previous travel records, provide more reliable driving suggestions and help users understand their bad behaviors during driving.

(2) Build vehicle health files. This function can obtain the real-time status of the vehicle, including the engine, gearbox, battery, fuel condition, etc. the user can query in real time through the terminal application to maintain and cultivate the vehicles in time.

(3) It has safety protection and anti-theft functions. It can track and understand whether the vehicle has collision and other abnormal conditions, such as vibration, ignition, startup and voltage change in real time, and timely notify the user through the terminal app.

(4) Enrich the online and offline functions, such as road navigation, car moving call, fault rescue, illegal deduction query, ticket and hotel reservation, online call for driving, parking space query, etc.

4.3. Other applications

Real time monitoring of traffic flow and collection of traffic data information is also an application of big data in intelligent transportation systems. In this process, the big data processing technology will show the following advantages: firstly, it will not randomly select some samples, but detect all traffic data. Secondly, using GPS positioning technology to collect traffic data information with vehicle electronic license plates as the object. Thirdly, due to the data processing stage, it is difficult to collect a single data form. Therefore, from the initial static data acquisition mode to the dynamic and static combined data acquisition mode. When big data technology processes images, the amount of information involved is greatly reduced, which will reduce storage costs and improve technology application efficiency. Fourth, by using big data technology, traffic controllers can break through the limitations of time and space when collecting traffic flow information, so as to track the current status of traffic operations in real time [28]. Moreover, they can also use road detection technology to detect traffic congestion in time, so that they can accurately predict traffic conditions in a short period of time. According to the predicted situation, the road traffic congestion can be optimized and adjusted in a timely and effective manner.

5. Challenges

With the perfection of intelligent transportation systems and the rapid development of big data technology, their future is limitless. However, to further improve these two technologies, people still need to face some challenges and difficulties [29]. For example, in an academic paper published by the PATET research group of Ho Chi Minh City Chiao Tung University, one of the obstacles in the current research on the application of big data to intelligent transportation systems is the policy and legal framework of big data technology. Secondly, Dr. P. Nunes and F. Pinheiro pointed out that the management of the traffic system is also a problem that needs to be discussed in their argumentative paper on the impact of intelligent transportation systems on the environment. In other words, should the system be managed centrally by the state or shared by the state and the private sector in order to develop this system rapidly.

6. Conclusion

In this article, it has highlighted the role of Big Data technology in intelligent transportation systems through published research and applications. With the current rapid development of science, the application of this technology to the transportation system is becoming more and more necessary. With a large amount of data being collected, processed, and analyzed, the intelligent transportation system is predicted to be an effective solution to reduce traffic accidents, as well as reducing harmful effects on the environment [30]. The data collection methods included in big data technology, the application of data analysis technology and machine learning technology have all realized their own value in the intelligent transportation system. They not only facilitate people's travel, but also ensure people's travel safety. With smart traffic systems as the core, smart cities can be born and further develop through the linkage of Big Data technology and smart traffic systems. Furthermore, people should collect more data to analyze the challenges faced by big data technology in intelligent transportation, so as to make the conclusions more convincing. Based on the principle that big data technology and intelligent transportation system will be of great benefit to people's lives in the future, analyze the problems they face from multiple angles and in an all-round way, so as to better cope with the upcoming challenges. Finally, though there are many factors that need to be researched, the benefits of the combination of Big Data technology and smart traffic systems are undeniable and bring many positive things to a country or region [31]. To be able to move towards smart cities, this combination is the core element [32]. In addition, the study on the cost of building an ITS system for large, medium, and small urban levels based on population is the target for further studies.

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