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New Approaches of Traffic Flow Prediction

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Abstract. Recently, transportation has become a part of people's workday lives, with the fierce development of information, technology, and living standards. Nevertheless, it causes a great deal of inevitable trouble, such as congestion. As artificial intelligence (AI) is becoming increasingly popular, people have begun looking for solutions from AI daily. To bring convenience to relevant scientific research, the author has reviewed some novel AI models for traffic flow forecasting designed in recent years, based on a brief introduction to both machine learning and deep learning. According to the newly proposed AI models, the author has also drawn some expectations of traffic flow prediction that have the potential to be widely applied, the expectation combines mathematical functions, statistical models, and AI algorithms, making the traffic flow forecasting and adjustment more scientific and precise. The integration of advanced AI models into traffic flow prediction holds significant promise for enhancing urban mobility and reducing congestion in our daily lives.

Keywords: Traffic flow, Artificial intelligence, Machine learning, Deep learning.

1. Introduction

With the rapid development of transportation, the problem of congestion is getting increasingly serious in most cities. Drivers are eager to be served by apps that forecast the traffic flow as intelligently as possible. As the popularity of artificial intelligence (AI) is burgeoning due to ChatGPT, more AI models used for traffic flow forecasting have emerged with the support of machine learning algorithms or, especially, deep learning algorithms, which have remarkably gotten people closer to AI.

With the help of AI models or algorithms, map apps will not only predict traffic flow and congestion but also adjust and relieve congestion simultaneously, which enhances the level of service. Furthermore, with the crazy development of a large language model (LLM) [1], it seems that every single category of apps can be added with LLM to serve the running of specific functions, including traffic flow prediction. At the same time, the traffic flow prediction for AI can be expected to be based on statistics. For instance, the long-term collection and analysis of congestion information can be used to fit mathematical functions, providing convenience for future temporal traffic flow forecasting. At the spatial angle, the point of interest (POI) data ought to be focused on carefully. At the spatial angle, the large vision model (LVM) can be utilized for traffic flow monitoring, majorly controlling signal light timing to realize the effect of the green wave band. Afterward, the fitting of the function can be checked by statistical formulas, for adjustment at apt times.

Intelligent Transportation System is a transportation management system based on advanced information and correspondence technology, aimed at enhancing the efficiency, security, and continuity

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of transportation. Its definition covers a wide field of technology and applications, including transportation information management, intelligent control of traffic lights, and cognition and tracking of vehicles [2].

This paper first provides an overview of machine learning, deep learning, and their new models, followed by an exploration of the expectations for future intelligent traffic flow forecasting and adjustment based on AI, computer programs, and mathematical, and statistical models. This paper aims to highlight the potential of these advanced techniques in transforming traffic flow management as well as enhancing urban mobility, ultimately contributing to more efficient, sustainable, and satisfying transportation systems.

2. The approaches of traffic flow prediction

2.1. Approaches based on machine learning

2.1.1. Overview of machine learning. The following examples show how to format a number of different figure/caption combinations. Machine learning is a subject that concentrates on researching how to utilize experience to enhance the property of the machines themselves by employing calculation, the prediction of which is based on experience [3]. In calculating systems of computers, experience often appears in the form of data [3]. Consequently, the major researched content of machine learning is about the algorithm that generates models from data amongst computers. It is a learning algorithm [3]. With its help, provided experience data are supplied, it can generate models based on these data [3]. Also, when encountering new situations, such as a watermelon that has not been cut, the models will provide us with relevant judgment, such as regard it as a nice watermelon [3]. If computer science is set to be a subject researching something about algorithms, machine learning can be also described as a subject researching learning algorithms [3].

Machine learning can be applied to dealing with computer problems, analyzing data of bioinformatics, data mining, forecasting weather, energy exploration, environmental monitoring, information searching, automatic driving, poll analyzing, and interpreting how humans learn [3]. Machine learning tends to make computers train specific models to predict the future, utilizing given experience.

2.1.2. Novel Proposal. Krumm et al. [4] have proposed two paths to vastly decline the transmission frequency, based on Markov random field to model for traffic velocities and densities. First, a few vehicles have to be reported at every location, followed by a process with proportion theory, which supports the vehicles themselves in deciding whether to transmit the reports through AI algorithms and helps protect the users' privacy. Second, the computers will calculate the potential value of every report and grasp the main characters of the reports that affect the deduction of global velocities. Solving the problem of the passengers' privacy regarding their locations and velocities, the two methods reduce the amount of correspondence for precisely deducing the speeds, promoting the apps to acquire reports of velocities to deduce the transportation situation more effectively.

2.2. Approaches based on deep learning

2.2.1. Overview of deep learning. Deep learning belongs to machine learning, which is a kind of technique to realize machine learning, which was first led into the realm of machine learning in 1986 [5, 6]. Deep learning majorly utilizes multi-layer neural networks. For instance, Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN), learning effectively [5]. Recently, deep learning algorithms have made remarkable achievements in the sphere of image and voice recognition, natural language process (NLP) and recommendation systems, etc. with the progress of computing capability, renewing the algorithms successively [5, 6]. The core of deep learning is neural networks, whose goal is to illustrate data abstractly through multi-layer networks [5]. Compared with conventional shallow neural networks, the ability of indication is stronger for deep learning, which renders the

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function of automatically learning the high-level features of data [5]. In the earlier years, the research on deep learning concentrated on the theories and methods of neural networks, such as Back Propagation, activation function, and so on [5]. Image recognition algorithm imitates the human beings' recognition mode, which cannot abstract the deep information of the images [5]. Deep learning refers to the neural networks with a larger number of layers [5]. The number of categories of neural networks is large as well, whose core idea is to input images into the models directly, output the best parameters through the multi-layer trains of the models, and ultimately realize the recognition of the specific areas [5]. The domestic and foreign researchers carried out massive research to facilitate the efficiency and precision of image recognition models [5]. CNN is a neural network and feedforward multi-layer neural network, majorly involving a convolutional layer, pooling layer, and fully connected layer [5]. Krizhevsky et al. [7] invented the Alexnet network model, after which deep learning developed rapidly in the realm of image recognition.

2.2.2. Novel proposal. Du et al. [1] introduced a traffic flow forecast deep learning model with the assistance of an attention mechanism and the graph convolution learning framework with a feature of multi-scale feature enhancement, which has been verified to outperform the most advanced model by utilizing traffic flow forecast benchmarks to experiment and evaluate widely. First, they introduced the integration proposal of the spatiotemporal dependency features enhancement module with the support of the base attention learning block through a memory embedding layer. Second, they proposed a traffic network topology features enhancement module with the spatial attention layer, realizing dynamic advanced learning of spatiotemporal dependency features. The general method enables the model to learn complicated and flexible spatiotemporal dependency relationships effectively, capturing the key mode amidst the traffic flow data.

Xu et al. [8] have proposed a Temporal Spectral Spatial Retrieval Graph Convolutional Network (TSSRGCN) model that shows the marvelous adaptivity to a diversity of temporal transportation models. This model is realized by extracting holistic as well as partial spatial messages, combining two graph convolutional network methods to learn the representations of nodes and edges. As a neural network model, it solved the problems of utilizing both spatial and temporal information, especially the varied temporal features and road characteristics, which used to be caused by the non-linear and complicated evolutional avenues. It efficiently enhanced traffic flow forecasting, which makes essential sense to facilitate the efficiency of traffic systems and the prediction of accidents. After the research was experimentally carried out, the model indicates a great effect of inspecting the relativity between the spatial and temporal transportation data.

Hu et al. [9] proposed the Heterogeneous Graph Transformer (HGT) architecture. This model can present the advantage in the perspective of modeling Web-scale heterogeneous graphs. Initially for modeling heterogeneity, node- and edge-type dependent parameters were designed to indicate the heterogeneous attention over each edge, which enabled HGT to keep specialized illustrations for various types of nodes and edges. On top of that for dealing with dynamic heterogeneous graphs, they introduced the relative temporal encoding technique into HGT. It is enabled to capture the dynamic structural dependency with arbitrary durations. Furthermore, for dealing with Web-scale graph data, they designed the heterogeneous mini-batch graph sampling algorithm - HGSampling, which assists in efficient as well as scalable training. It is proved that the algorithm successively exceeded all the novelly proposed GNN baselines by a range of 9% - 21% on every downstream task by massive experiments conducted with the Open Academic Graph of 179 million nodes as well as 2 billion edges.

Çetiner et al. [10] preliminarily attempted to convert the scenario, modeling the previous historical data through Artificial Neural Networks (ANNs), which aims at the traffic flow volume forecasting according to the previous data in every essential urban intersection. Following the mentioned method in the paper, ANNs gave inspiring results.

Lv et al. [11] proposed a novel deep-learning-based traffic flow prediction method, which pays much attention to the inherent correlation of spatial and temporal. A cumulated autoencoder model shows its function of learning generic traffic flow features, training itself in a greedy layerwise fashion. As far as

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they were concerned, this was the first time to utilize autoencoders as building blocks to illustrate traffic flow characteristics for forecasting and a deep architecture model was applied. Moreover, experiments have proved that the newly designed approach for traffic flow forecasting demonstrates outperforming capability.

3. Future Expectations of Traffic Flow Forecasting

With the help of AI models or algorithms, the orientation and navigation apps are expected to not only predict the traffic flows and congestions, but also adjust and relieve the congestions simultaneously, because when the apps calculate and recommend the routes according to the input places of departure, destinations, and levels of congestions, the output results will be the routes with least congestion. Thus, the numbers of the drivers will be divided into different routes on average, if there are not many differences between the routes such as distance, except for congestion. On top of that, the drivers are capable of arranging their journey, which enhances the experience of being served significantly. Currently, apps like AMAP have involved the function of expecting congestion when you pass the very location rather than merely overlooking the routes. With more support from AI, this work is expected to be done more efficiently, intelligently, and precisely.

Furthermore, with the crazy development of LLM [1], it seems that every app can be added with LLM to serve the running of specific functions. Amidst the realm of transportation, especially traffic flow forecasting, LLM can display an advantage in analyzing those characters reflecting moods or public opinions employing abstracting the words among the posts in social media, supported by NLP models. According to the location shown in the natural language text or the orientation where the posts are released, the LLM will analyze the congestion tendency of these positions.

At the same time, the traffic flow prediction for AI can be expected to be based on statistics. For instance, the long-term collection and analysis of congestion information can be used for fitting mathematical functions, providing convenience for future temporal traffic flow forecasting. At the spatial angle, the POI data ought to be focused on carefully. At the spatial angle, the LVM can be utilized for traffic flow monitoring, majorly controlling signal light timing to realize the effect of the green wave band. Afterwards, the fitting of the function can be checked by statistical formulas, for adjustment at apt times. Specifically, the POI information is different, corresponding with different temporal features, such as seasons, weekdays or weekends, and rush hours. Since these temporal factors affect congestion very much, it is supposed to be paid attention to, for example, the official area on weekdays and the entertainment area on weekends. Thus, the future development direction can be stressed towards modeling functions and setting them into AI algorithms to do traffic flow prediction more accurately, adjusting the parameters based on temporal features. On the other side, the LVM can be loaded by CCTV over the urban avenues, calculating the time cost to pass a section of road and setting the output results into the AI algorithms for adjusting traffic flow more intelligently using adjusting the signal lights timing automatically.

4. Conclusions

This paper briefly discusses some novel AI models proposed in recent years that can be utilized in the field of traffic flow prediction, which leads us to believe wider application occasions for AI to act effectively in traffic flow forecasting. Additionally, this paper also gives some possible development trends and application occasions in the future, using AI algorithms. Limited by lack of professional knowledge and experimental devices, the author failed to run any experiment about his expectation in intelligent traffic with the mentioned models, but it is believed that if the researchers can apply the models to those expectations more widely, the people's experience of the journey will be enhanced remarkably. In conclusion, the AI has a bright future in the field of transport. As it can truly bring us convenience in our lives, it is necessary to utilize it for tackling more problems in people's lives. In the future, it is predictable that there will be more examples of applying deep learning networks to make AI decisions more intelligent through massive imitation and training, inspired by the application of AI in the realm of transportation.

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