Deep Learning Approach for Spatial Extension of Traffic Sensor Points in Urban Road Network

Arthur Piazzi, Tamás Tettamanti

Dept. of Control for Transportation and Vehicle Systems
Faculty of Transportation Engineering and Vehicle Engineering
Budapest University of Technology and Economics, Hungary

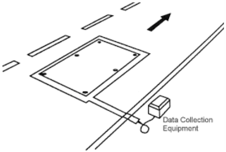
29^{th} of May 2019

Content

- Introduction
- Traffic Simulation
- Architecture and Optimization
- Results
- Conclusion

Background

- Real-time assessment of traffic condition is essential to ITS applications (e.g. traffic control, route planning...).
- Naturally, data acquisition is the most critical part of a monitoring system.




- Data augmentation is also vital (e.g. data fusion, traffic forecasting and spatial extension, etc.).

Background - Traffic Forecasting

Let's divide traffic estimation in two categories

- Temporal estimation (Traffic Forecasting).
  Estimate future traffic values.
  - Short-term forecasting of traffic states has enabled and enhanced ITS applications.
  - Data-driven approaches revolutionized the field, establishing state-of-art solutions.
  - Neural networks comprise the majority of recent solutions.
- Spatial estimation (Spatial extension).
  Estimate road links values without sensors

Background - Spatial extension

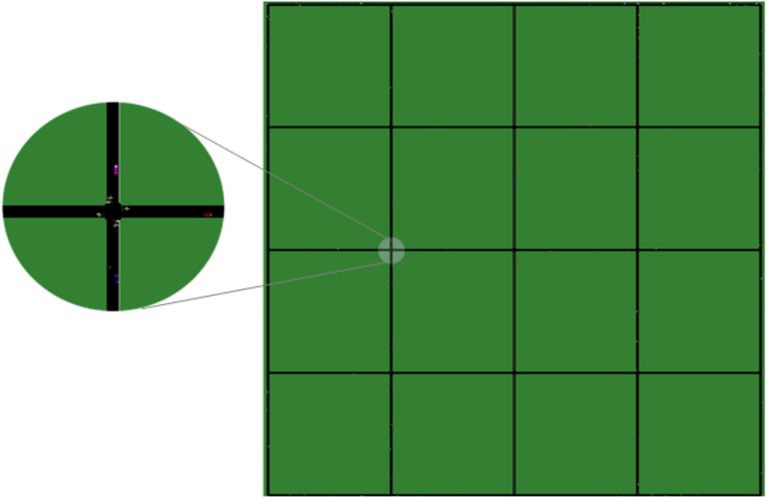
- Traffic forecasting can be considered as a mature field
- However, spatial extension is an embryonic research field

Current solutions:

- 1984 - Origin and Destination matrix update + link flow assignment.
- 2006 - Sensor virtualization based on similarity.
- 2016 and 2018 - Artificial Neural Network approach.

SUMO

- Simulation of Urban Mobility: a validated road traffic simulator in traffic engineering community
- A test network was applied: grid with 80 road links



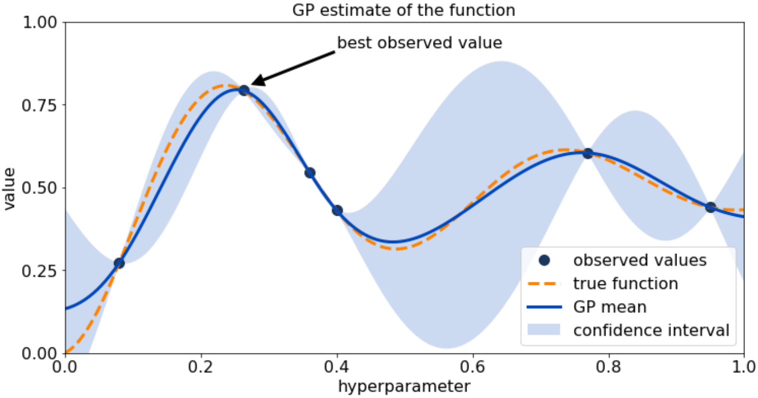
Architectures

- In order to exploit the temporal relation between measurements, the following neural network architectures were proposed:
  - TLNN: Time Lagged Neural Network
  - LSTM: Long Short Term Memory
- ANN was also implemented as a baseline.

Optimization

Model performance is sensible to network parameterization.

- For parameter tuning, a mixed of Bayesian search and exhaustive search was applied.



source: Bertrand et al., 2017

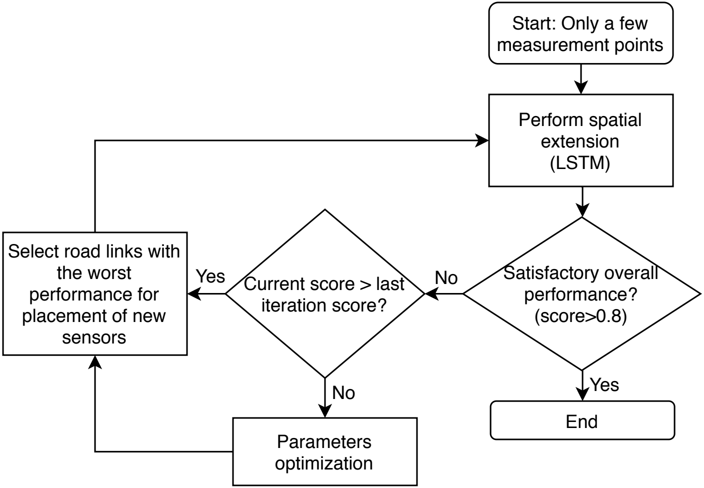
Sensor point selection

- In the simulated environment, the position and the number of sensor points can be freely chosen.
- Iterative constructive procedure for measurement points selection and parameter optimization.

Sensor point selection method

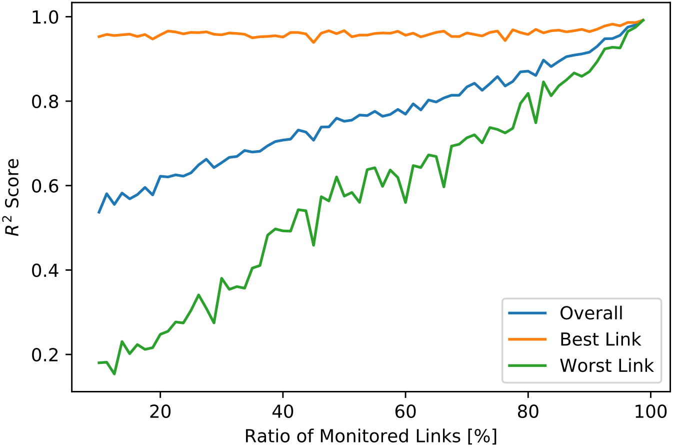
Results are presented in terms of R^2 for each link:

$$R^2 = 1 - \sum_i \frac{(y_i - v_i)^2}{(y_i - \bar{y})^2}$$



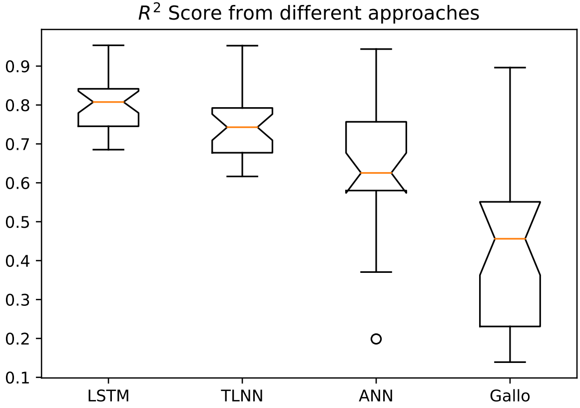
Sensor point selection result

Sensor point selection result for LSTM approach.



Comparison between approaches

- Same input/output configuration was used for all models.
- Input/output configuration based by LSTM approach.
- The parameters were optimized with Bayesian search.



Arthur Piazzi, Tamás Tettamanti

Conclusion

- The results show that it is possible to extend the coverage of traffic monitoring without increasing the installed infrastructural devices.
- Moreover, if one plans a new detector infrastructure, it is possible to determine a minimal sensor setup in a given network such that one obtain reliable estimation with a given R^2.
- The use of LSTM network for spatial extension yields better results than other approaches present in the literature.

THANK YOU FOR YOUR ATTENTION!

E-mail:

piazzi.arthur@mail.bme.hu

www.traffic.bme.hu