TraDWin: An interactive Digital Twin for City Traffic

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Problem: Traffic management and planning

- For given graph, how to do?
  - ❖ Prediction
  - ❖ Imputation
  - ❖ Reassignment on modification
- Why needed?
  - ❖ Data-driven insights
  - ❖ Better planning
  - ❖ Sustainable development

Fig. 1 Dublin road network with sensors

Challenges and issues with existing methods

- Simulation as de-facto way
  - Need OD pairs
- Existing methods
  - Only time-series analysis.
  - No graph modifications
  - Ignore other exogenous factors
    - Weather, road conditions, etc.
- Data collection
- Multiple scenarios

TraDWin: Traffic Digital Twin as Solution

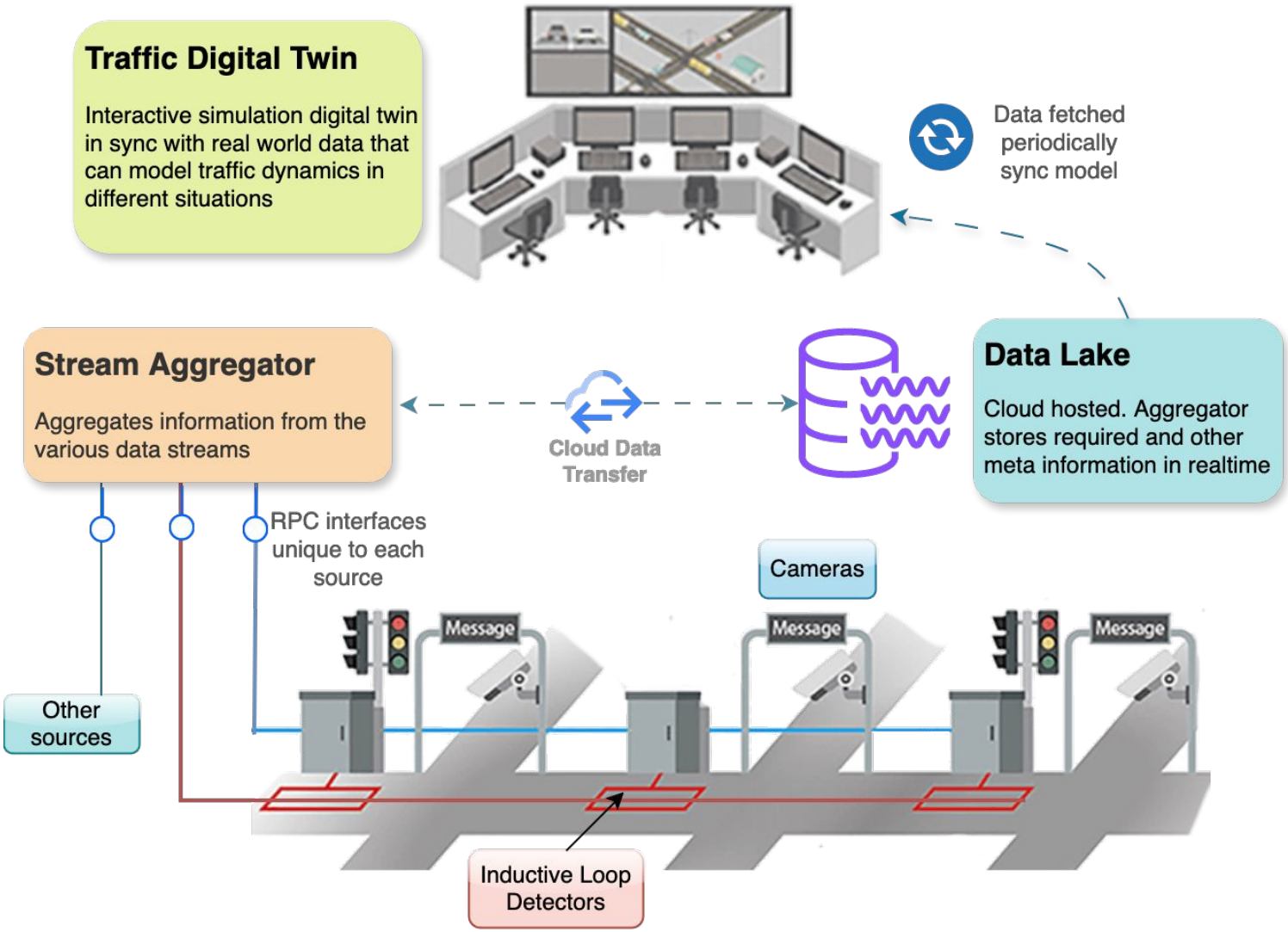


Fig. 2 Traffic Digital Twin overall schematic

Model Architecture: Input features

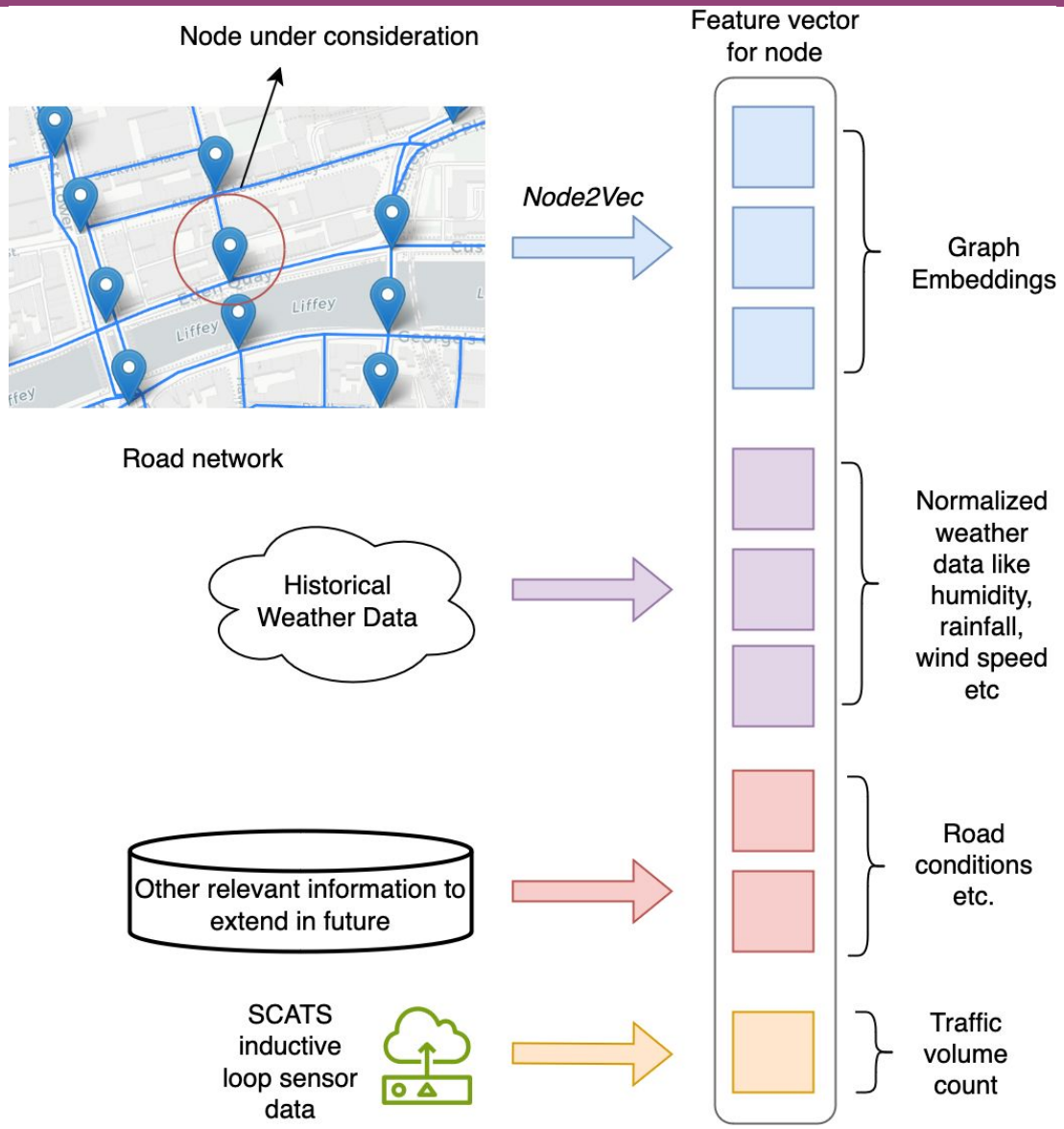


Fig. 3 Traffic Digital Twin overall schematic

Model Architecture

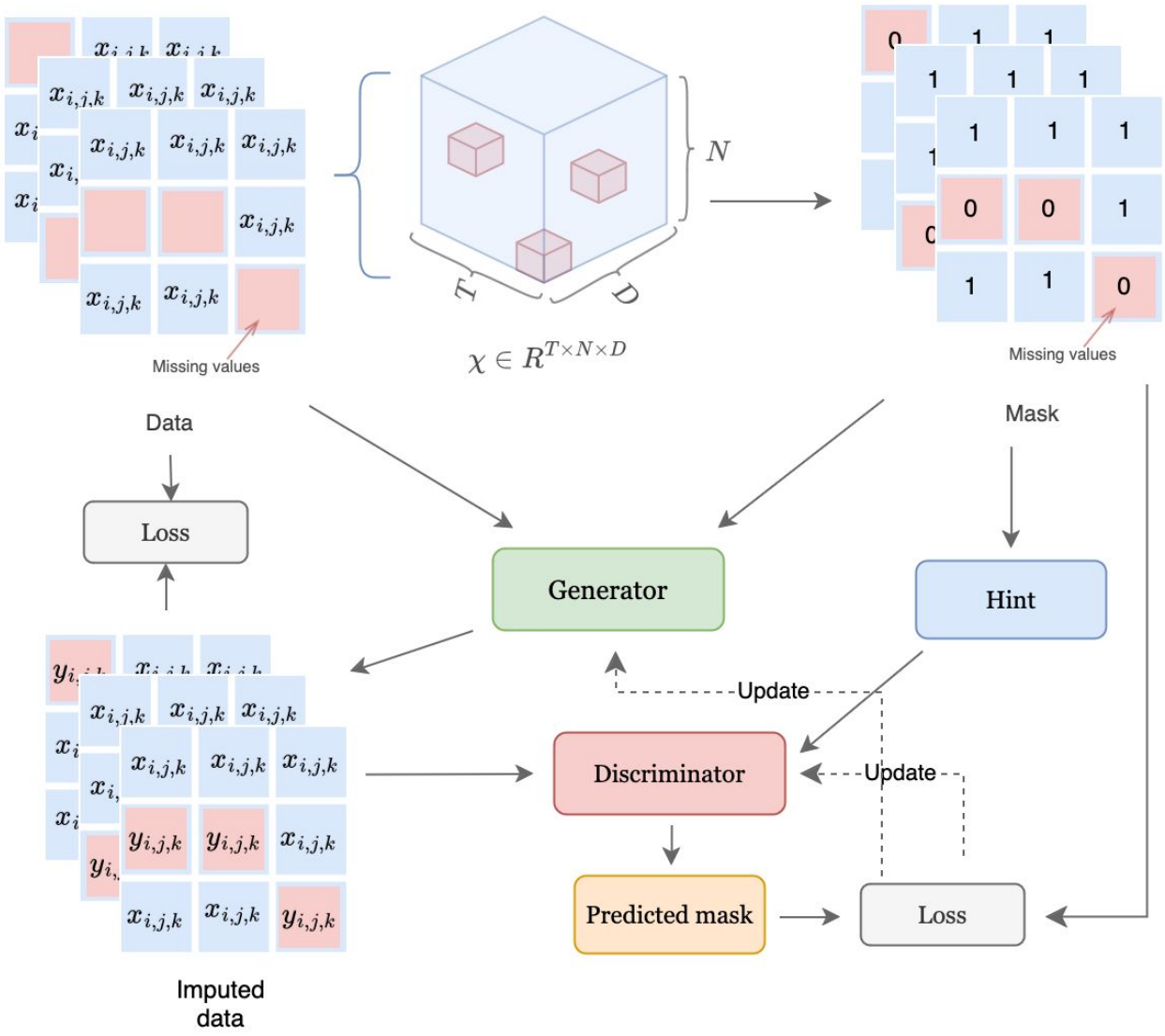


Fig. 4 TraDWin model details

Model Architecture: Conversation loss

- Reassignment on modification
  - MNAR imputation

- *Problem:* Non-conservation on reassignment.

- *Solution:* Biasing using additional conservation loss.

$$\mathcal{L}_{\text{PHY}} = (C - C_0)^2$$

C Total volume of traffic on the modified graph
C_0 Total volume of traffic on the original graph

$$\mathcal{L} = \mathcal{L}_{DL} + \lambda \cdot \mathcal{L}_{PHY}$$

Datasets

1. Dublin SCATS dataset:
   - 3 months (October 1, 2023 to December 31, 2023).
   - 825 sensors
   - Frequency 1 hour.

2. TAPASCologne Simulation Scenario:
   - SUMO simulation scenario

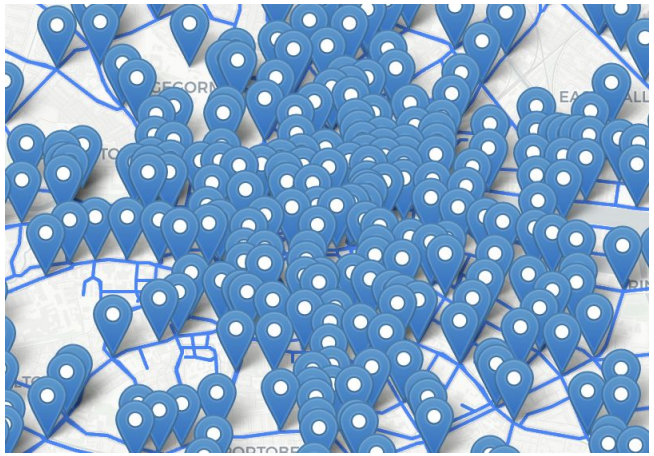


Fig. 5 Dublin city with SCATS sensors

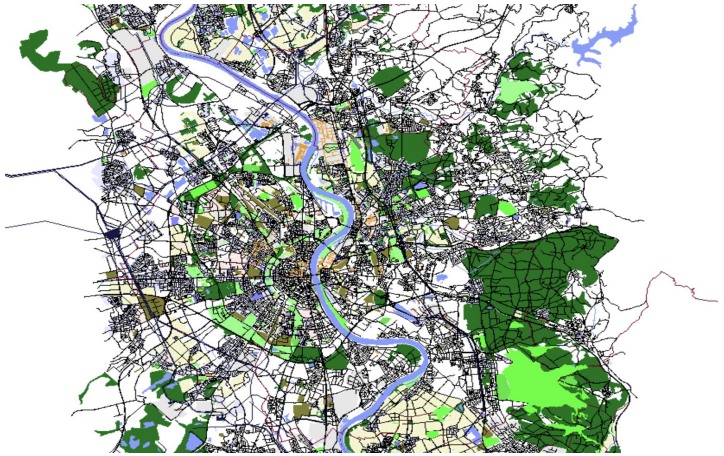


Fig. 6 SUMO TAPASCologne Scenario

Results: Prediction

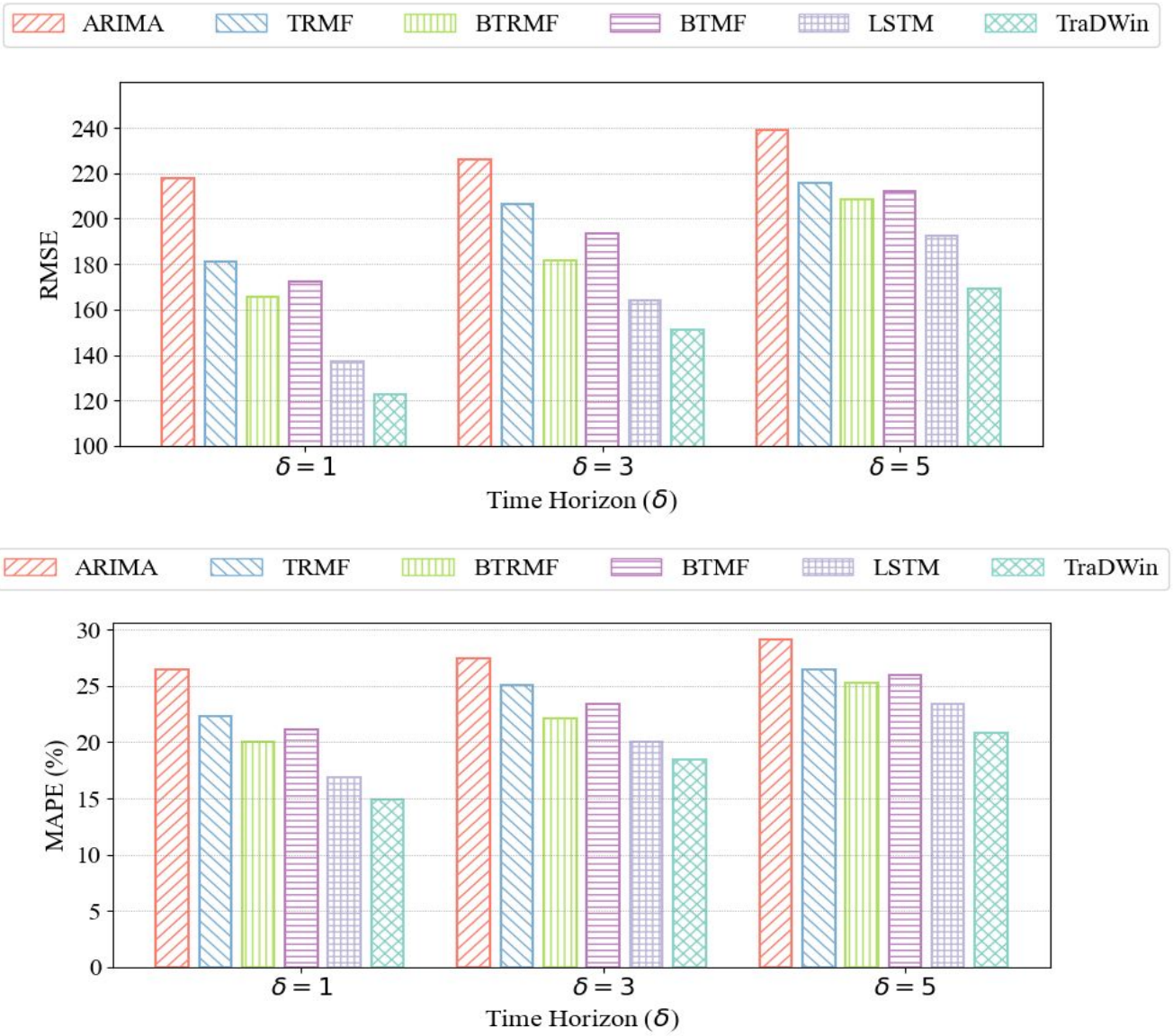
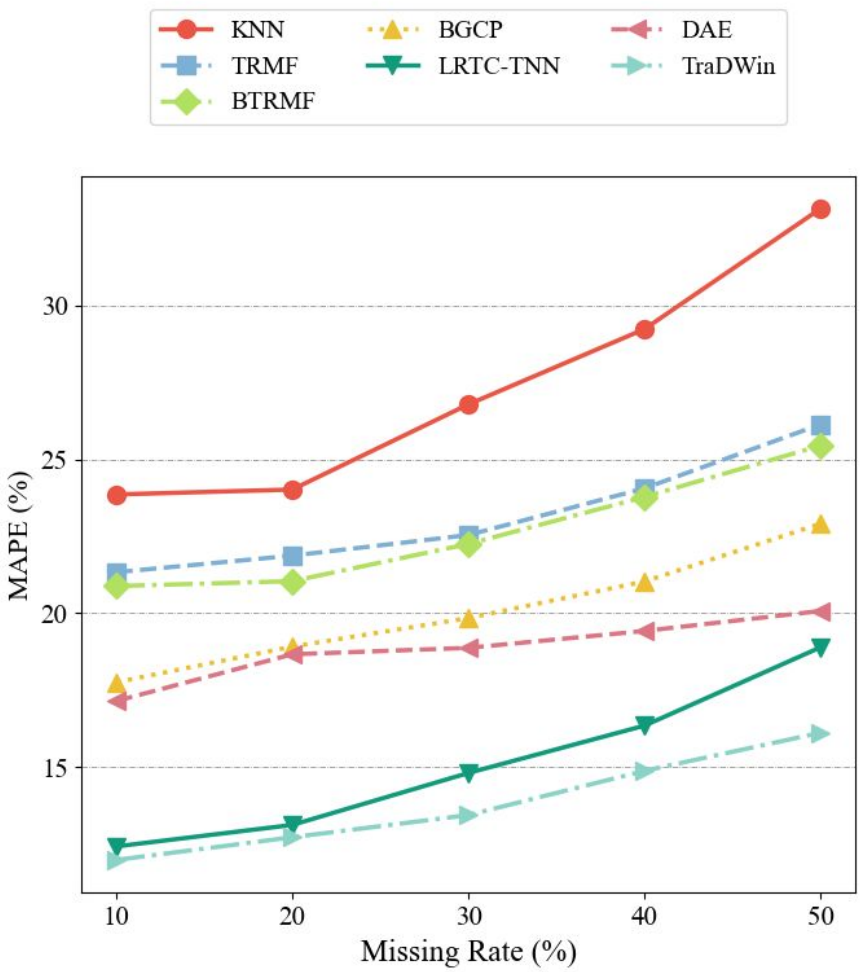


Fig. 7 Performance metrics on prediction task

Results: Imputation



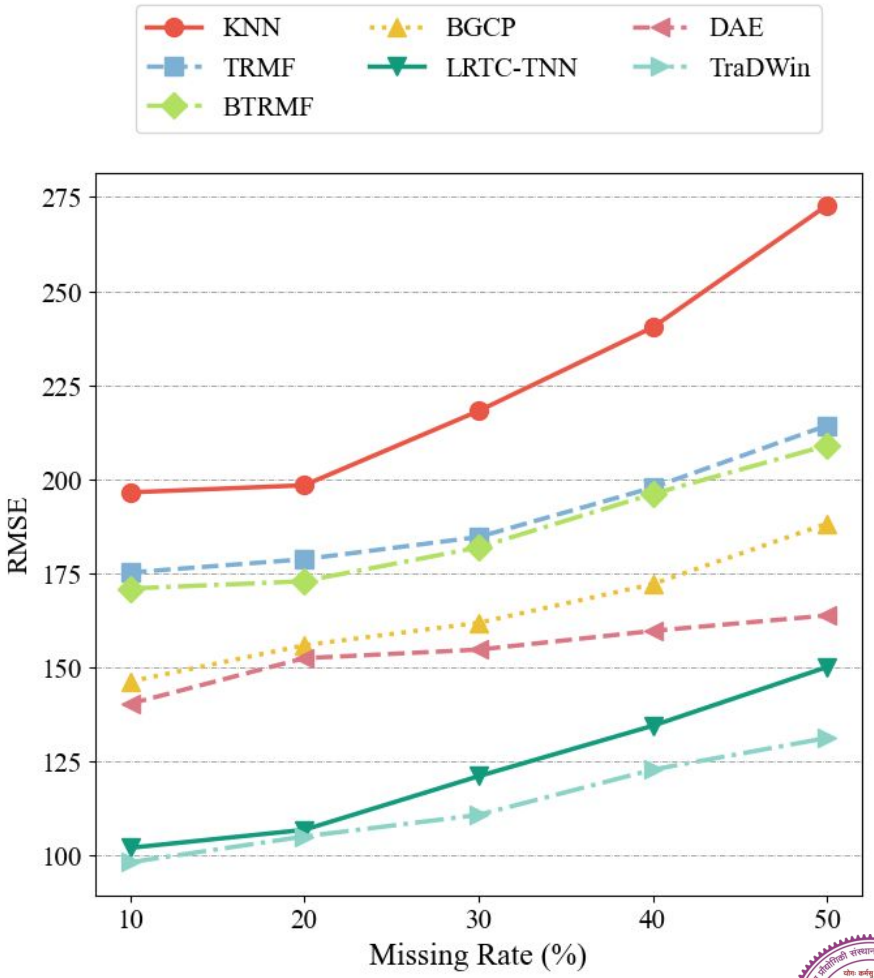


Fig. 8 Performance metrics on imputation task

Results: Re-Assignment on edge modification

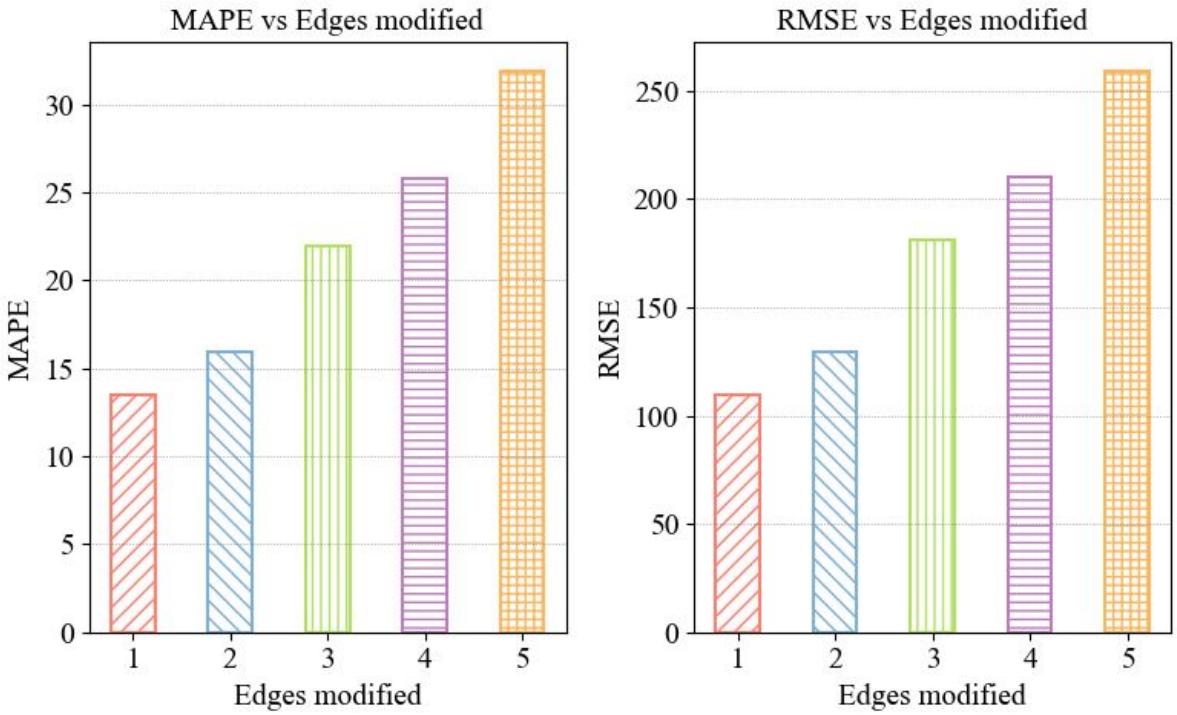


Fig. 9 Performance metrics on re-assignment task

Dataset	MAPE (%)	RMSE
Dublin SCATS	13.47	109.90
TAPASCologne	15.06	23.34

Table 1 Re-assignment metrics on different datasets

Conclusion and Future work

Contributions:

- Digital Twin framework
- Model
- Validation
- Real-world use cases

Future Work:

- Multi-task learning (MTL)