The Study of the Roles that Intelligent Transportation System Playing in the Development of a Smart City

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Abstract. With the acceleration of urbanization, cities in the future will encounter various kinds of problems such as providing adequate living space, water and transportation. To address these issues which cities may face in the future, the concepts of Intelligent Transportation System (ITS) and Smart City come into being. Since both two areas aim to address possible urban issues in the future, it's essential to study the relationship between ITS and Smart city. In this article, researchers will initially introduce serval reasons to conduct the study. Later, in the main body part, 3 possible roles are presented to illustrate the possible relationship between ITS and Smart City through reviewing other researchers' articles. Finally, this article will give serval evaluations and suggestions about those 3 roles above. The whole article aims to state that ITS is an essential part in the future development of smart city, though it is not mature now and may encounter many problems in the process of development.

Keywords: Intelligence Transportation System, Smart City, Emission Reduction, Accident Risk Prediction, Energy Conservation (key words).

1. Introduction

It is predicted that the global ratio of the population living in urban areas in 2050 would increase to about 70% [1]. At that time, cities would face a large pressure of supplying adequate essential resources, such as water, food and electricity, as well as other basic services like transportation [2]. To address these difficulties, the concept of a smart city comes into being. It would be defined as a city with an integration of physical, digital and telecommunication technology to create a safe, efficient and sustainable region for the citizens [2]. In addition, transportation is an important driver of urban and economy growth in human history. For this point, transportation would have a high possibility of playing an essential role in the future development of a smart city. Therefore, the concept of the Intelligent Transportation System (ITS) which assists the management of a smart city is proposed. It is referred to a system which promotes the overall safety and efficiency of the transportation system by using the technology and knowledge from electronics, computers, communication and management areas [3]. Both smart cities and ITS pay special attention to the future development of a city. Therefore, it's unavoidable to explore the correlation between these 2 areas.

Some researchers have already conducted various studies about ITS or Smart City. Ng et al. have already applied a master data management solution to Hong Kong in order to integrate transportation and construction data [4]. The goal of their research is facilitating information from different sectors of a city. However, those researchers find that current progress is limited and no quantitative data can be presented in the study. Moreover, Miles et al. introduced a Decision Support System (DSS) to lower the atmospheric pollution level from transportation part [5]. Although it also has an evaluation system to assess the policies or strategies from decision makers, Miles et al. also consider this model as a prototype which needs further study and application in practice [5]. In addition, Rath proposed a smart traffic management system to reduce traffic delay though automated mechanical and electronic devices [6]. The simulation result shows its good congestion solving capability. If viewing it in another way, the study is just on the stage of theoretical research, which indicates it still takes a long way to be truly utilized in the daily life. Except from Mamata's work, Khanna et al. also present an algorithm to predict optimal routes for vehicles on road in order to alleviate traffic congestions [7]. The result indicates its

excellent ability to predict traffic volume and not good accidents risk prediction rate, which suggests it still requires further improvement.

It can be known from recent studies above that ITS and smart city have the ability to solve or mitigate issues of a city in future development. However, many studies and researches are just in theoretical stage and need much further studies. Moreover, although many researchers direct the way to develop ITS and smart city, very few of them explain the role of ITS in the development of a smart city.

For those reasons above, in this paper, the role of ITS playing in the development of a smart city is analyzed by reviewing and evaluating recent literature. Moreover, 3 possible roles (accident risk prediction, energy consumption reduction and CO_2 emission reduction) that ITS can play in a smart city will be presented in the main body part. Later, serval limitations related to ITS technologies and possible issues or challenges in developing ITS and smart city together will be presented in the discussion part. By following the steps above, the correlation between ITS and smart city could be analyzed, and the current limitation and challenges of ITS is also discussed. The idea that ITS is an essential part in the development of a smart city would be illustrate clearly.

2. Possibel Roles that playing in samrt city

2.1. Accident Risk Prediction

ITS can play an essential role in accident risk prediction. The number of vehicles on road increases rapidly with the development of technology and improvement of living standards, which would increase the interaction between the vehicles and the possibility of traffic accidents [8]. In addition, one of the aims of a smart city is to create a safe locality for its citizens which is mentioned in the definition of a smart city above. Therefore, the overall safety level can be improved if traffic accidents can be predicted or even reduced in some way. For this purpose, Zhao et al. propose a traffic accident risk prediction model by using the technology of data mining (a process of acquiring useful data among a large amount of data) [8]. Data mining is a branch from computer science which can be also considered as a component of ITS according to the definition of ITS above. Data from British Transportation Department from 2013 to 2016 are used to formulate the accident risk prediction model [8]. Researchers also conduct a simulation to test the performance of the model.

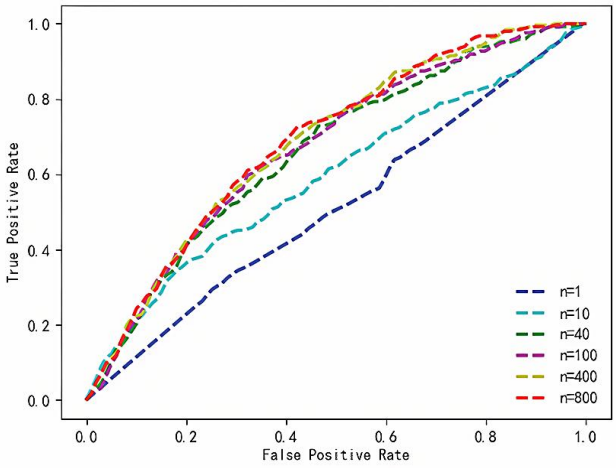

Figure 1. The Result of Zhao's Study [8]

The result shows that the prediction accuracy rate finally reaches very high (about 98%) when the training time goes up to about 800 times [8]. From the research above, it can be concluded that the application of data mining in the computer area of ITS can help the prediction of traffic accident risk. The improved prediction level of traffic accidents can finally assist a smart city to achieve the goal of safety improvement.

In Zhao's study, SMOT, One-Hot Encoding and AdaBoost algorithm are used in their study to achieve the accident prediction goal. The goal of their model is to classify the vehicles on road to 3 categories (low, medium and high). Those 3 kinds of algorithms are one of the most basic and common ways to do coding in machine learning areas. Therefore, this kind of model is relatively easy for the professional to operate and debug. Moreover, in Zhao's Study, the prediction accuracy is determined by the training time. For a specific program, due to the constrain of cost or planning level, it's not necessary to get a very accurate predication. Researchers managing a practical program can lower cost depending on their need.

2.2. Energy Reduction

ITS is able to assist smart city saving power in the subway and the trucking. Due to the massive transportation capacity and excellent convenience, the metro systems have been expanding rapidly in recent years [9]. For this reason, it can be supposed that the subway system may have a high possibility also acting as an essential part of public transportation in a smart city. However, with the increment in energy price and the public awareness of the environment protection, the massive energy consumption of the metro transit system becomes an urgent issue [9]. Moreover, a smart city concentrates on creating an efficient region for residents (mentioned in the definition of smart city), which involves improving the energy utilization level. Therefore, it's essential to reduce energy consumption for metro systems in a smart city. In Jin's study, researchers are able to save power in two ways with the application of ITS [9]. The first is establishing a more efficient timetable for departing and stopping time in the station based on the traffic volume need because ITS have the ability to monitor the real-time driving condition and location of the train [9]. The first method aims to increase the actual load rate. In other words, it uses less trains to achieve the same transportation work. The second method is an algorithm aiming to keep the optimal balance between speeding and deaccelerating to save energy [9]. To examine whether the algorithm is viable, the real traffic data from a Chinese city is put in the simulation as shown in Table 1 [9].

Table 1. The Result of Jin's Study [9]

Timetable type	Available RBE	Utilised RBE	Utilisation rate of RBE, %	Total Tractive energy consumption	Total operational energy consumption
PSP-PT	1080.81	321.25	28.9	1965.51	1653.16
PSP-OT	1080.81	436.65	40.4	1965.51	1528.86
OSP-PT	1019.64	261.03	25.6	1844.52	1583.49
OSP-OT	908.01	337.78	37.2	1799.19	1461.41

The result shows that the energy consumption declines by 8.46% after applying the algorithm [9]. According to Jin et al., the optimization of speeding and deaccelerating is solved by Mixed Integer Linear Programming (MILP) [9]. There also exists another study aiming to do the same optimization goal. Yang et al. introduced a genetic algorithm to find the optimal coasting point to keep the balance between speeding and decelerating [10]. Compared to Yang's study, the MILP model can be solved by software directly, which indicates that it can be solved with less calculation or energy consumption. In addition, the whole process of reducing energy consumption is quite same for Yang's and Jin's research. This suggests that this method to reduce energy consumption in metro line is relatively mature and is more likely to be taken into practice.

In recent years, with the continuous and steady growth of road network mileage, the scale of road freight has been improved and trucking assumes the great majority of the cargo transportation task. Nevertheless, trucking intensifies the consumption of petroleum energy, which causes great pressure on environmental protection and energy conservation [11]. According to Tan's research, apart from the traditional idea of a spontaneous platoon of trucks on a stable search scope, a dynamic spatiotemporal search scope may save fuel consumption to the maximum by analyzing the data collected from ITS [11]. Based on large-scale real truck track data in Liaoning Province, China,

researchers found that the platoons' fuel savings will increase with the increase of the maximum platoon length and converge to a range eventually as shown in figure 2.

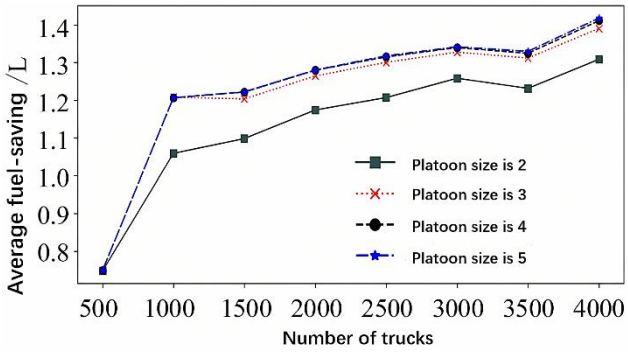

Figure 2. Average fuel-saving of trucks in platoons [11]

As shown in the figure, in the situation of platoons with five trucks compared with those of platoons with two trucks, the average fuel-saving can be improved by up to 13.92% [11]. The prioritization scheme is applied to a larger-scale truck dataset which is closely related to the ITS with more energy consumption that can be reduced. And the algorithm can actually have a promising application potential with further study.

2.3. Emission Reduction

ITS can lower emission and fuel consumption in the development of a smart city. In recent years, the process of burning fossil fuels, which produces CO_2, has been considered as the major contributor to the emission of greenhouse gases [12]. In addition, the phenomenon of global warming is an issue that the whole human beings need to overcome together. Moreover, transportation is one of the major contributors of emission and air pollution in many developing countries. Apart from above, a smart city aims to achieve sustainability which incorporates the goal of emission reduction (mentioned in the definition of a smart city). One of the most conventional ways cutting down emissions in transportation area is to alleviate traffic congestion. However, the traditional method of alleviating traffic congestion may take a long time to calculate and has the possibility of generating new traffic congestion [12]. Therefore, Brennand et al. invented an algorithm based on other researchers' works to find out and minimize the traffic congestion in metropolitan areas with the application of ITS as shown in figure 3 [12].

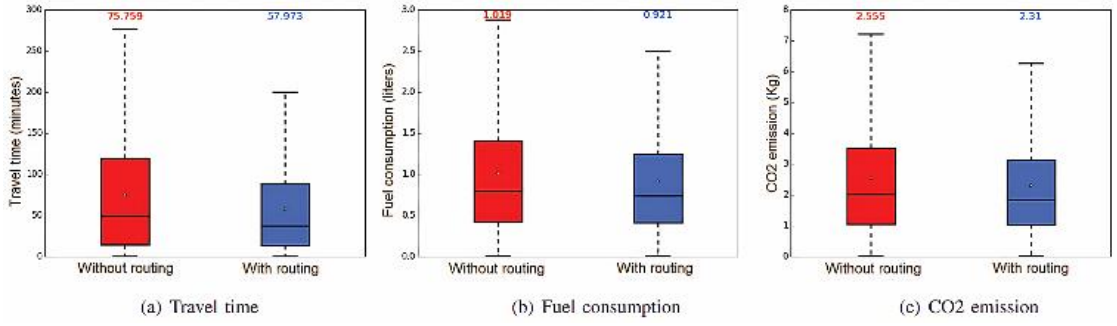

Figure 3. The Result of Brennand's Study [12]

By inputting the real traffic data from a German city, the simulation result shows that 9% fuel consumption and 10% CO_2 emission can be reduced compared to the algorithm used before [12]. This suggests that ITS can achieve the sustainability goal of a smart city by reducing CO_2 emission.

In Brennand's study, researchers achieve emission reduction goal in 3 steps [12]. The first is to find the optimal distribution of Road Side Unite (RSU), which can use less RSUs to spread the same level of signal for the same area. The second is allocating proper level of information to the nearest RSU. This step aims to reduce calculation time and energy consumption. The final step is using EcoTrec and EBkSP algorithm which consider the environmental impact and the influence of each

vehicle's route choices to the other vehicles. With all these steps done, the goal of congestion alleviation is achieved. The highlight of Brennand's study is not only the consideration of the route choosing impact between each vehicle, but is also the optimization of RSU. There are many studies which aims to reduce traffic congestion. However, very few researchers take the energy consumption of hardware devices into account. Taking the optimization of hardware and algorithm together would have higher capability to make the achievement of this study used in reality.

Another way is to promote the process of the urban smart public transport. However, the problem of information asymmetry between public transportation operations and passengers is a bottleneck of traditional public transportation services. Smart public transport can effectively solve this problem by enabling the management to use data-driven technology to extract more accurate and time-sensitive passenger flow characteristics from the ITS [13].

The distribution of passenger flow on bus lines is dynamic and uneven at different times and in different spaces. Through short-term prediction of passenger flow on bus lines, bus operators can understand travel demand in time and adjust bus frequency and routes in time to make bus travel more convenient for the public, thus improving the bus travel rate and realizing the virtuous cycle of urban transportation to ensure maximum passenger demand and profit of the operator. At the same time, the daily activities of the public will be changed in response to the unexpected situation in urban transportation, and the discovery of sudden changes can provide objective support for urban emergency management [13]. Therefore, the prediction of bus passenger flow can improve the use of urban public transportation, maximize the use of urban roads, and reduce energy consumption and air pollution caused by urban congestion [13].

3. Further disscussion

Although ITS can act as an essential role in the development of a smart city, it still faces various limitations. The researchers designing the accident risk prediction model mentioned above do not present how this technology can be applied in ITS system to reduce the occurrence of traffic accidents. These researchers only concentrate on how an accident is predicted rather than prevented. Therefore, the value of this model cannot be truly utilized in an optimal way. Moreover, Jin et al. state in their research that the 2 methods to reduce energy consumption in the metro system can only be applied in a single line [9]. In other words, these methods fail to produce the maximum energy efficiency for the whole urban metro system. It still takes a long way to improve the efficiency of a metro network. Moreover, Jin's steps to reduce energy consumption is very similar to Yang's study. This suggests that the steps to reduce energy consumption is not innovative. There should be some new methods to reduce energy consumption in other aspects. In addition, for the algorithm aiming to alleviate traffic congestion, researchers only states that this technology can solve the congestion issue in advance because it does traffic prediction according to the Brennand et al. [12]. If the congestion has already taken place, the algorithm can only reduce traffic congestion with less improvement [12]. The effect is not able to be guaranteed.

Apart from limitations, there also exists some challenges or issues in developing ITS and smart city together. The new technologies and the increasing level of connectivity between the vehicles raise the possibility of cyber-attack in ITS [14]. Moreover, the public is more and more concerned about the privacy issue with the collection of travel behavior data from ITS [14]. Hahn et al. introduce a method that attackers are able to change the passenger's routine by giving the wrong GPS location [14]. This would greatly challenge the current security technology applied in ITS. In addition, from the study of Hahn et al., some personal information including the first and last name, driver's license number and car registration number are stored in ITS [14]. Ensuring the safety of these data also proposes a higher requirement of the researchers studying ITS.

4. Conclusion

In conclusion, this article aims to argue that ITS is an essential part of a smart city. The key definitions of Intelligent Transportation System (ITS) and smart city are illustrated in the introduction. The reason and significance of conducting this study is also proposed in the introduction. In the next part, the essay proposes 3 possible roles (accident risk prediction, energy consumption reduction and emission reduction) that the ITS can play in the development of a smart city. These 3 roles correspond to the 3 goals of a smart city which are mentioned in the definition. Therefore, by playing these 3 roles, the importance of ITS in a smart city is presented and the correlation between ITS and a smart city is also illustrated. In the discussion part, this essay figures out the current limitation of ITS by analyzing the researches above. Some security and privacy issues and challenges are also proposed by reviewing the study from Hahn et al. Although ITS are facing various limitations and challenges, it is still an essential part of a smart city because ITS can achieve the goal of a smart city perfectly. The reason why ITS encounters various limitations and challenges is that ITS is a relatively new area which is still developing. Moreover, both ITS and smart cities focus on the future development of a city and provide a new way compared to conventional methods to solve the problems that all human beings would face together in the future. Therefore, it is an area that is promising and worth developing. It is an essential part in the development of a smart city.

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