Graph Neural Networks for Long-Term Traffic Forecasting

Can GNNs effectively handle long-term predictions and how does their accuracy degrade over time?

Author: Vlad-Gabriel Vrânceanu
(V.G.Vranceanu@student.tudelft.nl)

Supervisor: Elena Congeduti

TU Delft Delft University of Technology

1. Introduction

Definitions:
Traffic forecasting deals with predicting the volume or speed of traffic in a road network.
GNNs - Graph Neural Network: Graph neural network refers to any neural network working on the graph data.[1]
Long-Horizon Forecasting - 10 hours ahead of the current time. It encompasses the working day of an average person in California (2 hours max for commute[2] and 8 hours average working day[3]).

2. Subquestions

1. Does the **performance** of the GNN noticeably **degrade** at **specific points in time** during long-term traffic forecasting?
2. Do **fluctuations in traffic volume/speed contribute to the decline in** the GNN's **performance** for long-term traffic forecasting?
3. Are **there specific configurations of road networks** (e.g. straight roads, multiple intersections) that **contribute to the decline in** the GNN's **performance** for long-term traffic forecasting?

3. Methodology

GNN model **-** The **D2STGNN**[4] model. Trained model on the **METR-LA** dataset with a **maximum horizon of 10 hours with 450 epochs**.

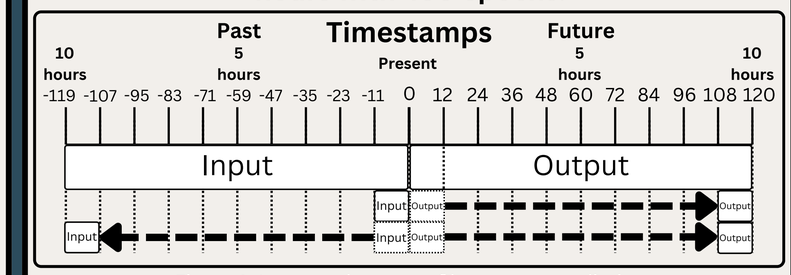

Figure 1. Input and output of long-term predictions

4. Dataset Used

METR-LA

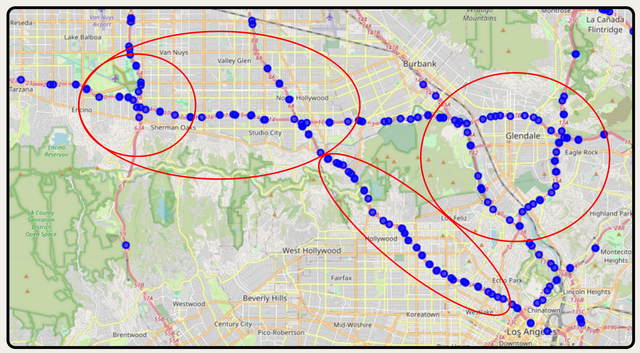

Figure 2. METR-LA sensor map and the selected subsets

5. Results

Long-term forecasting performance

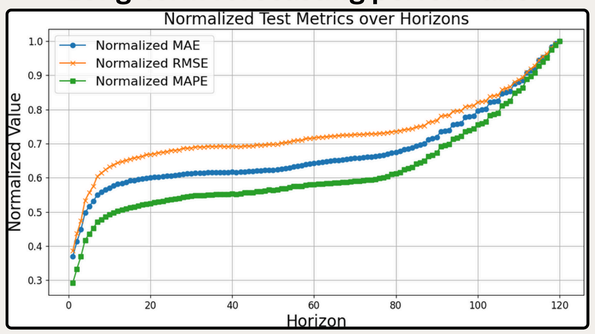

Figure 3. Normalized error values for 120 horizons with 20 nodes

Road network configuration results

Subset	MAE
Straight Road - 35 nodes	7.53
One Intersection - 20 nodes	7.78
Two Intersections - 40 nodes	6.29
Three Intersections - 55 nodes	10.15

Figure 6. Subsets and their MAE values at epoch 320 averaged over 120 horizons.

Subset	Mean	Var.	Std. Dev.	Missing Values %
Straight Road	56.23	226.08	14.16	7.54
One Intersection	53.84	213.17	14.22	7.8
Two Intersections	55.55	190.75	13.21	7.44
Three Intersections	61.39	65.47	6.96	8.92

Figure 7. Subsets and their mean, variance, standard deviation, and # zeros.

Fluctuations in traffic speed METR-LA

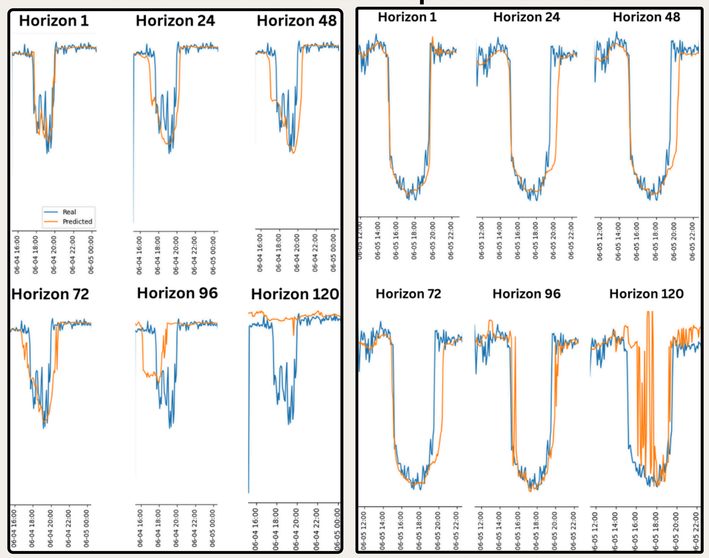

Figure 4. Comparison for multiple horizons across 10 hours for sensor 767350

Figure 5. Comparison for multiple horizons across 10 hours for sensor 717499

6. Conclusions

Interpreting the results:

- **Logarithmic growth** for average error in prediction until timestamp 80 as seen in *Figure 3*. It didn't continue as the model needed more training, which would lead to overfitting.
- **Fluctuations in traffic speed** contribute to the degradation of predictions, as seen in *Figures 4 and 5*.
- It is inconclusive if **specific road network configurations** have an impact on GNN performance

Future Work:

- Build **isolated subsets** to concretely answer the **third sub-question**
- Redo the experiments with **datasets** that record **traffic volume**
- Use **datasets** that are **recorded** on **roads different** from **highways**.

7. References

[1] L. Wu, P. Cui, J. Pei, and L. Zhao. Graph Neural Networks: Foundations, Frontiers, and Applications. Springer, Singapore, 2022
[2]**URL:**https://fred.stlouisfed.org/series/B080ACS006037
[3]**URL:**https://www.bls.gov/sae/tables/annual-average/table-3-average-hours-and-earnings-of-production-employees-on-manufacturing-payrolls-by-state.htm
[4] Zezhi Shao, Zhao Zhang, Wei Wei, Fei Wang, Yongjun Xu, Xin Cao, and Christian S. Jensen. Decoupled dynamic spatial-temporal graph neural network for traffic forecasting,2022.