Master Thesis Topic

Transfer learning for transportation system resilience estimation using floating car data

Background

Considering the frequent occurrence of natural disasters (e.g., hurricanes and earthquakes) in recent years, understanding the capability of transportation systems for withstanding and absorbing potential disruptions caused by such events, and recovering to the original operation state or a *new* equilibrium becomes imperative. System resilience is a common indicator used to measure this kind of capability. A graphical illustration of the so-called *resilience triangle* is provided in Figure 1. COVID-19, from its outbreak to now, has also demonstrated its tremendous *damage* to urban transportation systems. Despite the fact that it does not destroy infrastructures and facilities directly as other disasters, the containment policies implemented by the governments still result in a demand loss of local transportation, showing a similar shape as the resilience triangle. This provides an unprecedented opportunity to investigate the transportation system resilience problem due to the availability of a large amount of data (since most cities have ever suffered or are experiencing the COVID-19 pandemic). However, the difference between pandemics and natural disasters should also be particularly considered.

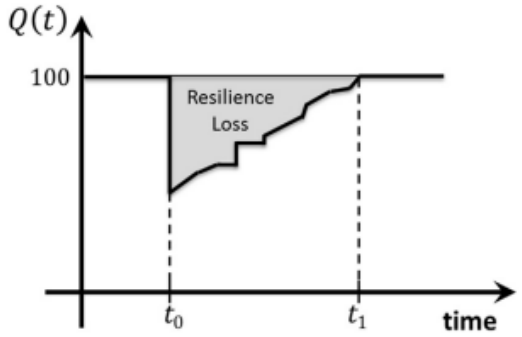

Figure 1: Measure of resilience---conceptual definition (Bruneau et al., 2003)

Methodology

Using floating car data from 10 diverse cities in years 2019 and 2020, this thesis is to develop a model that can be commonly used to evaluate and estimate the system resilience of local transportation. To this end, transfer learning will be used to distil knowledge about system resilience from source cities and apply it to target cities (Pan and Yang, 2010, Li et al., 2021). System resilience will be evaluated by the resilience triangle, which is a definite integral of the deviation of system functionality from the operational state. Mathematically, it is given by

$$R = \int_{t_0}^{t_1} 100 - Q(t)\, dt$$

Note, some specific indices that can capture the dynamics of the resilience triangle might be needed to discover and define, such as the method applied in Wang et al. (2020). Moreover, the system functionality should also be defined properly. Besides the demand deviation, the student should also explore the applicability of other traffic representatives to this problem.

Results

A model that can accurately estimate the dynamics of the resilience triangle and evaluate the transportation system resilience.

Previous knowledge expected

- Completed the “Statistical Learning and Data Analytics for Transportation Systems” course or similar.
- Programming basis.

Selected references

Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., ... & Von Winterfeldt, D. (2003). A framework to quantitatively assess and enhance the seismic resilience of communities. *Earthquake spectra*, *19*(4), 733-752.

Zhu, Y., Ozbay, K., Xie, K., & Yang, H. (2016). Using big data to study resilience of taxi and subway trips for Hurricanes Sandy and Irene. Transportation Research Record, 2599(Figure 1), 70–80.

Wang, H. W., Peng, Z. R., Wang, D., Meng, Y., Wu, T., Sun, W., & Lu, Q. C. (2020). Evaluation and prediction of transportation resilience under extreme weather events: A diffusion graph convolutional approach. Transportation Research Part C: Emerging Technologies, 115(441).

Pan, S. J., Yang, Q. (2010) A survey on transfer learning. *IEEE Transactions on Knowledge and Data Engineering*, 22(10), 1345-1359.

Li, J., Guo, F., Sivakumar, A., Dong, Y., Krishnan, R. (2021) Transferability improvement in short-term traffic prediction using stacked LSTM network. *Transportation Research Part C: Emerging Technologies*, 124, 102977.

Relevant projects

- DARUMA: https://www.mos.ed.tum.de/en/vvs/forschung/projekte/daruma/
- PANAMERA: https://www.mos.ed.tum.de/vvs/forschung/projekte/panamera/

Starting date

From November 2022

How to apply:

This thesis will be supervised by Qinglong Lu and Cheng Lyu. Interested applicants should contact Qinglong Lu and Cheng Lyu (qinglong.lu@tum.de, cheng.lyu@tum.de) by sending an email including your resume, a short explanation of why you are interested in this thesis topic and your starting date.