Variants of Graph Convolutional Neural Networks for Traffic Prediction

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Traffic Forecasting Problem

Description:

Predict future traffic speed/conditions by leveraging previously observed data.

Impact:

- Vehicle Routing Problem
- Vehicle Scheduling problem
- HeadLights Algorithms

$$[\boldsymbol{X}^{(t-T'+1)}, \cdots, \boldsymbol{X}^{(t)}; \mathcal{G}] \xrightarrow{h(\cdot)} [\boldsymbol{X}^{(t+1)}, \cdots, \boldsymbol{X}^{(t+T)}]$$

$\mathcal{G}$: Road sensor network

$\boldsymbol{X}^{(t)}$: Road traffic conditions at time t

Li, Y., Yu, R., Shahabi, C., & Liu, Y. (2018, February). *DIFFUSION CONVOLUTIONAL RECURRENT NEURAL NETWORK: DATA-DRIVEN TRAFFIC FORECASTING.* ICLR 2018. https://arxiv.org/pdf/1707.01926.pdf

Graph Convolutions

- Representing road sensor network as **directed graph** captures the **spatial dependencies** of the road network [1].
- Inspired by CNN's (Convolutional Neural Networks) for image data, GNN's (Graph Neural Networks) apply a weight filter over the the graph. One main difference being that graph convolutions deal with non-euclidean structured data (more abstract) as nodes are unordered with varying degree [2].

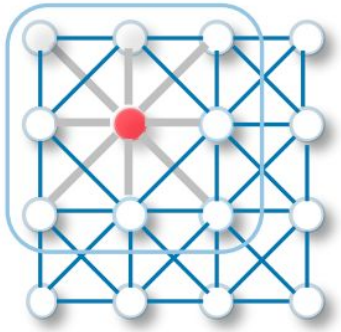
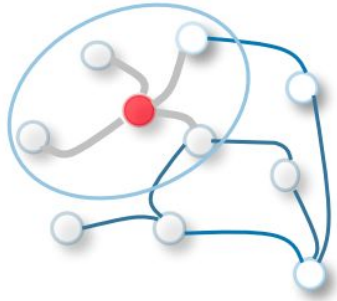


Image Convolution



Graph Convolution [2]

[1] Li, Y., Yu, R., Shahabi, C., & Liu, Y. (2018, February). *DIFFUSION CONVOLUTIONAL RECURRENT NEURAL NETWORK: DATA-DRIVEN TRAFFIC FORECASTING*. ICLR 2018. https://arxiv.org/pdf/1707.01926.pdf

[2] Mayachita, I. (2020, June 10). *Understanding Graph Convolutional Networks for Node Classification*. Towardsdatascience.Com. https://towardsdatascience.com/understanding-graph-convolutional-networks-for-node-classification-a2bfdb7aba7b

Current Solutions

Parametric:

- **ARIMA** - Auto-Regressive Integrated Moving Average

Non-Parametric:

- **RF** - Random Forests
- **SVR** - Support Vector Regression
- **DCRNN** (2017) [1] - Diffusion Convolutional Recurrent Neural Network
- **LSTM** (RNN) [2]- Long Short Term Memory is an artificial Recurrent Neural Network architecture
- ***SLCNN** (2020) [3]- Structure Learning Convolutional Neural Network
- ***3D-TGCN** (2019) [4]- 3D Temporal Graph Convolutional Network

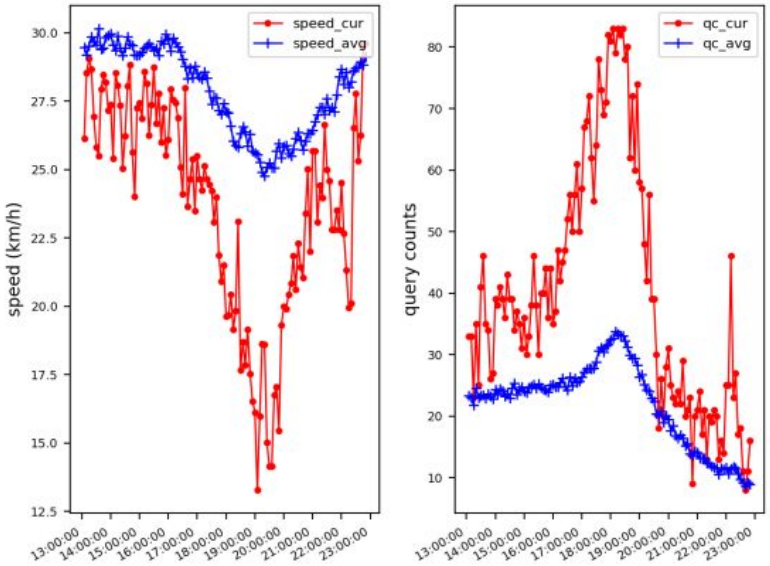
Variants of the LSTM have been very successful when equipped with Graph Convolution.

[1] Li, Y., Yu, R., Shahabi, C., & Liu, Y. (2018, February). *DIFFUSION CONVOLUTIONAL RECURRENT NEURAL NETWORK: DATA-DRIVEN TRAFFIC FORECASTING*. ICLR 2018. https://arxiv.org/pdf/1707.01926.pdf
[2]Ilya Sutskever, Oriol Vinyals, and Quoc V Le. Sequence to sequence learning with neural networks. In NIPS, pp. 3104–3112, 2014.
[3]Zhang, Q., Chang, J., Meng, G., Xiang, S., & Pan, C. (2020). Spatio-Temporal Graph Structure Learning for Traffic Forecasting. AAAI-20. https://ojs.aaai.org//index.php/AAAI/article/view/5470
[4]Yu, B., Li, M., Zhang, J., & Zhu, Z. (2019, March). 3D Graph Convolutional Networks with Temporal Graphs: A Spatial Information Free Framework For Traffic Forecasting. https://arxiv.org/pdf/1903.00919v1.pdf

Motivations

- Many external factors correlate with traffic congestion/speeds: historic speeds; weather; time of day, time of week, time of year; online route queries; road network etc.

- Proposed methods tend to either make strong use of external factors with weaker methods, or strong method with fewer external factors.



Online route queries and traffic speeds [1]

[1] Liao, B., Zhang, J., Wu, C., McIlwraith, D., Chen, T., Yang, S., Guo, Y., & Wu, F. (2018). Deep Sequence Learning with Auxiliary Information for Traffic Prediction. *ArXiv:1806.07380v1*, 2. https://arxiv.org/pdf/1806.07380.pdf

Goal:

- Understand, reproduce and improve state of the art non-parametric methods for traffic forecasting.

Proposed Methodology:

- Make effective use of external factors as well as combining ideas from successful methods.

Data Sets Considered:

Q-Traffic Dataset [1]- Online queries sub-dataset, traffic speed sub-dataset, road network sub-dataset

PeMS-M - Used by many State of the Art methods as a benchmark

METR-LA- Used by many State of the Art methods as a benchmark

[1] Liao, B., Zhang, J., Wu, C., McIlwraith, D., Chen, T., Yang, S., Guo, Y., & Wu, F. (2018). Deep Sequence Learning with Auxiliary Information for Traffic Prediction. *ArXiv:1806.07380v1*, 2. https://arxiv.org/pdf/1806.07380.pdf

Proposed Timeline

Before March Break:

- Literature review
- chose datasets
- Finalise project goal and experiments

During March Break:

- Reproduce results
- Implement my own approach

After March Break:

- Finalise Project Report + Demo

Questions?