Traffic Flow Prediction - Report

Nowadays, traffic Flow prediction is a major problem. Traffic flow prediction can be divided in **short term** (prediction in the next minutes or hours) and **long term** (next day prediction).

It is notable that the majority of the studies being analyzed use **RNNs with LSTM implementation**, in order to predict the future positions of a car, as **this architecture is efficient method and gives good results**.

There are also papers that transform the traffic data into a graph and use whole graphs to predict the future traffic flow.

Paper's title: An LSTM Network for Highway Trajectory Prediction [1]

Question	Answer
What is the problem being solved?	Consistent longitudinal and lateral **trajectory prediction** for vehicles on a highway. This is a regression problem.
Model type	Using LSTN neural networks, a particular implementation of RNN
Input	A vector X = [lateral position, longitudinal position, lateral velocity, longitudinal velocity, type of car]
Output	A vector y = (x,y) of the future coordinators of the car.
Details	Using previously observed data, they predict future car trajectories
Dataset being used	Next generation simulation dataset (NGSIM US101 dataset)

Paper's title: Hybrid LSTM Neural Network for Short-Term Traffic Flow Prediction [2]

Question	Answer
What is the problem being solved?	Predict the short-term traffic flow prediction. The model being used is applied to every road section and intersection in the actual road network.
Model type	Hybrid LSTM neural network, based on the LSTM model. The LSTM model can remember long-term sequences.
Input	A vector X = [Current Node, Source Node, Traffic Flow]
Output	Vehicle flow **a** road section or intersection in the actual traffic network
Details	Short term traffic prediction (5 minutes)
Dataset being used	The experimental data set is the local road network traffic data from September 1st to September 8th in Yunyan District, Guiyang City, Guizhou Province.

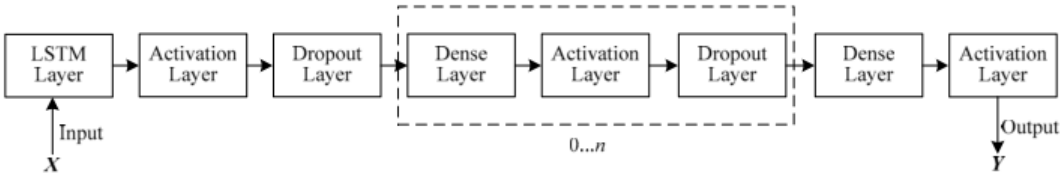

Figure 1. Hybrid Long Short–Term Memory (LSTM) neural network structure.

Paper's title: T-LSTM: A Long Short-Term Memory Neural Network Enhanced by Temporal Information for Traffic Flow Prediction [3]

Question	Answer
What is the problem being solved?	Short-term traffic flow prediction using temporal features (these features are associated with time)
Model type	Temporal information enhancing Long Short-Term Memory neural networks (T-LSTM)
Input	The input to the model is a vector x = (x1,x2,x3,…,xn), where each xi contains a time label and the traffic flow information. The input to the LSTM model is a 8x2 matrix (8 historical data are used to predict traffic flow of the next moment).
Output	The output of the model is a 2D vector y = (time label, traffic flow) of the next moment.
Details	• They combine time label and LSTM to fully explore the temporal characteristics of traffic flow and improve the accuracy of short-term traffic flow prediction. **They pay sufficient attention to time information and add a time label to the traffic flow at each moment.** Then an LSTM-based model is trained with the samples and corresponding time labels. The model is named T-LSTM, an LSTM model enhanced by temporal information. • The time interval for predictions is set to 16 minutes.
Dataset being used	The traffic detector data from Shibalidian Bridge to Hongyan Bridge of the East Fourth Ring Road in Beijing (March 1 to August 30, 2014) is selected to validate the T-LSTM.

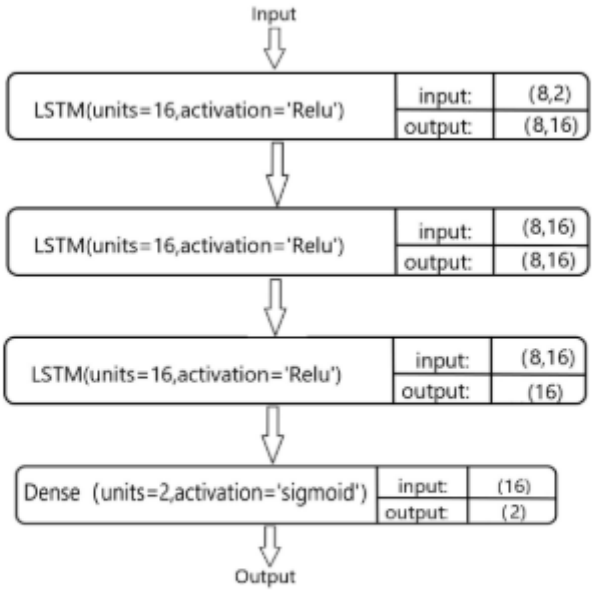

FIGURE 4. The structure of the T-LSTM model. The three layers of LSTMs are stacked as the hidden layers and the one-layer fully connected layer is stacked as the output layer.

Paper's title: ATTENTION-BASED RECURRENT NEURAL NETWORK FOR URBAN VEHICLE TRAJECTORY PREDICTION [4]

Question	Answer
What is the problem being solved?	Trajectory prediction. They analyze trajectories of people and vehicles moving around a city to make predictions on their next locations.
Model type	Attention-based RNN model, which embeds an attention interface to enable the RNN model to **consider the current traffic state as an additional input to location prediction**.
Input	A vector X of a cell sequence. X = [X0,X1,X2, ...,Xm] ≡ [#start, c1, c2, ..., cm]
Output	A vector Y = [Y0, Y1, Y2, ..., Ym] ≡ [c1, c2, ..., cm,#end]. So the #end in the output vector Y is the location prediction of the object.
Details	• They predict the sequence of next locations that the subject vehicle would visit, based on the information **on the previous locations from the origin of the current trip** and historical database representing the urban mobility patterns. • They divide the whole road network in partitions-cells, using the Voronoi tessellation method.
Dataset being used	The vehicle trajectory data used in this research are collected from the Bluetooth sensors in Brisbane, Australia, provided by Queensland Department of Transport and Main Roads (TMR) and Brisbane City Council (BCC).

Due to the fact that our major problem is trajectory prediction, we can simply focus on the RNN implementation of the study, which is a follows below:

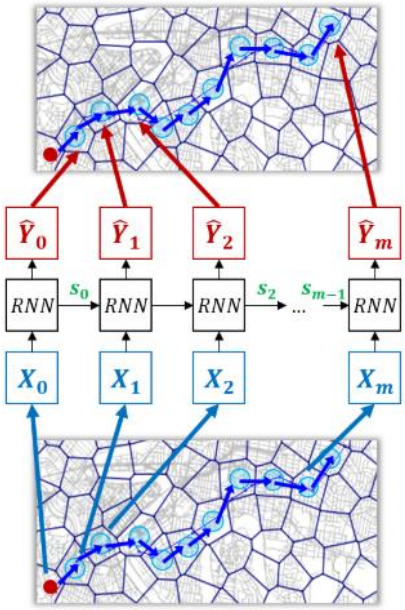

Figure 2: Structure of the basic Recurrent Neural Network model (RNN) for cell sequence prediction

Paper's title: Sequential Graph Neural Network for Urban Road Traffic Speed Prediction [5]

Question	Answer
What is the problem being solved?	Urban road traffic speed prediction
Model type	Traffic speed prediction model called SeqGNN (Sequential Graph Neural Network).
Input	Their proposed model feeds the whole road network into the neural network and learns to forecast the traffic flow. The input is sequential graphs
Output	The output of the model is another graph with the predicted traffic flow.
Details	• The **cause** of traffic congestion is the topology of the road network. • Traffic speeds are calculated on a 5-min intervals.
Dataset being used	Road network data and road segment speed data from Beilin District, Xi'an City, are used to evaluate the model. The road network dataset includes basic information such as the **width, length, and type of the road segments**.

Paper's title: Graph Hierarchical Convolutional Recurrent Neural Network (GHCRNN) for Vehicle Condition Prediction [6]

Question	Answer
What is the problem being solved?	Prediction of urban vehicle flow and speed
Model type	**Graph Hierarchical Convolutional Recurrent Neural Network Model**, which effectively extracts the hierarchical structure information, eliminates noise, improves efficiency and reduces memory usage rate.
Input	The input is a time series X. The input is historical data.
Output	Output is another times series Y. Output is future prediction.
Details	• the model proposed in this paper adds Pooling and Unpooling layers, which can effectively extract the hierarchical structure information of the road network, reduce the time and space complexity, and solve the large graph with time and space structure information • Use of convolutional operation to **extract graph features from images** • The data are feeded to a **seq2seq model (Encoder – Decoder)**
Dataset being used	The speed data of Los Angeles is the average speed of each detection station in 5 minutes as one data. A total of 207 stations are selected and the period is 4 months, so there is total of 207 × 34272 data, the vehicle speed of each node in the graph is one data in a time period and input to the model.

Paper's title: TTDM: A Travel Time Difference Model for Next Location Prediction [7]

Question	Answer
What is the problem being solved?	This study solves the problem of next location prediction using past data (given a query trajectory sequence, predicting the next location that a user will arrive at)
Model type	Travel Time Difference Model (TTDM for short) to predict next locations.
Input	They give to the model all the trajectories (in order to create the graph road network and compute the shortest paths between every two nodes in the graph). After that, for each prediction, we just give the trajectory sequence of a specific moving object.
Output	Prediction of the next (with the highest probability) location of the specific moving object.
Details	• This paper does not use Neural Networks. Here, the next location prediction is mined from the past data. • The method being used based in travel time difference. • The road network is modelized as a graph, each edge contains the average travel time between the two nodes being connected.
Dataset being used	In the experiments, they use two datasets: the vehicle passage record (VPR) data and the taxi trajectory data.

Github code: https://github.com/tracyitbird/TTDM

Paper's title: DeepCrowd: A Deep Model for Large-Scale Citywide Crowd Density and Flow Prediction [8]

Question	Answer
What is the problem being solved?	Traffic prediction. They predict not only how many objects will be in each location at the next timestamp (crowd density prediction), but also how many objects will leave and visit each location at the next timestamp (crowd in-out flow prediction).
Model type	The model is called DeepCrowd. It is used for large-scale citywide crowd density and in-out flow prediction, by designing pyramid ConvLSTMs, 4D high-dimensional attention block, and early-fusion mechanism.
Input	multiple steps of **historical** observations
Output	the next-step prediction result
Details	the pyramid architecture plays a vital role in capture the spatial dependency.
Datasets being used	BousaiTYO and BousaiOSA. Each record includes user ID, timestamp, latitude, and longitude.

Github code: https://github.com/deepkashiwa20/DeepCrowd

Bibliography

[1] F. Altche and A. De La Fortelle, "An LSTM network for highway trajectory prediction," *IEEE Conf. Intell. Transp. Syst. Proceedings, ITSC*, vol. 2018-March, pp. 353–359, 2018, doi: 10.1109/ITSC.2017.8317913.

[2] Y. Xiao and Y. Yin, "Hybrid LSTM neural network for short-term traffic flow prediction," *Inf.*, vol. 10, no. 3, 2019, doi: 10.3390/info10030105.

[3] L. Mou, P. Zhao, H. Xie, and Y. Chen, "T-LSTM: A long short-term memory neural network enhanced by temporal information for traffic flow prediction," *IEEE Access*, vol. 7, pp. 98053–98060, 2019, doi: 10.1109/ACCESS.2019.2929692.

[4] S. Choi, J. Kim, and H. Yeo, "Attention-based Recurrent Neural Network for Urban Vehicle Trajectory Prediction," *Procedia Comput. Sci.*, vol. 151, pp. 327–334, 2019, doi: 10.1016/j.procs.2019.04.046.

[5] Z. Xie, W. Lv, S. Huang, Z. Lu, B. Du, and R. Huang, "Sequential Graph Neural Network for Urban Road Traffic Speed Prediction," *IEEE Access*, vol. 8, pp. 63349–63358, 2020, doi: 10.1109/ACCESS.2019.2915364.

[6] M. Lu, K. Zhang, H. Liu, and N. Xiong, "Graph Hierarchical Convolutional Recurrent Neural Network (GHCRNN) for Vehicle Condition Prediction," 2019, [Online]. Available: http://arxiv.org/abs/1903.06261.

[7] Q. Liu, Y. Zuo, X. Yu, and M. Chen, “TTDM: A travel time difference model for next location prediction,” *Proc. - IEEE Int. Conf. Mob. Data Manag.*, vol. 2019-June, no. Mdm, pp. 216–225, 2019, doi: 10.1109/MDM.2019.00-54.

[8] R. Jiang *et al.*, “DeepCrowd: A Deep Model for Large-Scale Citywide Crowd Density and Flow Prediction,” *IEEE Trans. Knowl. Data Eng.*, vol. 4347, no. c, pp. 1–15, 2021, doi: 10.1109/TKDE.2021.3077056.