International Journal of Advance Research in Science and Engineering
Volume No.06, Issue No. 12, December 2017
www.ijarse.com
IJARSE
ISSN: 2319-8354

A SURVEY ON BIG DATA BASED VEHICLE TRAFFIC FLOW PREDICTION USING DEEP LEARNING ALGORITHMS

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ABSTRACT

Exact and well-timed traffic flow information is important for the successfuldeployment of intelligent transportation systems. Over the last few years, traffic data have been report, and we have really entered the era of big data for transportation. Existing traffic flow prediction methods mostly use shallow traffic prediction models and are still unsatisfying for many real-world applications. The goal of the intelligent transportation system (ITS) is using the communication system to strictly combine the transport system of people, vehicles and road. Advanced traffic control system and progressive traffic management system are required to provide real-time traffic flow information. The traditional traffic flow model is termed the traffic flow state variables (velocity, density and flow) with the change of time and space. Traffic flow analysis is important research concept in the transportation system. DeepLearning is a form of machine learning used to predict traffic flow. This situation inspires us to take the traffic flow prediction problem based on deep architecture models with big traffic data.

Keywords:Intelligent Transportation Systems (ITS), Short term traffic Flow Prediction, Deep Learning.

I.INTRODUCTION

Traffic information such as flow, volume, speed, occupancy, travel time, density, vehicle classification, emission level etc [31] along road networks is important for planning, control and management of transport systems.With the fastincreasing urbanization and traffic demand, transportation problems are becoming important issue everywhere in the world. Infrastructure growth is limited because of the size, space constraints and because of lack of planning, technology. So the solution to this critical problem is to design intelligent systems to provide innovative and smarter services to the transport users. One such application is traffic flow prediction on short term basis which makes the transport users to be better informed and makes the transport network smarter, safer and more coordinated.

According to a latest survey approximately 60 percent of people will live in cities by 2050 and as a result, millions of cars will run on the roads leading to a critical strain on the intelligence transportation system. Large volume of traffic data is recorded by intelligent transportation system under all weather conditions. The recorded data is analyzed to assist in predicting slow moving traffic. Since no model exists that provides a 100 percent efficiency in predicting traffic flow, further research has been done in order to increase the accuracy in traffic prediction. The current system utilizes shallow techniques to predict traffic flow which is deemed inefficient. deep learning algorithm will be applied to understand deep traffic patterns and make for more accurate predictions [10].

1.1 Traffic Data Management

Traffic Big data term is being applied to large data sets which cannot be processed by traditional data processing techniques. The big data area is growing very rapidly because with fact growth of technology with mobile devices, intelligent sensors, etc. it is much easier now to collect huge amount of data, which need to be processed. Bigdata usually has multiple dimensions and this make it much more difficult to process because data the processing complexity grows rapidly with dimensionality increase. The advent of Big Data has triggered disruptive changes in many fields including Intelligent TransportationSystems (ITS). The emerging connected technologies created around global digital devices have opened unique opportunities to enhance the performance of the ITS. Traffic big data holds several characteristics, such as temporal correlation, spatial correlation, historical correlation, and multistate.

Hua-pu Lu, Zhi-yuan Sunet al[15] studies the method of real-time traffic flow state identification and prediction based on big data-driven theory. Traffic big data holds several characteristics, such as temporal correlation, spatial correlation, historical correlation, and multistate. Traffic flow state quantification, the basis of traffic flow state identification, is achieved by a SAGA-FCM (simulated annealing genetic algorithm based fuzzy *c*-means) based traffic clustering model. Considering simple calculation and predictive accuracy, a bilevel optimization model for regional traffic flow correlation analysis is established to predict traffic flow parameters based on temporal-spatial-historical correlation. A two-stage model for correction coefficients optimization is accelerative to simplify thebilevel optimization model. The first stage model is built to calculate the number of temporal-spatial-historical correlation variables. The second stage model is present to calculate basic model formulation of regional traffic flow correlation.

Dawei Chenproposes an optimized prediction algorithm of radial basis function neural network based on an improved artificial bee colony (ABC) algorithm in the big data environment. To verify the efficiency of this algorithm in the big data environment, apply it to Lozi and Tent chaotic time series and measured traffic flow time series, and then compare it with K-nearest neighbor model, radial basis function (RBF) neural network model, improved back propagation neural network model, and RBF neural network based on a cloud genetic algorithm model[4].

Some Applications are,

- Traffic Analysis
- Traffic Prediction
- Traffic Forecasting

➢ Breakdown Flow Prediction

➢ Predicting Freeway work zone Delays

II.TRAFFIC FLOW PREDICTION

Traffic flow prediction is an important element of traffic modeling, operation, and management. Accurate real-time traffic flow prediction can (1) suggest information and guidance for road users to optimize their travel decisions and to reduce costs and (2) help authorities with innovative traffic management strategies to alleviate congestion. With the availability of high resolution traffic data from intelligent transportation systems (ITS), traffic flow prediction has been increasingly addressed using data driven approaches. In this regard, traffic flow prediction is a time series problem to estimate the flow count at a future time based on the data collected over previous periods from one or more observation locations.

There are two ways of traffic flow prediction

1. Short Term Traffic flow Prediction
2. Long Term Traffic Flow Prediction

ChengchengXu et al [20], aimed to develop a simple and effective hybrid model for forecasting traffic volume that combines ARIMA and the Genetic Programming (GP) models. The ARIMA model was used to model the linear component of the traffic flow time series. Then the GP model was applied to capture the nonlinear component by modelling the residuals from the ARIMA model. The hybrid models were fitted for four different time-aggregations: 5, 10, 15, and 20 min. The results indicated that the hybrid models had better predictive performance than utilizing only ARIMA model for different aggregation time intervals under typical conditions.

SelvarajVasanthaKumar was proposed a prediction scheme based on Kalman filtering technique (KFT) and evaluation requires only limited input data. Only previous two days flow observations has been used in the prediction scheme developed using KFT for predicting the next day flow values with a desired accuracy. Traffic flow prediction using both historic and real time data on the day of interest was also attempted. Promising results were obtained with mean absolute percentage error (MAPE) of 10 between observed and predicted flows and this indicates the suitability of the proposed prediction scheme for traffic flow forecasting in ITS applications [1].

MinalDeshpande et al implemented traffic flow prediction model using support vector machine. Rough set is used as a post processing tool to validate the prediction result. The objective is to improve traffic flow prediction performance. It is found that the use of rough set results in satisfactory performance improvement which is evaluated using mean square error as the performance measures [6].

Zhiyuan Ma and Guangchun Luo, proposed an adaptive prediction model based on a variant of Extreme Learning Machine (ELM), namely On-line Sequential ELM with forgetting mechanism, is built. The model has the capability of updating itself using incoming data, and adapts to the changes in real time. However, limitations, such as the requirements of large number of neurons and dataset size for initialization, are discovered in practice. To improve the applicability, another scheme involving sequential updating and network reconstruction is proposed [23].

Qiang Shang et al [23], proposed a hybrid model (SSA-KELM) based on singular spectrum analysis (SSA) and kernel extreme learning machine (KELM). SSA is used to filter out the noise of traffic flow time series. Then, the filtered traffic flow data is used to train KELM model, the optimal input form of the proposed model is determined by phase space reconstruction, and parameters of the model are optimized by gravitational search algorithm (GSA). And the SSA-KELM model is compared with several well-known prediction models, including support vector machine, extreme learning machine and single KLEM modelThe prediction models in the literature can be broadly divided into parametric and nonparametric models [9].

Parametric models are

- ARIMA, seasonal ARIMA,
- Kalman filtering

Non Parametric Model

- Neural Network
- Back Propagation
- Deep Learning

ARIMA ,Kalman Filtering Technique are used in earlier days and time consumes more with less accuracy. Nowadays most of the research used ANN and Deep Learning. It gives good accuracy than parametric models.

2.1 Short Term Traffic Flow Prediction

Short term traffic flow prediction has become one of the important research fields in intelligent transportation system [6]. The prediction of this traffic flow information quickly and accurately is important for traffic control and guidance to initiate the measuring steps well in advance. It makes the transport users better informed and makes the transport network smarter, safer and more coordinated. It plays a crucial role in individual dynamic route guidance, advance traffic information system (ATIS) and advance traffic management system (ATMS).

For parametric analysis, linear time series models have been widely applied [2]. An early study in 1979 investigated the application of the ARIMA model for short-term traffic data forecasts. The results suggest that the ARIMA model could be used for one-time interval prediction. Levin and Tsao proposed that ARIMA (0, 1, 1) is the most statistically significant for both local and express lanes prediction. In addition, many other modified ARIMA models have been examined, such as subset ARIMA, ARIMA with explanatory variables, and seasonal ARIMA. Okutani and Stephanedes introduced Kalman filtering theory into this field and results indicated improved performances. Based on Kalman filter theory, there have also been some modifications and hybrid models.

Xianyao Linget al [7] proposed a novel short-term traffic flow prediction algorithm, which is based on Multi-kernel Support Vector Machine (MSVM) and Adaptive Particle Swarm Optimization (APSO). They explore both the nonlinear and randomness characteristic of traffic flow, and hybridize Gaussian kernel and polynomial kernel to constitute the MSVM. Then they optimized the parameters of MSVM with a novel APSO algorithm by considering both the historical and real-time traffic data.

2.2 ANN to predict traffic flow prediction

Due to the stochastic and nonlinear characteristics of traffic flow, it is difficult to overcome the limitations of parametric models. Nonparametric machine learning methods have become gradually popular.Non Parametric approach is the most famous and currently used in research.Artificial neural networks (NN) have been commonly utilized for this problem, which can be regarded as the general pattern of machine learning application in traffic engineering. Smith and Demetsky developed a NN model which was compared with traditional prediction methods and their results suggest that the NN outperforms other models during peak conditions. Dougherty et al. studied back-propagation neural network (BPNN) for the prediction of traffic flow, speed, and occupancy and the results show some promise. Since then, NN approaches have commonly been used for traffic flow forecasting. In addition, many hybrid NN models have been proposed to improve performance. Other nonparametric models have also been studied, such as -nearest neighbor (NN) models and support vector regression [9].

Felix Kunde Alexander Hartenstein et al[17]. Implement a concept of feeding sensor data to an Artificial Neural Network (ANN). We train the ANN with different spatial and temporal holdups to find an optimal setup for an entire city. They have worked on a sensor network that is distributed across an entire city and got the best results when they included measurements from all sensors. Including sequence information enhanced the prediction only marginally. After work with RNNs, it should be greater for time series analysis because they support to learn short and long sequences.

Vedat TOPUZ et al.[11] proposed different artificial neural network (ANN) models for predicting the hourly traffic flow.Because the traffic system is a difficult and adjustable system that involves a people's activity, the traffic flow state has high randomness and uncertainty. The traditional traffic flow forecast methods such as Kalmanfilter, Moving Average (MA), Autoregressive Integrated Moving Average (ARIMA) and etc had been unable to satisfy the demand of the forecast precision that was increasing in practice (CHEN & MA, 2009) On the other hand, artificial neural networks (ANNs) have been applied to a large number of problems because of their non-linear system modeling capability by learning ability using collected data. During the last decade ANNs have been applied widely to prediction of the traffic data.[1]Compared the generalization performance of the different ANN models such as Multi-Layer Perceptron (MLP), Radial Basis Function Network (RBF), Elman Recurrent Neural Networks (ERNN) and Non-linear Auto Regressive and exogenous input (NARX) type.

WushengHU, Yuanlin LIU, Li LI et al.[13] selected BP neural network model in which the traffic flow difference was taken as the input parameter, applied the concept of dynamic rolling prediction to project a new shortterm traffic flow prediction method. Then using the actual observation data of traffic flow presented the model structure, thought and calculation steps of this new method. The results show this method is feasibility, reliability, and of some practical value.

Kang Kai , Han Jinfenget al[16]. Proposes an optimal resource service method that based on grid computing pool model, builds a traffic flow prediction model based on grid method, and predicts the traffic by using genetic algorithm based on higher-order generalized neural networks. In the traffic flow prediction process, the optimal resource service method on the basis of grid computing pool model is utilized to automatically request the best CPU under the current status in traffic information platform to perform the prediction, in order to enhance the service quality and efficiency. When multiple users request traffic forecasting at the same time, the optimal resource service can meet the requirements of real-time traffic forecasts. The model of genetic algorithm based on the higher-order generalized neural networks is built to predict traffic flow at last.

Kranti Kumar, M. Paridaet al[14]. applies Artificial Neural Network (ANN) for short term prediction of traffic flow using past traffic data. The model incorporates traffic volume, speed, density, time and day of week as input variables. Speed of each category of vehicles was considered separately as input variables in disparity to previous studies reported in literature which consider average speed of combined traffic flow.

2.3 Deep Learning Based Traffic Flow Prediction

Deep learning is a form of machine learning that can be viewed as a nested hierarchical model which includes traditional neural networks.Deep-learning is increasingly being recognized as an essential tool for artificial intelligence research, with applications in several areas. Deep-learning algorithms can be roughly classified into four types: Deep Neural Network (DNN), Convolution Neural Network (CNN), Recurrent Neural Network (RNN) and Q-learning.

With the fast development of ITS, it is possible to get access to huge amount of traffic data as well as multisource environmental data. However, both the typical parametric and nonparametric models tend to make assumptions to ignore additional manipulating factors, due to the shallow architecture and inability to deal with big data as well as inefficient training strategies. The deep learning method, a type of machine learning, has been well developed recently to address this problem. Deep learning has some advantages in pattern recognition and classification. For traffic flow prediction, Huang et al. proposed a deep belief network (DBN) architecture for multitask learning and experiments results show that the DBN could achieve about 5% improvements over the other algorithms. Another method used a stacked autoencoder model (SAE) to implement prediction considering explicitly the spatial and temporal correlations. These papers are the indications in applying deep learning in traffic flow prediction.Furthermore, to capture the time series characteristics in the training and prediction, another deep learning model is introduced as the recurrent neural network (RNN), which is designed to deal with time series data prediction problem. In terms of traffic data, a time series data, the RNN can use memory cells to save the temporal information from previous time intervals. One of the most famous RNN is the long short-term memory (LSTM) model, which can automatically adjust some hyper parameters and can capture the long temporal features of the input data.

2.3.1 Deep Learning Methods To Predict Traffic Flow

Nicholas G. Polson developed of an architecture [5] that combines a linear model that is fitted using `1 regularization and a sequence of tanh layers. The challenge of predicting traffic flows are the sharp nonlinearities due to transitions between free flow, breakdown, recovery and congestion. We show that deep learning architectures can capture these nonlinear spatio-temporal effects. The first layer identifies spatio-temporal relations among predictors and other layers model nonlinear relations.

Hongsuk Yi, HeeJin Jung et al[10].proposed a deep-learning neural-network based on TensorFlow™ is suggested for the prediction traffic flow conditions, using real-time traffic data. There is no research has applied the TensorFlow™ deep learning neural network model to the estimation of traffic conditions. The suggested supervised model is trained by a deep learning algorithm, which uses real traffic data accumulated every five minutes.

XiaoleiMa ,Zhuang Dai et al[19] proposeda convolutional neural network (CNN)-based method that learns traffic as images and predicts large-scale, network-wide traffic speed with a high accuracy. Spatiotemporal traffic dynamics are converted to images describing the time and space relations of traffic flow via a two-dimensional time-space matrix. A CNN is applied to the image following two consecutive steps: abstract traffic feature extraction and network-wide traffic speed prediction. The CNN can train the model in a realistic time and, thus, is suitable for large-scale transportation networks [19].

Yuanfang Chen, Falin Chen et al. proposes a deep learning based prediction algorithm,DeepTFP, to collectively predict the traffic flow on each and every traffic road of a city. This algorithm uses three deep residual neural networks to model temporal closeness, period, and trend properties of traffic flow. Each residual neural network consists of a branch of residual convolutional units. DeepTFP aggregates the outputs of the three residualneural networks to optimize the parameters of a time series prediction model. They used mobile time serious data from the transportation system. The proposedDeepTFP outperforms the Long Short-Term Memory (LSTM)[18].

Hongxin Shao et al[8],discovered the application of Long Short-Term Memory Networks (LSTMs) in short-term traffic flow prediction. As a deep learning approach, LSTMs are able to learn more abstract representations in the non-linear traffic flow data. The key feature of capturing long-term dependencies in a sequential data also makes it a proper choice in traffic prediction. Experiments on real traffic data sets indicate a good performance of model.

HongsukYiet.al [3] adeep-learning neural-network based on TensorFlow is suggested for the prediction traffic flow conditions, using real-time traffic data. The suggested supervised model is trained by a deep learning algorithm, which uses real traffic data aggregated every five minutes. Results demonstrate that the model's accuracy rate is around 99%.

Haiyang Yu et al[24]. Propose a network grid representation method that can retain the fine-scale structure of a transportation network. Network-wide traffic speeds are converted into a series of static images and input into a novel deep architecture, namely, spatiotemporal recurrent convolutional networks (SRCNs), for traffic forecasting. The proposed SRCNs inherit the advantages of deep convolutional neural networks (DCNNs) and long short-term memory (LSTM) neural networks. The spatial dependencies of network-wide traffic can be captured by DCNNs, and the temporal dynamics can be learned by LSTMs.

YishengLv, a novel deep-learning-based traffic flow prediction method is proposed, which considers the spatial and temporal correlations inherently. A stacked auto encoder model is used to learn generic traffic flow features, and it is trained in a greedy layer wise fashion. To the best of our knowledge, this is the first time that a deep architecture model is applied using auto encoders as building blocks to represent traffic flow features for prediction. Moreover, experiments demonstrate that the proposed method for traffic flow prediction has superior performance [26].

Yaguang Li et al [27]. Proposed Graph Convolutional Recurrent Neural Network to incorporate both spatial and temporaldependency in traffic flow. They further integrate the encoder-decoder framework and scheduledsampling to improve long-term forecasting. When evaluated on real-world road networktraffic data, their approach can accurately capture spatiotemporal correlations and consistentlyoutperforms state-of-the-art baselines by 12% - 15%.

Li Li,Xiaonan Su et al[28].introduce a multiple-step strategyto process the raw ‘‘Big Data’’ into time series for regressionand causality analysis. They used the Granger causality to define thepotential dependence among data, and produce a much condensed set of times serieswho are also highly dependent. Next, they deployed a decomposition algorithm to separatedaily-similar trend and non-stationary bursts components from the traffic flow time seriesyielded by the Granger test. The decomposition results are then treated by two rounds ofLasso regression: the standard Lasso method, robust Lasso method. The obtained causal dependence graph reveals the relationship between the structure of road networks and the correlations among traffic time series.All these discoveries are useful for building better traffic flow prediction models.

2.3.2 Other Factors with Deep Learning (Rainfall, Weather)

Nowadays other factors such as weathers and rainfall are used to predict with deep learning and considered as a multisource input. With regard to the impact of rainfall, there is general consensus that it significantly affects traffic flow characteristics and leads to congestion and accidents. Without a comprehensive understanding of the weather influence on traffic flow, traffic management authorities cannot consider relevant factors in related operational policies to improve traffic efficiency and safety. For rainfall-integrated traffic flow prediction using machine learning methods, Dunne and Ghosh combined stationary wavelet transform and BPNN to develop a predictor that could choose between a dry model and a wet model depending on whether rainfall is expected in the prediction hour. The results show that rainfall-integrated predictor could improve the prediction accuracy during rainfall events. Deep learning tools provide a promising way to incorporate the impacts of rainfall in traffic flow prediction.

Yuhan Jia et al. [2] introduce the deep belief network (DBN) and long short-term memory (LSTM) to predict urban traffic flow considering the impact of rainfall. The rainfall-integrated DBN and LSTM can learn the features of traffic flow under various rainfall scenarios. Experimental results indicate that, with the consideration of additional rainfall factor, the deep learning predictors have better accuracy than existing predictors and also yield improvements over the original deep learning models without rainfall input. Furthermore, the LSTM can outperform the DBN to capture the time series characteristics of traffic flow data.
AriefKoesdwiady et al [21]. Used whether conditions for traffic flow prediction. Specifically, inclement weather conditions may have drastic impact on travel time and traffic flow. It has two objectives: first, to investigate a correlation between weather parameters and traffic flow, and to improve traffic flow prediction by proposing a novel holistic architecture. It incorporates: 1) deep belief networks for traffic and weather prediction and, 2) decision-level data fusion scheme to enhance prediction accuracy using weather conditions.
The recent emergence of new technologies such as sensor networks, smartphones, and new paradigms such as crowdsourcing social networks has induced profound transformations in the way traffic management will be done in the future.

III. RECENT TRENDS IN TRAFFIC FLOW PREDICTION

Intelligent Transportation systems helps to travellers reach their destination at an estimated time. Smart cities have deployed latest technologies to satisfy the needs of travellers through efficient navigation [30].It has the potential to help road users make better travel decisions, alleviate traffic congestion, reduce carbon emissions, and improve traffic operation efficiency [26]. Real-time traffic flow prediction aims at evaluating anticipated traffic flow state at a future time.Traffic flow estimation and forecasting aims to understand and develop road networks forefficient mobility.To identifying and analyze relevant spatio-temporal analytics and data mining conceptsand methods for short–term urban road traffic flow prediction. Predict the traffic with real time data improves accuracy.
Some of the real applications are,

- Application of probe vehicle data for a real time prediction and short term on a freeway.
- Neural networks for real time traffic signal control.
- Network state estimation and prediction for real time traffic management.

IV. RESEARCH CHALLENGES AND ISSUES

- In the context of traffic predictions, relating the representations of input vectors to the fundamental properties of traffic flow is a challenging problem which needs to be studied [5].
- CNN is applied to the image following two consecutive steps: abstract traffic feature extraction and network-wide traffic speed prediction. Specifically, CNN can first extract abstract traffic features from a transportation network Other models, such as the combination of CNN and LSTM NN, would be an interesting attempt [20].
- Additional factors, such as the weather, social events, can consider further with traffic control.

- In order to test the robustness of the proposed model, more data in different cities are required to validate the seasonal variation effect on the prediction accuracy.
- Moreover, the training efficiency can be also enhanced by optimizing pre-training methods, which may reduce the number of iterations while achieving more accurate results.
- Another intriguing research direction is to develop novel transportation network representation approaches.
- By eliminating theblank regions without any roadway network, the computational burden of training SRCNs should begreatly reduced [25].

V. CONCLUSION

In this paper, a brief overview of traffic flow prediction is presented.With over a decade of extensive research, there has been a tremendous development and application activities inthe data mining with deep learning domain for preventing traffic flow.There are many challenging research problems to predict and forecast traffic flow from both spatial and temporal data. Parametric and non-parametric methods are used to predict. Also deep learning is a fastest method to predict traffic flow with accuracy. Still need other methods and factors to predict with privacy.

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