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A Multitask Learning Model for Traffic Flow and Speed Forecasting

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Abstract:
This project aims to develop a tool for predicting accurate and timely traffic flow Information. Traffic Environment involves everything that can affect the traffic flowing on the road, whether it's traffic signals, accidents, rallies, even repairing of roads that can cause a jam. If we have prior information which is very near approximate about all the above and many more daily life situations which can affect traffic then, a driver or rider can make an informed decision. Also, it helps in the future of autonomous vehicles. In the current decades, traffic data have been generating exponentially, and we have moved towards the big data concepts for transportation. Available prediction methods for traffic flow use some traffic prediction models and are still unsatisfactory to handle real-world applications. This fact inspired us to work on the traffic flow forecast problem build on the traffic data and models.It is cumbersome to forecast the traffic flow accurately because the data available for the transportation system is insanely huge. In this work, we planned to use machine learning, genetic, soft computing, and deep learning algorithms to analyse the big-data for the transportation system with much-reduced complexity. Also, Image Processing algorithms are involved in traffic sign recognition, which eventually helps for the right training of autonomous vehicles

Introduction:
India is the most populated country in the world and one of the fastest developed country. The rapid growth of personal vehicles (cars and two wheelers) in addition to private and public transport(cabs, tucks and RTC buses etc..) result in huge traffic congestion in most of the cities in India. In recent years Intelligent Transport System(ITS) is being applied to reduce congestion. The prediction of short term traffic and future traffic conditions based on present and past traffic is a major component of Intelligent Transport System(ITS) applications. The importance of traffic flow forecasting for ITS has important applications such as development of traffic control strategies in Advanced Traffic Management Systems[4] and Advanced Traveler Information Systems[5]. Short term traffic flow forecasting involves predicting the traffic volume in the next time interval usually in the range of 5 minutes to 30 minutes. For this study we have considered 5days traffic data at 6 no. junction, Amberpet, Hyderabad, Telangana state, India. In any junction it is very important to forecast the short term traffic flow to design planning and operations of traffic signals and various traffic strategies. In this paper an attempt was made to develop a short term traffic flow forecasting model using Artificial Neural Network(ANN). An Artificial Neural Network(ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as brain, spinal cord process information. In this study MultiLayer Perceptron(MLP) network has been used for the prediction of short term traffic flow.

Literature Review:
In the past few years, a large number of papers around the world have reviewed state-of-art traffic prediction methods at their time. In [1], Nagy et al. not only reviewed prediction models classified in naive models, parametric models and non-parametric models, they also had a deep review of different types of open-source dataset. The dataset is classified by the mobility of the collector sensor, and the authors compared advantages and disadvantages of these datasets. In addition, the authors compared different types of data models used in traffic prediction tasks according to different contexts addressed by the task. In [2], Do et al. put more focus on the neural network-based (NN) models used in traffic prediction tasks. The authors first introduced the basic concepts used in NN model prediction. The authors then reviewed the NN models categorized by their neural structure, layer structure, and activation function. In the end, a summary of the reviewed NN models is made based on different prediction situations. Along with the development of the Deep-Learning structure in the NN model, some papers have also focused on the Deep-Learning based (DL) model used in traffic flow prediction. In [3], the authors reviewed DL models and the related work-flows used to build up a usable DL prediction model. The authors also compared the DL models by applying them to different kinds of traffic state prediction tasks using the same dataset, which can give the reader a more intuitive view of the advantages and disadvantages between different DL prediction models. According to the papers under this topic, we have found that Machine Learning-based (ML) is more and more popular for traffic flow prediction task. The reason is that less prior knowledge about the relationship among different traffic patterns for model building, less restriction on prediction tasks, and have better non-linear features [4]. In this paper, we will focus on the ML

models used in traffic prediction tasks. Meanwhile, we also pay attention to the applicable scenarios the ML model has been applied to. It is important that we compare different types of models on their accuracy, as well as features such as the ability to deal with some specific problems, and the efficiency of the model, the hardware and data dependency of the model.

Problem Identification

Combined a linear model and a sequence of layers to develop a deep learning model to forecast traffic low.

Proposed a deep learning-based traffic low prediction model with convolutional neural networks (CNN) layer to learn spatial features and GRU to capture temporal features.

Introduced Generative Adversarial Networks (GAN) to estimate trip travel times the consideration of network-wide spatiotemporal correlations.

However, most existing models are single task learning (STL), which cannot take the advantages of information sharing among related tasks.

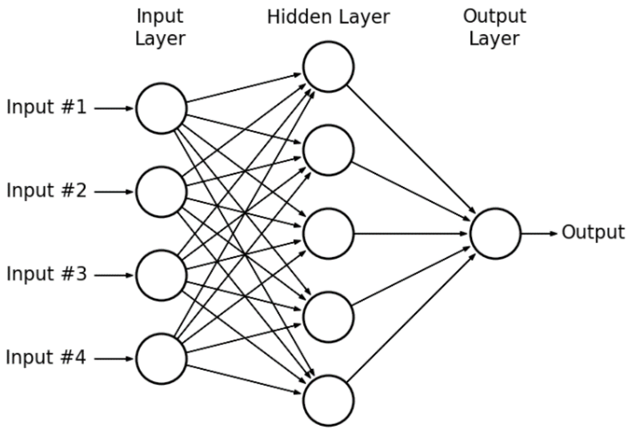
Strategy

To increase the accuracy level for prediction of traffic flow forecasting we are going to use Deep Learning Algorithm - GRU model with multitask learning, previously ARIMA model has been used for forecasting but the performance is undesirable when the traffic data show significant stochastic and nonlinear characteristics. Dataset used here is Traffic Flow Prediction in Caltrans Performance Measurement System.

Algorithms Used in the Prediction:

Multilayer perceptron

Neural networks have broad applicability to real world. Since, neural networks are best for identifying patterns or trends in data, they are well suited for prediction or forecasting needs. Multilayer perceptron(MLP) is most widely used network structure of Artificial Neural Network (ANN). Multilayer perceptron(MLP) is able to solve non linearly separable problems, a number of neurons connected in layers to build a Multilayer perceptron. Each of the perceptrons is used to identify small linearly separable sections of the inputs. Outputs of the perceptrons are combined into another perceptron to produce the final output. The architecture of the MultiLayer Perceptron includes the neurons are arranged into an input layer an output layer and one or more hidden layers.



MultiLayer Perceptron uses the “back propagation rule” which calculates an error function for each input and back propagates the error from one layer to the previous one. The weights for a particular node are adjusted indirect proportion to the error in the units to which it is connected. An activation function is applied to the weighted sum of the inputs of a neuron to produce the output. In this study we used sigmoid function as activation function.

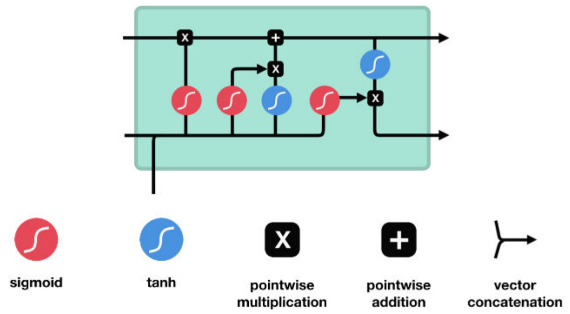
The MLP learning algorithm using the back propagation rule includes initialise weights(to small random values) and transfer function and adjust weights by starting from output layer and working backwards. A unit in the output layer determines its activity by following a 2- step procedure.

Step1: It computes the total weighted input $XXjj$ using the formula $XXjj = \sum_i \boldsymbol{y_i}\, \boldsymbol{W}_{ij}$ Where $\boldsymbol{y_i}$ is the activity level of the j^{th} unit in the previous layer.

Step2: Calculate the activity $\boldsymbol{y_j}$ using sigmoid function of the total weighted input once the activities of all output units have been determined, the network computes the error E.

LSTM

An LSTM has a similar control flow as a recurrent neural network. It processes data passing on information as it propagates forward. The differences are the operations within the LSTM’s cells.

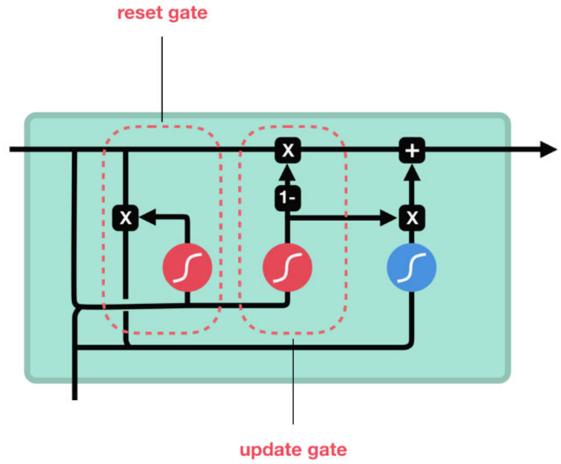


The core concept of LSTM's are the cell state, and it's various gates. The cell state act as a transport highway that transfers relative information all the way down the sequence chain. You can think of it as the "memory" of the network. The cell state, in theory, can carry relevant information throughout the processing of the sequence. So even information from the earlier time steps can make it's way to later time steps, reducing the effects of short-term memory. As the cell state goes on its journey, information get's added or removed to the cell state via gates. The gates are different neural networks that decide which information is allowed on the cell state. The gates can learn what information is relevant to keep or forget during training.

GRU

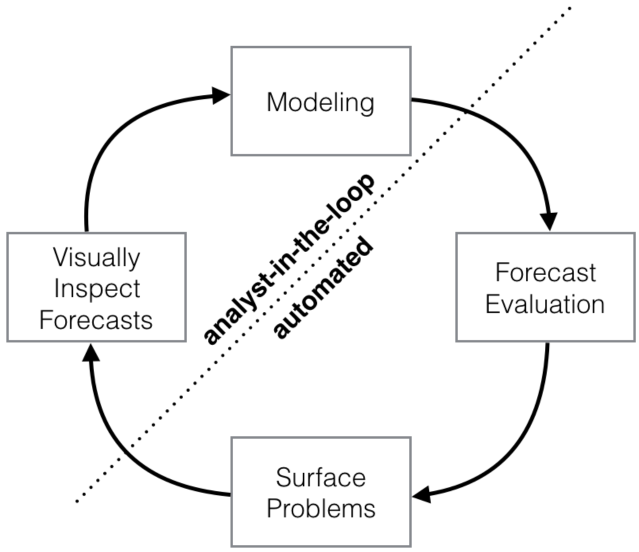
The GRU is the newer generation of Recurrent Neural networks and is pretty similar to an LSTM. GRU's got rid of the cell state and used the hidden state to transfer information. It also only has two gates, a reset gate and update gate.

RU's performance on certain tasks of polyphonic music modeling, speech signal modeling and natural language processing was found to be similar to that of LSTM.GRUs have been shown to exhibit better performance on certain smaller and less frequent datasets.



Prophet or FBProphet: Automatic Forecasting Procedure

Prophet is a procedure for forecasting time series data based on an additive model where non-linear trends are fit with yearly, weekly, and daily seasonality, plus holiday effects. It works best with time series that have strong seasonal effects and several seasons of historical data. Prophet is robust to missing data and shifts in the trend, and typically handles outliers well. Prophet is open source software released by Facebook's Core Data Science team .



Requirements

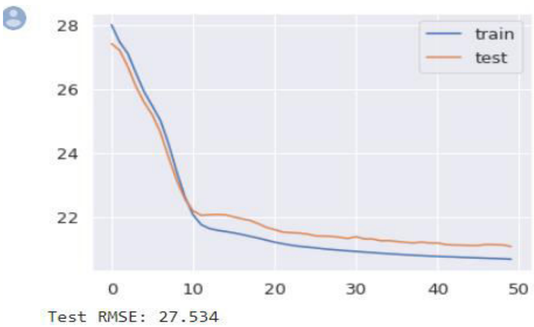
Programing Language	: Python
IDE	: Google Colab
Framework	: TensorFlow

Libraries Used : Sklearn, Keras, Math, Numpy, Pandas
Plotting Libraries : Seaborn, Matplotlib
Dataset Details Name : Traffic Flow Data set
Source : Kaggle
License : CC0 Public Domain
Size : 20MB (36 Files)

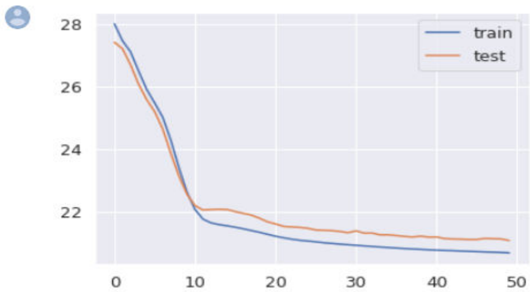
Results:

	Multilayer Perceptron	GRU	FB Prophet
RMSE	**8.33**	**31.263**	**11.194**
MAE	**5.832**	**-**	**-**
R^2	**0.74654**	**-**	**0.5727**

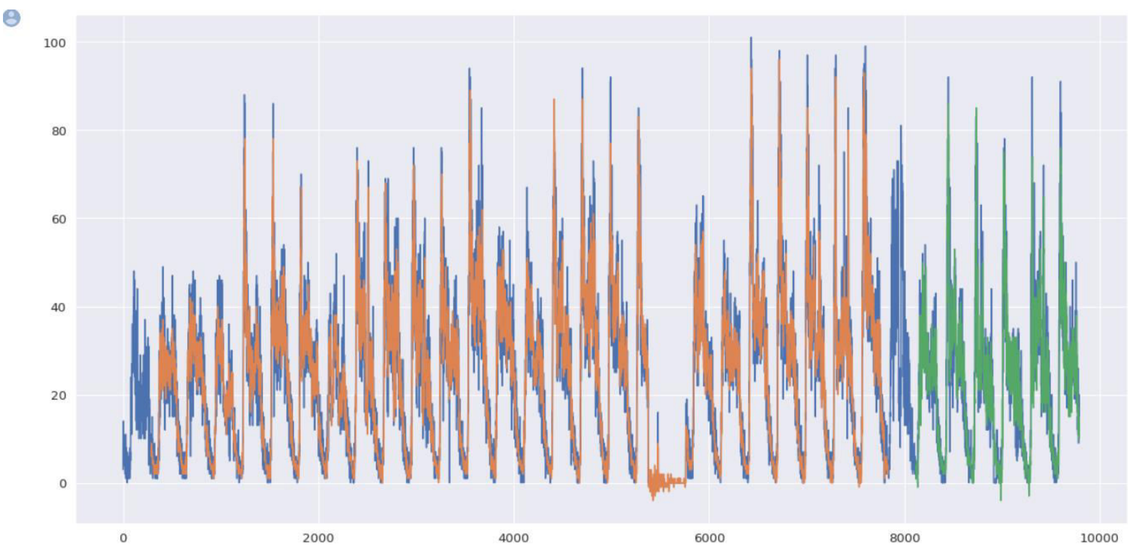
LSTM Model Prediction:



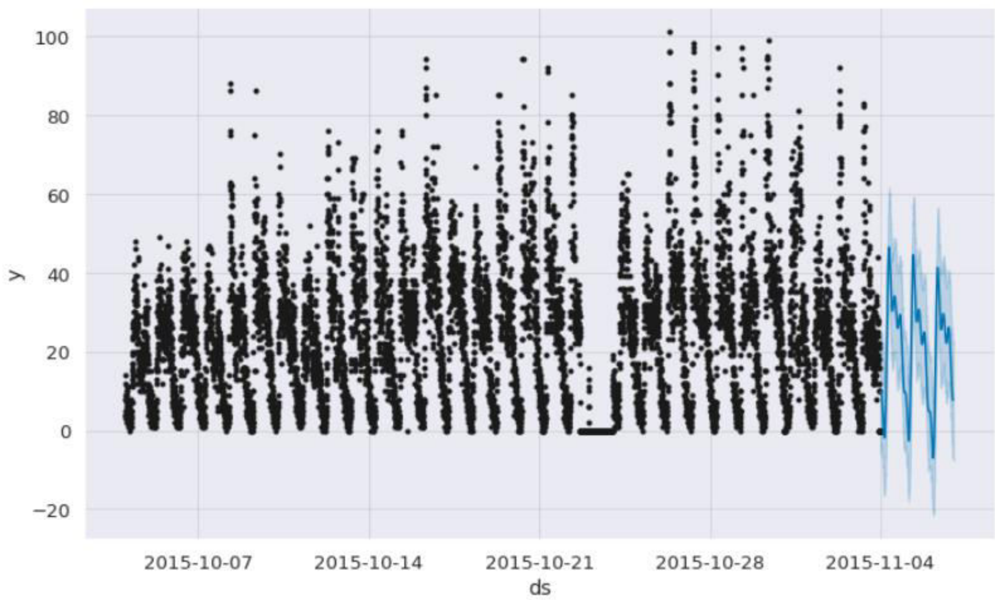
Multilayer perceptron model convergence:

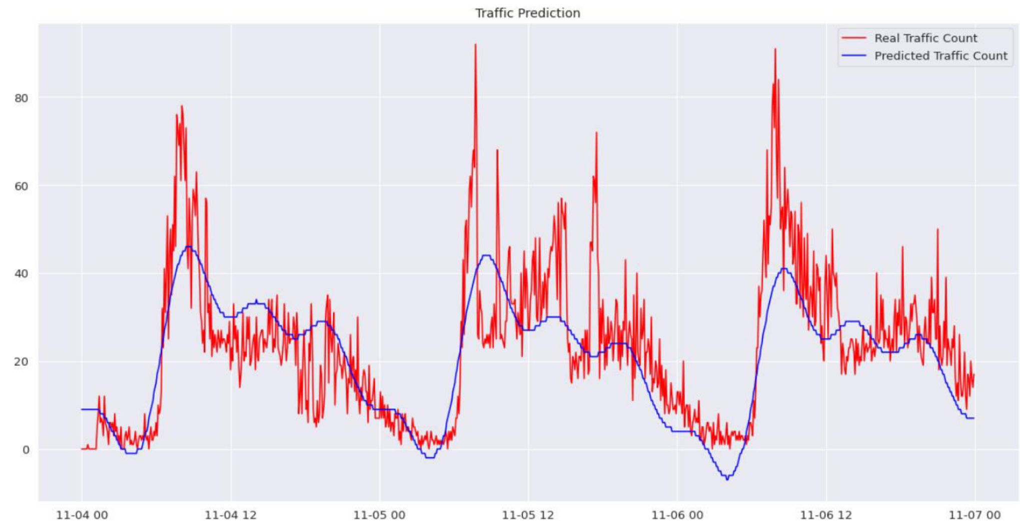


Predictions Using GRU:

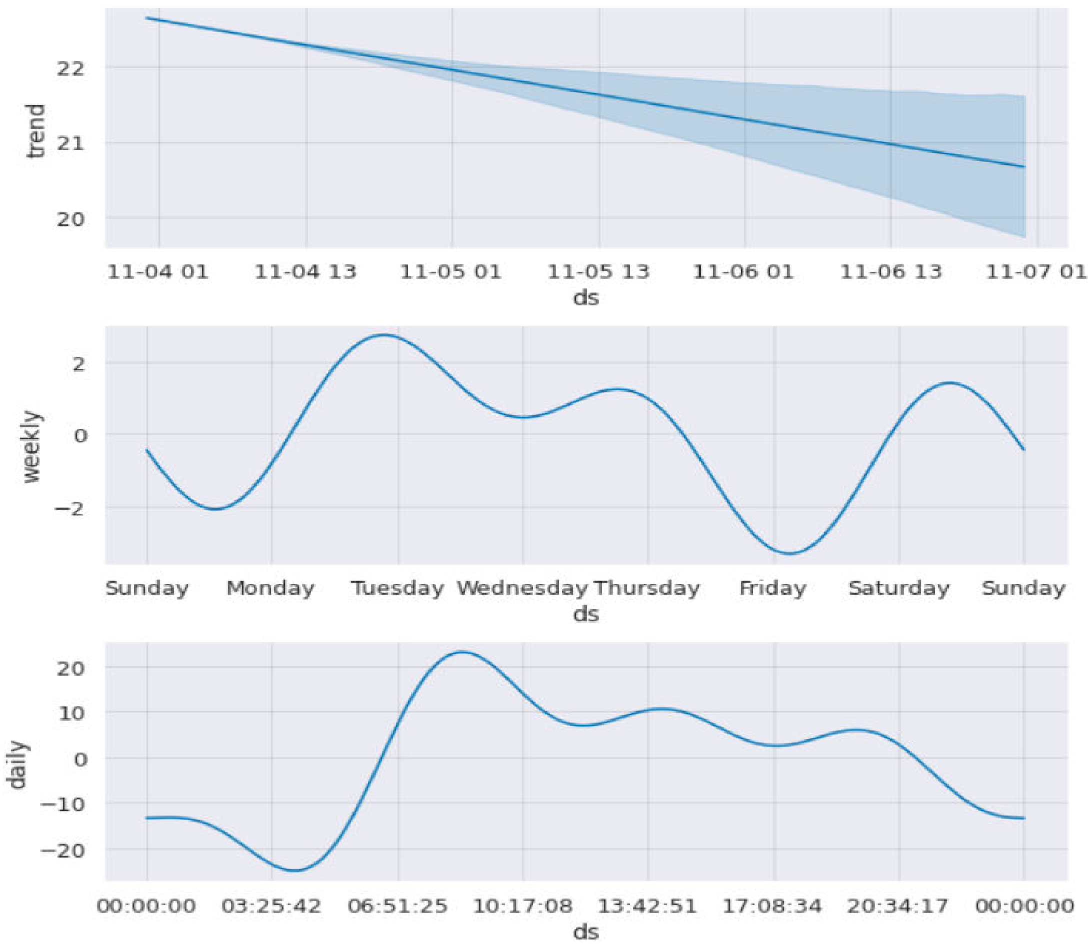


Predictions Using FB Prophet:





Trends obtained:



Conclusion

Traffic prediction is an essential step to construct an efficient preventive congestion control schemes for the high-speed network. We apply ANN predictors (MLP, GRU and FBProphet) and combine their forecasts to predict the JPEG, and MPEG video, Ethemet and lntemet traffic. The MLP and FNN predictors give better results compared to the AR model using the same number of the lagged traffic values. The two-stage predictor outperforms the individual ANN predictors. We investigate different combination schemes. The nonlinear combination schemes give better results than the linear schemes. The results also indicate that the nature of the traffic, coding scheme and the time scale have significant effect on the predictability and the performance of predictors.

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