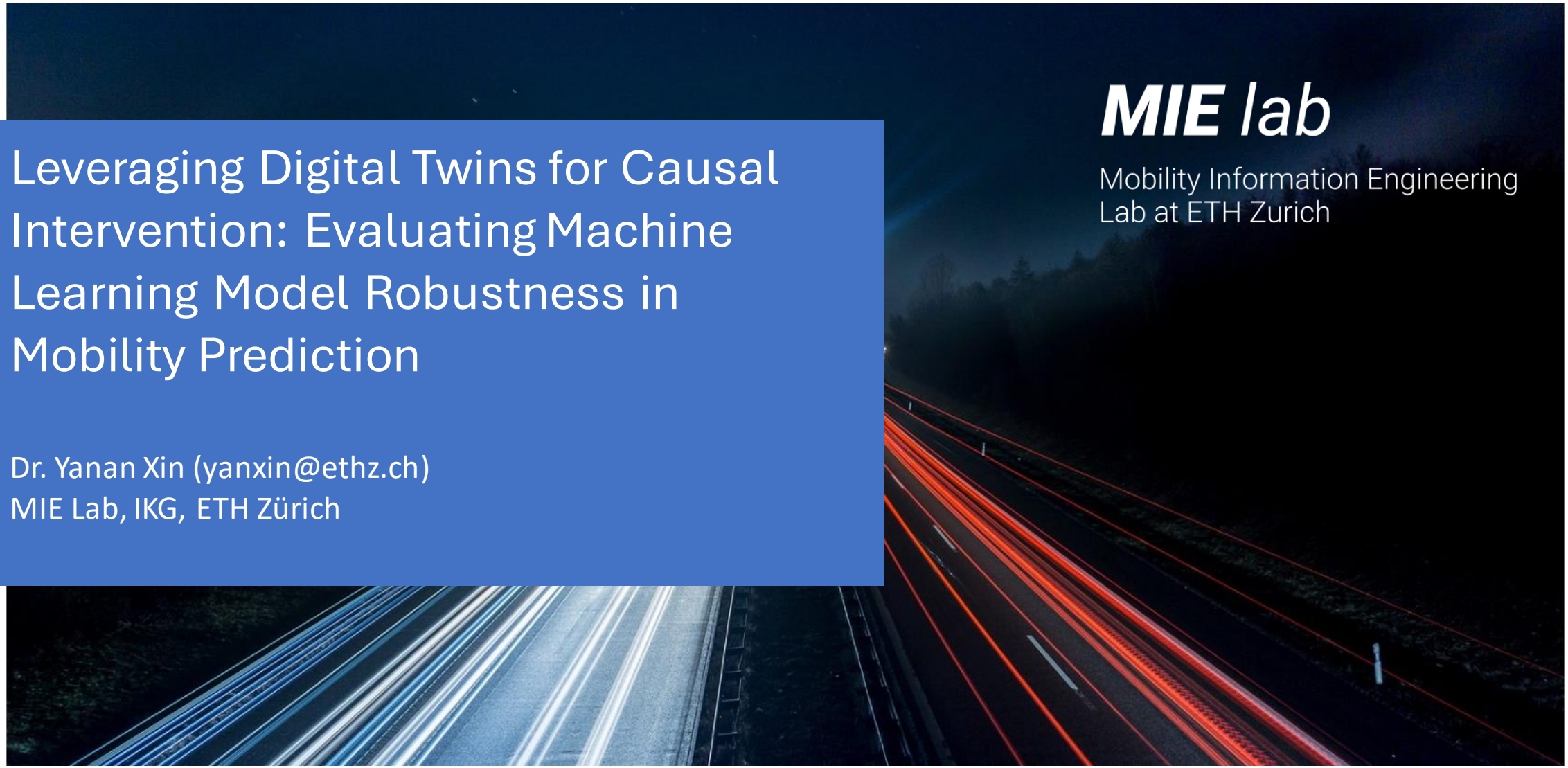

Leveraging Digital Twins for Causal Intervention: Evaluating Machine Learning Model Robustness in Mobility Prediction

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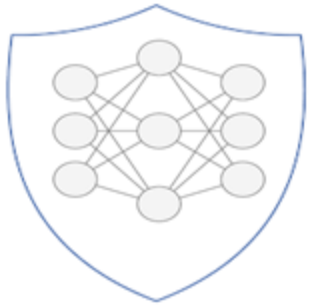
MIE Lab, IKG, ETH Zürich

ETH zürich SDSC
HASLERSTIFTUNG



Interpretable and Robust Machine Learning for Mobility Analysis

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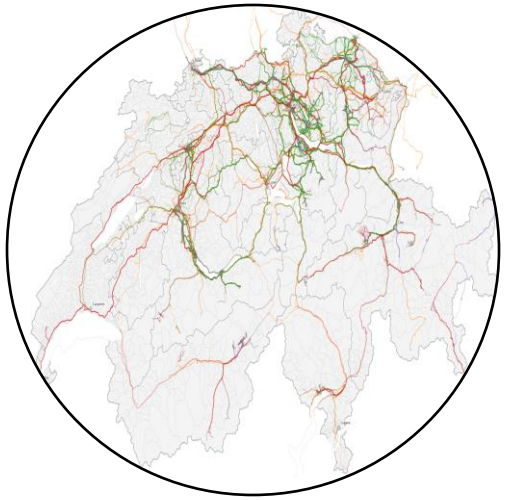
How robust is the model when data change?

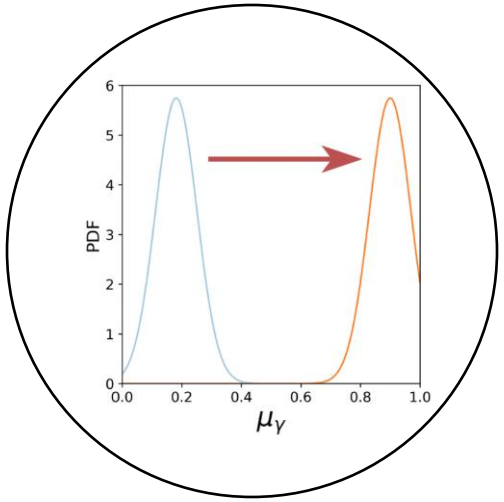
Observational Data

Mobility Pattern Change

Data Distribution Shifts

	Accuracy
Model 1	✓
Model 2	✓



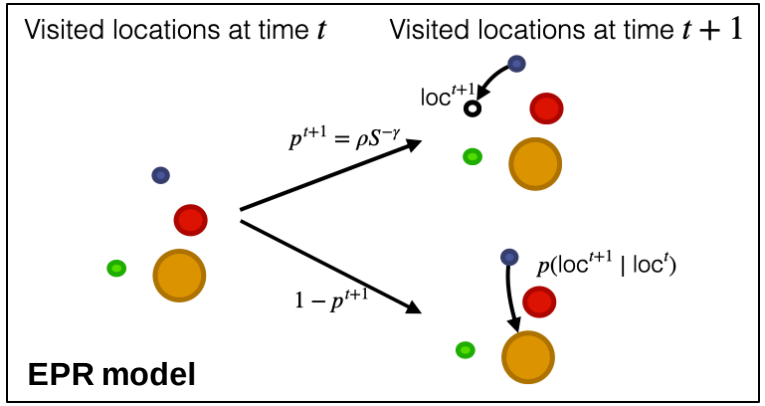


	Accuracy
Model 1	✓
Model 2	✗

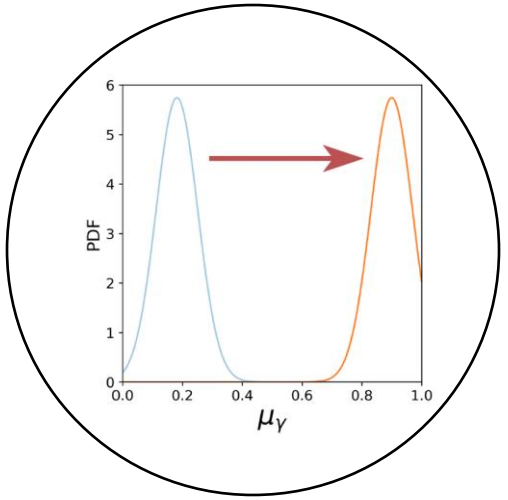
Lack of standards for evaluating models' robustness

Xin, Y., Hong, Y., Dirmeier, S., Perez-Cruz, F., & Raubal, M. (2023). Evaluating the Robustness of Deep Learning Models for Mobility Prediction Through Causal Interventions. In *Center for Sustainable Future Mobility: Symposium 2023 (CSFM'23)*.

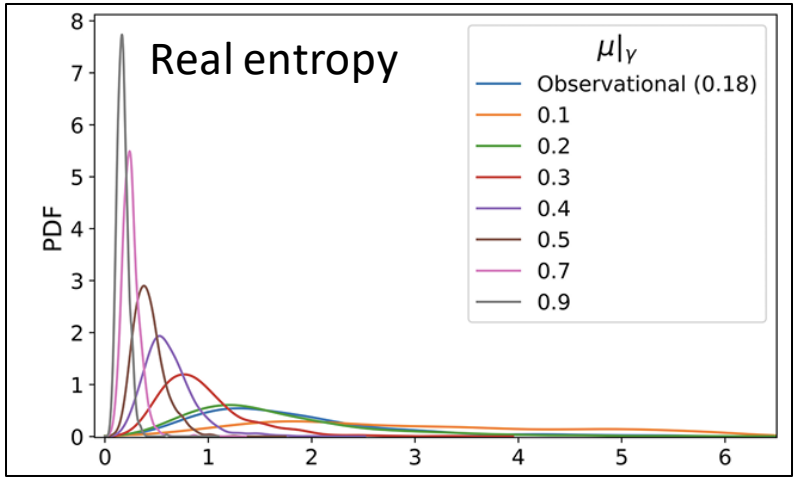
Benchmark Interventional Data Generation



Mobility Data Generation Process



Interventional Data via Causal Intervention

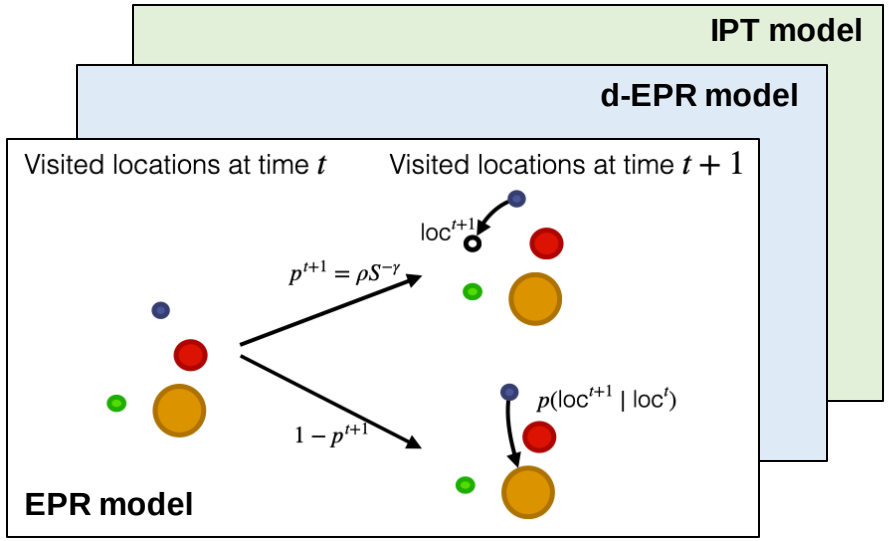


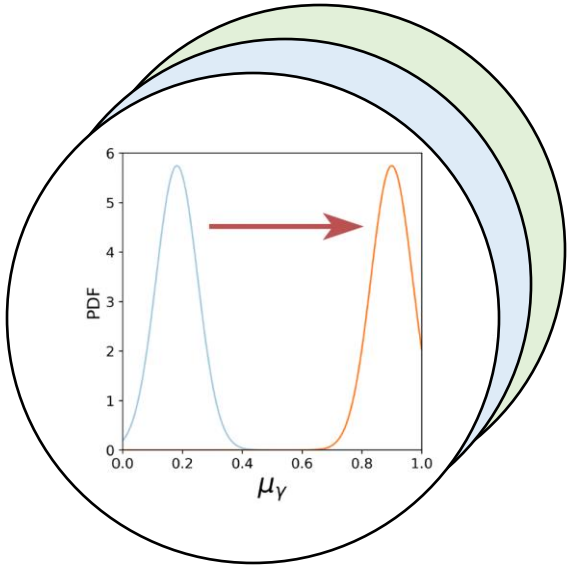
Characterization of Mobility Data Distribution Shifts

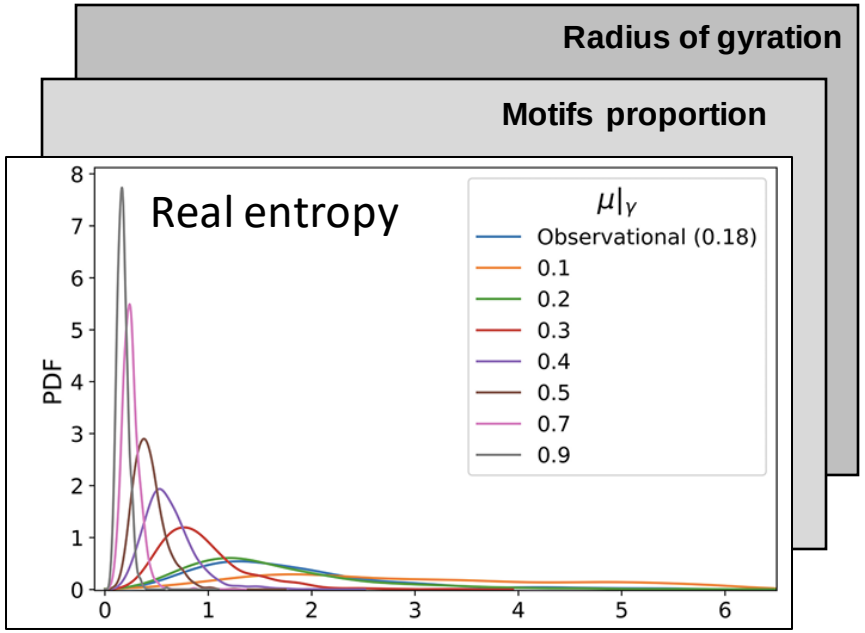
Hong, Y., Xin, Y., Dirmeier, S., Perez-Cruz, F. and Raubal, M., 2023. Revealing behavioral impact on mobility prediction networks through causal interventions. *arXiv preprint arXiv:2311.11749*.

Xin, Y., Tagasovska, N., Perez-Cruz, F. and Raubal, M., 2022, November. Vision paper: causal inference for interpretable and robust machine learning in mobility analysis. In *Proceedings of the 30th International Conference on Advances in Geographic Information Systems* (pp. 1-4).

Benchmark Interventional Data Generation







Mobility Data Generation Process

Interventional Data via Causal Intervention

Characterization of Mobility Data Distribution Shifts

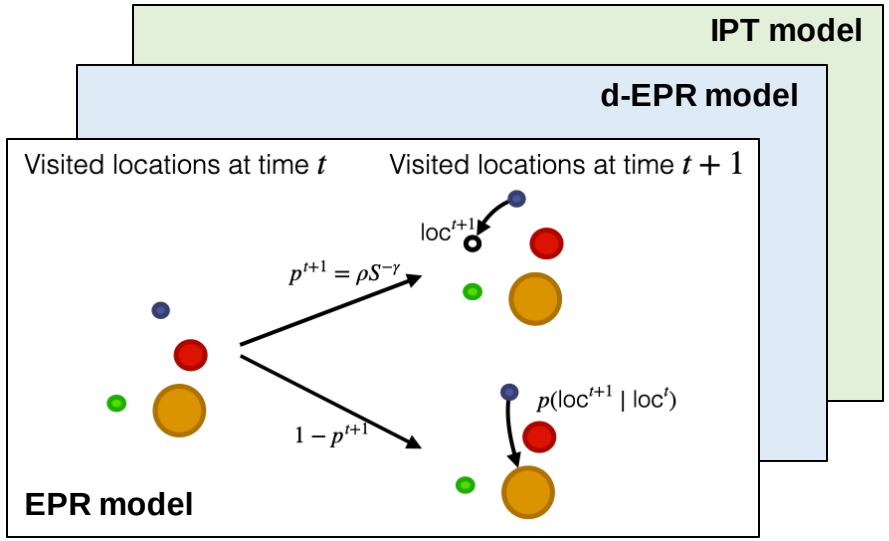
Mobility Simulation [1]

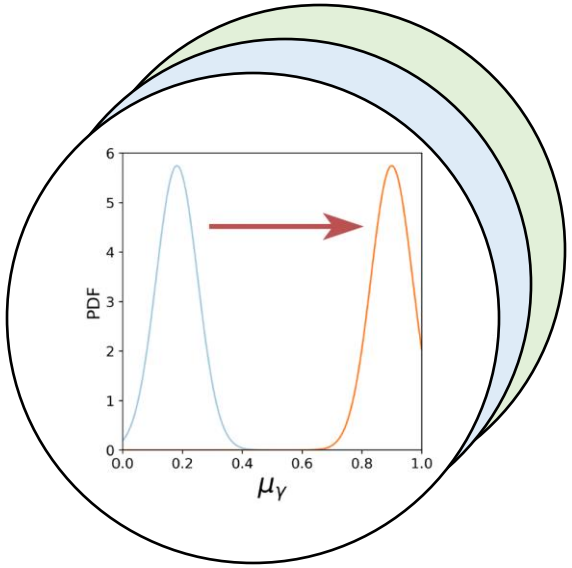
Mobility Metrics [2]

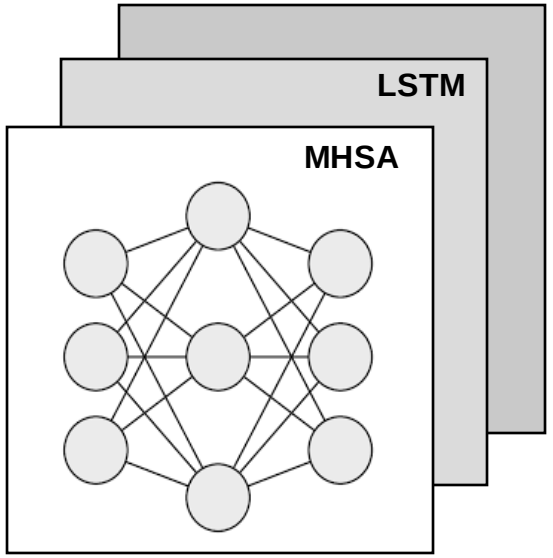
Hong, Y., Xin, Y., Dirmeier, S., Perez-Cruz, F. and Raubal, M., 2023. Revealing behavioral impact on mobility prediction networks through causal interventions. *arXiv preprint arXiv:2311.11749*.

1. https://github.com/irmlma/mobility-simulation
2. https://github.com/irmlma/mobility-metrics

Evaluating Model's Robustness







Mobility Data Generation Process

Interventional Data via Causal Intervention

Performance Evaluation of Prediction Networks

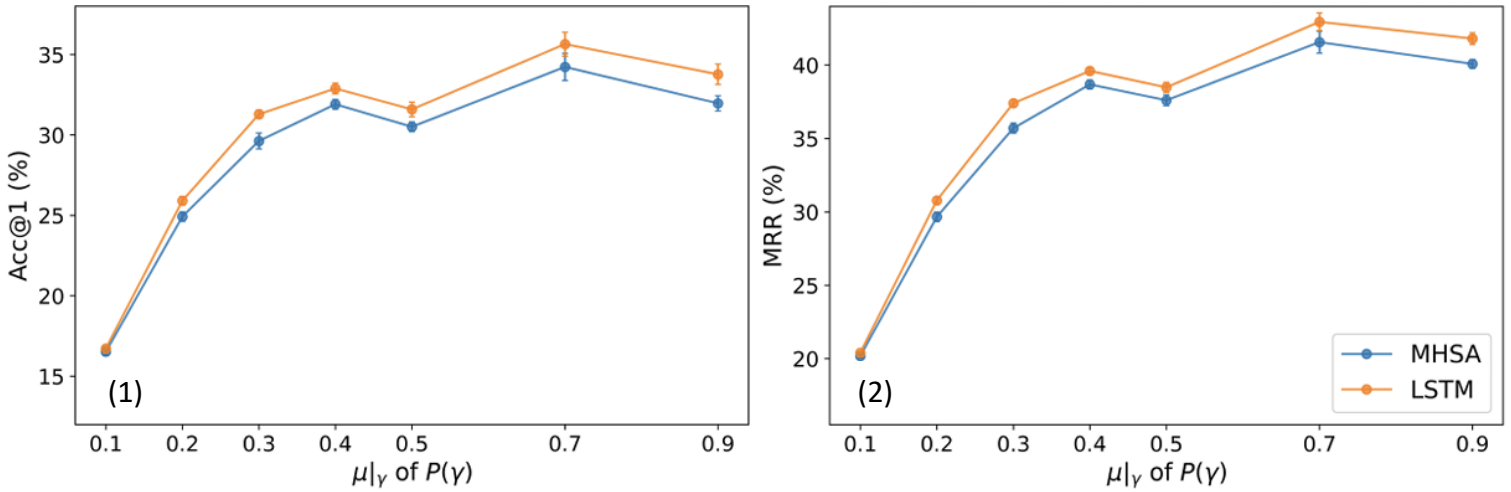
Mobility Simulation [1]

Next Location Prediction [2]

Hong, Y., Xin, Y., Dirmeier, S., Perez-Cruz, F. and Raubal, M., 2023. Revealing behavioral impact on mobility prediction networks through causal interventions. *arXiv preprint arXiv:2311.11749*.

1. https://github.com/irmlma/mobility-simulation
2. https://github.com/irmlma/next-location-prediction

Results of Model Evaluation

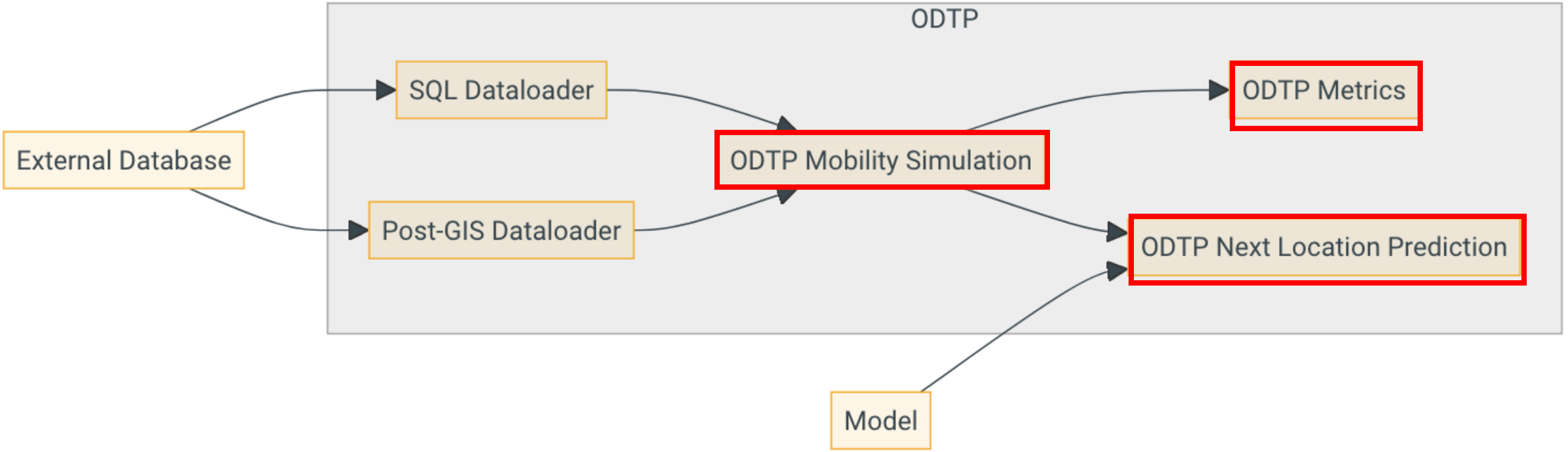


- LSTM model has better generalization ability to OoD data than the MHSA model

Hong, Y., Xin, Y., Dirmeier, S., Perez-Cruz, F. and Raubal, M., 2023. Revealing behavioral impact on mobility prediction networks through causal interventions. *arXiv preprint arXiv:2311.11749*.

Integration with the Open Digital Twin Platform

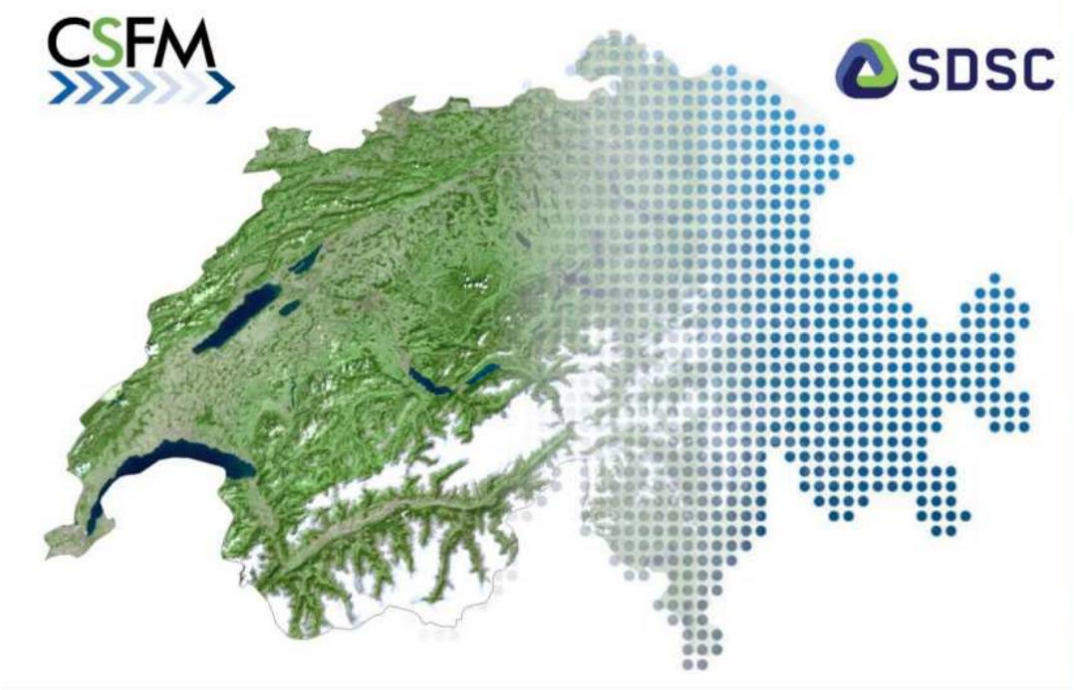
Mobility Causal Intervention Workflow in ODTP



https://odtp-org.github.io/odtp-manuals/usecases/mobility-causal-interventions/

Integration with the Open Digital Twin Platform

1) Support traceability, reusability, inspection, and querying
2) Support access control for sensitive data
3) User-friendly, empowers domain experts and policy makers



The Open Digital Twin Platform (ODTP).

Grübel, J., Vivar Rios, C., Balać, M., Xin, Y., Franken, R.M., Ossey, S., Raubal, M., Axhausen, K.W. and Riba Grognuz, O., 2023, May. "CH on the move": Introducing the Prototype Digital Twin of The Swiss Mobility System. In *Swiss Transport Research Conference*. STRC.

ETH zürich MIE lab

Thank you!

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