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|  | Titel, Authors, Date of publication, place of publication | Link | Abstract |
| 1 | Yang, X., Zou, Y., Tang, J., Liang, J., Ijaz, M., 2020. Evaluation of short-term freeway speed prediction based on periodic analysis using statistical models and machine learning models. Journal of Advanced Transportation 2020. | [Evaluation of Short-Term Freeway Speed Prediction Based on Periodic Analysis Using Statistical Models and Machine Learning Models (hindawi.com)](https://www.hindawi.com/journals/jat/2020/9628957/) | Accurate prediction of traffic information (i.e., traffic flow, travel time, traffic speed, etc.) is a key component of Intelligent Transportation System (ITS). Traffic speed is an important indicator to evaluate traffic efficiency. Up to date, although a few studies have considered the periodic feature in traffic prediction, very few studies comprehensively evaluate the impact of periodic component on statistical and machine learning prediction models. This paper selects several representative statistical models and machine learning models to analyze the influence of periodic component on short-term speed prediction under different scenarios: (1) multi-horizon ahead prediction (5, 15, 30, 60 minutes ahead predictions), (2) with and without periodic component, (3) two data aggregation levels (5-minute and 15-minute), (4) peak hours and off-peak hours. Specifically, three statistical models (i.e., space time (ST) model, vector autoregressive (VAR) model, autoregressive integrated moving average (ARIMA) model) and three machine learning approaches (i.e., support vector machines (SVM) model, multi-layer perceptron (MLP) model, recurrent neural network (RNN) model) are developed and examined. Furthermore, the periodic features of the speed data are considered via a hybrid prediction method, which assumes that the data consist of two components: a periodic component and a residual component. The periodic component is described by a trigonometric regression function, and the residual component is modeled by the statistical models or the machine learning approaches. The important conclusions can be summarized as follows: (1) the multi-step ahead prediction accuracy improves when considering the periodic component of speed data for both three statistical models and three machine learning models, especially in the peak hours; (2) considering the impact of periodic component for all models, the prediction performance improvement gradually becomes larger as the time step increases; (3) under the same prediction horizon, the prediction performance of all models for 15-minute speed data is generally better than that for 5-minute speed data. Overall, the findings in this paper suggest that the proposed hybrid prediction approach is effective for both statistical and machine learning models in short-term speed prediction. |
| 2 | Song, C., Lee, H., Kang, C., Lee, W., Kim, Y.B., Cha, S.W., 2017. Traffic speed prediction under weekday using convolutional neural networks concepts, in: 2017 IEEE Intelligent Vehicles Symposium (IV), IEEE. pp. 1293–1298.   * (No access) | [Traffic speed prediction under weekday using convolutional neural networks concepts | IEEE Conference Publication | IEEE Xplore](https://ieeexplore.ieee.org/abstract/document/7995890) | For providing drivers with robust traffic information and Optimizing the energy management of Hybrid Electric Vehicles (HEVs), it is important to predict traffic information accurately with past traffic information. As acquisition of the traffic information have been easier by the development of Intelligent Transportation System (ITS), active study on traffic prediction is currently underway. Multi-Layer Perceptron (MLP) model have been widely utilized for predicting traffic information since it is appropriate to represent the non-linear characteristics inherent in traffic prediction. However, the MLP model doesn't reflect local dependencies of traffic data and is prone to noise in traffic data. Convolutional Neural Networks (CNN) based model, on the other hand, can capture the local dependencies of traffic data and is less prone to disturbance in data. In this paper, we use temporal data and speed data collected on main roads in Seoul, South Korea to construct traffic prediction models. The speed data which are collected by every 5 minutes are provided by Ministry of Land, Infrastructure and Transport in South Korea. We construct the CNN based model and two MLP models which predict traffic speed and compare performance of the prediction models in this paper. The comparison results show that the CNN based model's prediction performance is higher than the prediction performance of the other two MLP models. |
| 3 | Bao, X., Jiang, D., Yang, X., Wang, H., 2021. An improved deep belief network for traffic prediction considering weather factors. Alexandria Engineering Journal 60, 413–420 | [An improved deep belief network for traffic prediction considering weather factors - ScienceDirect](https://www.sciencedirect.com/science/article/pii/S1110016820304464) | The timely access to accurate traffic data is essential to the development of intelligent traffic systems. However, the existing traffic prediction methods cannot achieve satisfactory results, mainly because of three factors: the structure is too simple to extract deep features; many external factors are overlooks, such as weather and traffic incidents; the nonlinearity of traffic flow is not well handled. To solve the problem, this paper improves the [deep belief network](https://www.sciencedirect.com/topics/engineering/deep-belief-network) (DBN), a [deep learning](https://www.sciencedirect.com/topics/engineering/deep-learning) method, for accurate traffic prediction under poor weather. Firstly, the data of poor weather and traffic data were collected from IoV, rather than [induction coils](https://www.sciencedirect.com/topics/engineering/induction-coil) in traditional methods. Next, the support vector regression (SVR) was introduced to improve the classic DBN. In the improved DBN, the underlying structure is a traditional DBN that learns the key features of traffic data in an unsupervised manner, and the top layer is an SVR that performs supervised traffic prediction. To verify its effectiveness, the improved DBN was applied to predict the traffic data based on the traffic data from the control center of an expressway and the weather data from local monitoring stations, in comparison with the autoregressive integrated moving average (ARIMA) model and the traditional neural network. The experimental results show that the improved DBN controlled the traffic prediction error within 9%, and maintained good robustness despite the extension of the time interval. To sum up, this paper provides an effective way to predict traffic flow under poor weather, shedding new light on the application of deep learning in traffic prediction. |
| 4 | Wu, Y., Tan, H., Qin, L., Ran, B., Jiang, Z., 2018. A hybrid deep learning based traffic flow prediction method and its understanding. Transportation Research Part C: Emerging Technologies 90, 166–180.   * (No access) | [A hybrid deep learning based traffic flow prediction method and its understanding - ScienceDirect](https://www.sciencedirect.com/science/article/abs/pii/S0968090X18302651) | Deep [neural networks](https://www.sciencedirect.com/topics/social-sciences/neural-network) (DNNs) have recently demonstrated the capability to predict traffic flow with big data. While existing DNN models can provide better performance than shallow models, it is still an open issue of making full use of spatial-temporal characteristics of the traffic flow to improve their performance. In addition, our understanding of them on traffic data remains limited. This paper proposes a DNN based traffic flow prediction model (DNN-BTF) to improve the prediction accuracy. The DNN-BTF model makes full use of weekly/daily periodicity and spatial-temporal characteristics of traffic flow. Inspired by recent work in machine learning, an attention based model was introduced that automatically learns to determine the importance of past traffic flow. The convolutional neural network was also used to mine the spatial features and the recurrent neural network to mine the temporal features of traffic flow. We also showed through visualization how DNN-BTF model understands traffic flow data and presents a challenge to conventional thinking about neural networks in the transportation field that neural networks is purely a “black-box” model. Data from open-access database PeMS was used to validate the proposed DNN-BTF model on a long-term horizon prediction task. Experimental results demonstrated that our method outperforms the state-of-the-art approaches. |
| 5 | Zheng, H., Lin, F., Feng, X., Chen, Y., 2020b. A hybrid deep learning model with attention-based conv-lstm networks for short-term traffic flow prediction. IEEE Transactions on Intelligent Transportation Systems   * (No access) | [A Hybrid Deep Learning Model With Attention-Based Conv-LSTM Networks for Short-Term Traffic Flow Prediction | IEEE Journals & Magazine | IEEE Xplore](https://ieeexplore.ieee.org/abstract/document/9112272) | Accurate short-time traffic flow prediction has gained gradually increasing importance for traffic plan and management with the deployment of intelligent transportation systems (ITSs). However, the existing approaches for short-term traffic flow prediction are unable to efficiently capture the complex nonlinearity of traffic flow, which provide unsatisfactory prediction accuracy. In this paper, we propose a deep learning based model which uses hybrid and multiple-layer architectures to automatically extract inherent features of traffic flow data. Firstly, built on the convolutional neural network (CNN) and the long short-term memory (LSTM) network, we develop an attention-based Conv-LSTM module to extract the spatial and short-term temporal features. The attention mechanism is properly designed to distinguish the importance of flow sequences at different times by automatically assigning different weights. Secondly, to further explore long-term temporal features, we propose a bidirectional LSTM (Bi-LSTM) module to extract daily and weekly periodic features so as to capture variance tendency of the traffic flow from both previous and posterior directions. Finally, extensive experimental results are presented to show that the proposed model combining the attention Conv-LSTM and Bi-LSTM achieves better prediction performance compared with other existing approaches. |
| 6 | Luo, X., Li, D., Yang, Y., Zhang, S., 2019. Spatiotemporal traffic flow prediction with knn and lstm. Journal of Advanced Transportation 2019. | [Spatiotemporal Traffic Flow Prediction with KNN and LSTM (hindawi.com)](https://www.hindawi.com/journals/jat/2019/4145353/) | The traffic flow prediction is becoming increasingly crucial in Intelligent Transportation Systems. Accurate prediction result is the precondition of traffic guidance, management, and control. To improve the prediction accuracy, a spatiotemporal traffic flow prediction method is proposed combined with k-nearest neighbor (KNN) and long short-term memory network (LSTM), which is called KNN-LSTM model in this paper. KNN is used to select mostly related neighboring stations with the test station and capture spatial features of traffic flow. LSTM is utilized to mine temporal variability of traffic flow, and a two-layer LSTM network is applied to predict traffic flow respectively in selected stations. The final prediction results are obtained by result-level fusion with rank-exponent weighting method. The prediction performance is evaluated with real-time traffic flow data provided by the Transportation Research Data Lab (TDRL) at the University of Minnesota Duluth (UMD) Data Center. Experimental results indicate that the proposed model can achieve a better performance compared with well-known prediction models including autoregressive integrated moving average (ARIMA), support vector regression (SVR), wavelet neural network (WNN), deep belief networks combined with support vector regression (DBN-SVR), and LSTM models, and the proposed model can achieve on average 12.59% accuracy improvement |
| 7 | Yao, H., Tang, X., Wei, H., Zheng, G., & Li, Z. (2019). Revisiting Spatial-Temporal Similarity: A Deep Learning Framework for Traffic Prediction.   * (No access) | [Revisiting Spatial-Temporal Similarity: A Deep Learning Framework for Traffic Prediction | Proceedings of the AAAI Conference on Artificial Intelligence](https://ojs.aaai.org/index.php/AAAI/article/view/4511) | Traffic prediction has drawn increasing attention in AI research field due to the increasing availability of large-scale traffic data and its importance in the real world. For example, an accurate taxi demand prediction can assist taxi companies in pre-allocating taxis. The key challenge of traffic prediction lies in how to model the complex spatial dependencies and temporal dynamics. Although both factors have been considered in modeling, existing works make strong assumptions about spatial dependence and temporal dynamics, i.e., spatial dependence is stationary in time, and temporal dynamics is strictly periodical. However, in practice the spatial dependence could be dynamic (i.e., changing from time to time), and the temporal dynamics could have some perturbation from one period to another period. In this paper, we make two important observations: (1) the spatial dependencies between locations are dynamic; and (2) the temporal dependency follows daily and weekly pattern but it is not strictly periodic for its dynamic temporal shifting. To address these two issues, we propose a novel Spatial-Temporal Dynamic Network (STDN), in which a flow gating mechanism is introduced to learn the dynamic similarity between locations, and a periodically shifted attention mechanism is designed to handle long-term periodic temporal shifting. To the best of our knowledge, this is the first work that tackle both issues in a unified framework. Our experimental results on real-world traffic datasets verify the effectiveness of the proposed method. |
| 8 | J. Mena-Oreja and J. Gozalvez, "A Comprehensive Evaluation of Deep Learning-Based Techniques for Traffic Prediction," in IEEE Access, vol. 8, pp. 91188-91212, 2020, doi: 10.1109/ACCESS.2020.2994415.   * (No Access) | [A Comprehensive Evaluation of Deep Learning-Based Techniques for Traffic Prediction | IEEE Journals & Magazine | IEEE Xplore](https://ieeexplore.ieee.org/abstract/document/9092975) | Deep learning-based techniques are the state of the art in road traffic prediction or forecasting. Several deep neural networks have been proposed to predict the traffic but they have not been evaluated under common datasets. Current studies analyze their capacity to predict road traffic in general but do not focus on their capacity to predict the formation of congestions. This is critical for avoiding congestions or mitigate their negative impact. This paper progresses the current state of the art by presenting a comprehensive comparison of the state-of-the-art deep neural networks for road traffic prediction. The comparison is conducted using the same real traffic datasets, and under normal and congested traffic conditions. The evaluation includes new deep neural networks and error recurrent models. Our study first demonstrates that accurately predicting the traffic overall does not imply that a deep neural network can accurately predict the traffic when congestions are being formed. This reinforces the idea that prediction techniques must also be evaluated under congestion conditions. Our analysis also shows that exploiting the spatiotemporal evolution of the traffic (and not just the temporal one) provides better prediction accuracy overall and in particular under congestion conditions. The study also demonstrates that error recurrent models outperform deep neural networks that do not utilize an error feedback both under normal and congested traffic conditions. In particular, our study shows that the error recurrent model eRCNN is the deep learning technique that achieves to date the best traffic prediction accuracy. It is also important emphasizing that error recurrent models achieve better prediction accuracy with shallower neural networks and therefore lower computational cost. |
|  | Y. Gu, W. Lu, X. Xu, L. Qin, Z. Shao and H. Zhang, "An Improved Bayesian Combination Model for Short-Term Traffic Prediction With Deep Learning," in IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 3, pp. 1332-1342, March 2020, doi: 10.1109/TITS.2019.2939290.   * (No Access) | [An Improved Bayesian Combination Model for Short-Term Traffic Prediction With Deep Learning | IEEE Journals & Magazine | IEEE Xplore](https://ieeexplore.ieee.org/abstract/document/8842618) | Short-term traffic volume prediction, which can assist road users in choosing appropriate routes and reducing travel time cost, is a significant topic of intelligent transportation system. To overcome the error magnification phenomena of traditional combination methods and to improve prediction performance, this paper proposes an improved Bayesian combination model with deep learning (IBCM-DL) for traffic flow prediction. First, an IBCM framework is established based on the new BCM framework proposed by Wang. Then, correlation analysis is used to analyze the relevance between the historical traffic flow and the traffic flow within the current interval. Three sub-predictors including the gated recurrent unit neural network (GRUNN), autoregressive integrated moving average (ARIMA), and radial basis function neural network (RBFNN) are incorporated into the IBCM framework to take advantage of each method. The real-world traffic volume data captured by microwave sensors located on the expressways of Beijing was used to validate the proposed model in multiple scenarios. The overall results illustrate that the IBCM-DL model outperforms the other state-of-the-art methods in terms of accuracy and stability. |
| 9 | Aqib, M.; Mehmood, R.; Alzahrani, A.; Katib, I.; Albeshri, A.; Altowaijri, S.M. Smarter Traffic Prediction Using Big Data, In-Memory Computing, Deep Learning and GPUs. Sensors **2019**, 19, 2206. https://doi.org/10.3390/s19092206 | [Sensors | Free Full-Text | Smarter Traffic Prediction Using Big Data, In-Memory Computing, Deep Learning and GPUs (mdpi.com)](https://www.mdpi.com/1424-8220/19/9/2206) | Road transportation is the backbone of modern economies, albeit it annually costs 1.251.25 million deaths and trillions of dollars to the global economy, and damages public health and the environment. Deep learning is among the leading-edge methods used for transportation-related predictions, however, the existing works are in their infancy, and fall short in multiple respects, including the use of datasets with limited sizes and scopes, and insufficient depth of the deep learning studies. This paper provides a novel and comprehensive approach toward large-scale, faster, and real-time traffic prediction by bringing four complementary cutting-edge technologies together: big data, deep learning, in-memory computing, and Graphics Processing Units (GPUs). We trained deep networks using over 11 years of data provided by the California Department of Transportation (Caltrans), the largest dataset that has been used in deep learning studies. Several combinations of the input attributes of the data along with various network configurations of the deep learning models were investigated for training and prediction purposes. The use of the pre-trained model for real-time prediction was explored. The paper contributes novel deep learning models, algorithms, implementation, analytics methodology, and software tool for smart cities, big data, high performance computing, and their convergence. |
| 10 | Hou, Y., Han, C., Wei, W., Scherer, R., Połap, D. (2022). Deep Learning Methods in Short-Term Traffic Prediction: A Survey. Information Technology and Control, 51(1), 139-157. https://doi.org/10.5755/j01.itc.51.1.29947 | [Deep Learning Methods in Short-Term Traffic Prediction: A Survey | Information Technology and Control (ktu.lt)](https://itc.ktu.lt/index.php/ITC/article/view/29947) | Nowadays, traffic congestion has become a serious problem that plagues the development of many cities around the world and the travel and life of urban residents. Compared with the costly and long implementation cycle measures such as the promotion of public transportation construction, vehicle restriction, road reconstruction, etc., traffic prediction is the lowest cost and best means to solve traffic congestion. Relevant departments can give early warnings on congested road sections based on the results of traffic prediction, rationalize the distribution of police forces, and solve the traffic congestion problem. At the same time, due to the increasing real-time requirements of current traffic prediction, short-term traffic prediction has become a subject of widspread concern and research. Currently, the most widely used model for short-term traffic prediction are deep learning models. This survey studied the relevant literature on the use of deep learning models to solve shortterm traffic prediction problem in the top journals of transportation in recent years, summarized the current commonly used traffic datasets, the mainstream deep learning models and their applications in this field. Finally, the challenges and future development trends of deep learning models applied in this field are discussed. |
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