

# Physics-Informed Neural Networks for Traffic Assignment Optimization

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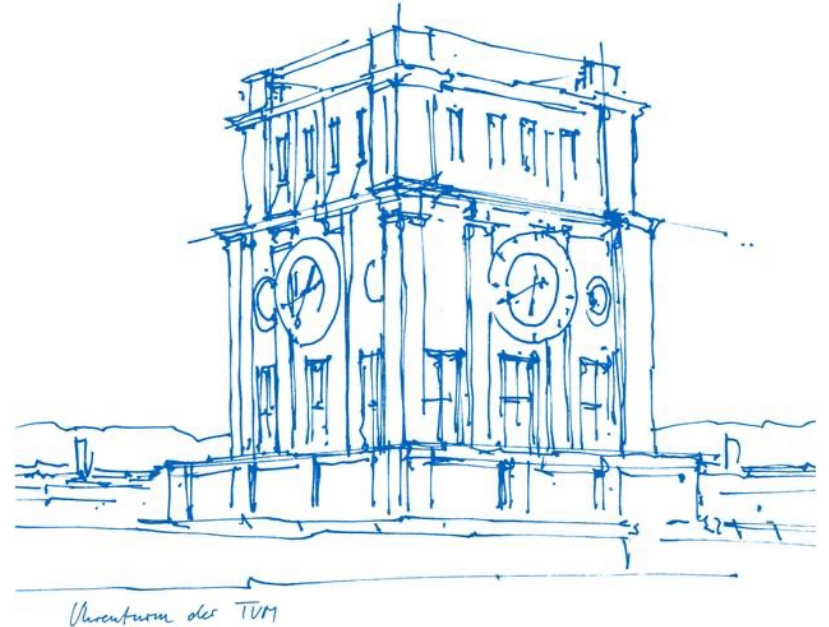
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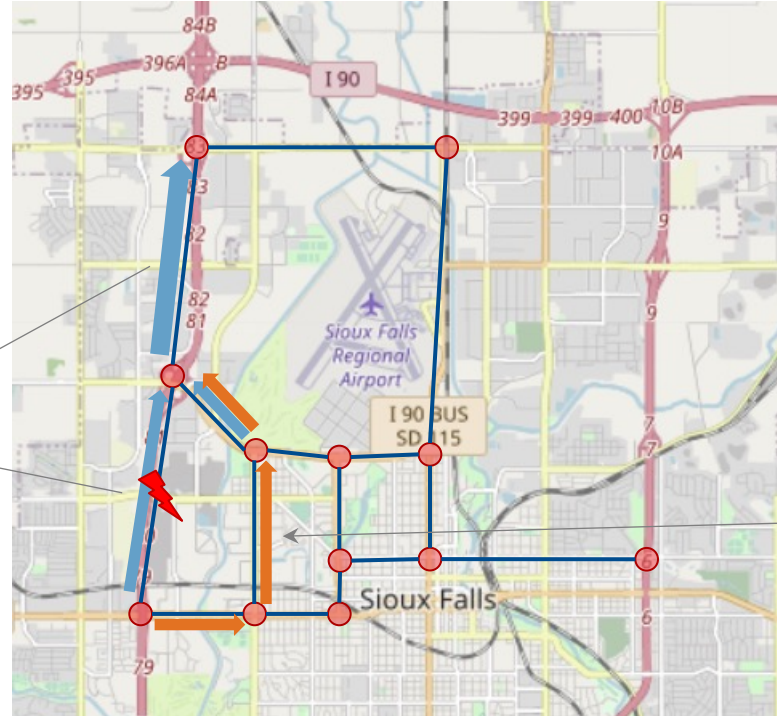
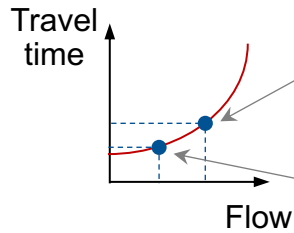
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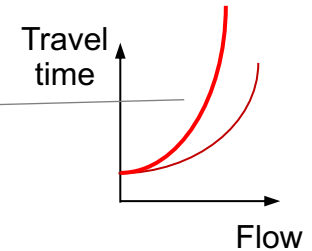
# Problem: Traffic Assignment and Hazard Scenarios

Traffic assignment by user equilibrium optimization



Hazard occurrence reducing road capacity

$$t \cdot \left( 1 + \alpha \left( \frac{\text{Flow}}{\text{capacity} \downarrow} \right)^\beta \right)$$



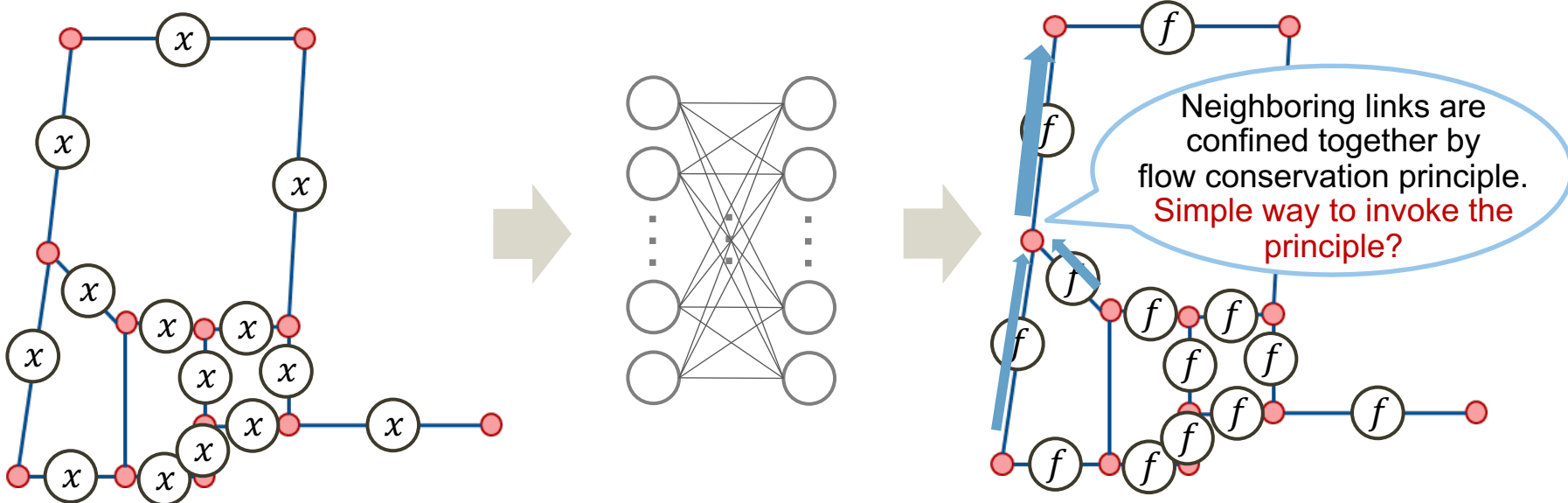
When roads' capacities change, optimization needs to be performed again.

# Rapid Optimization using Neural Networks

Monte Carlo Simulation (MCS) for network reliability analysis

$$\mathbb{E}[f(\mathbf{X})] \approx \frac{1}{N} \sum_{i=1}^N f(\mathbf{x}_i)$$

Neural network – capacities  $x$  and flows  $f$ :



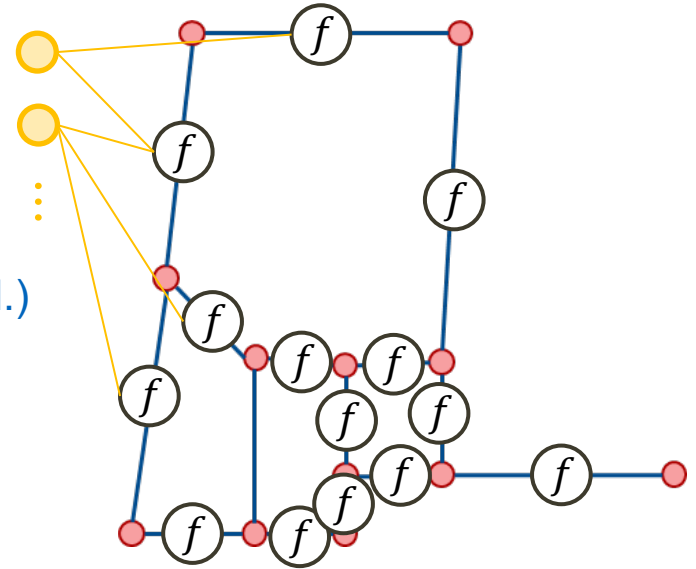
# Proposed Physics-based Neural Networks

Loss function as filters on neighboring links:

$$\|f(x) - \hat{f}(x)\|^2 + \|r(\hat{f}(x))\|^2$$

Prediction error

Residual flows at nodes  
(Ensures physics to be satisfied.)



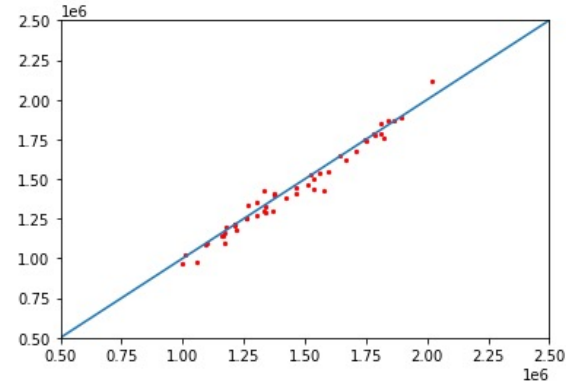
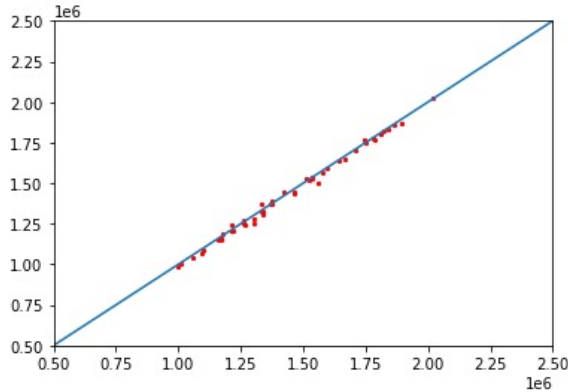
- Enhance extrapolation capability by providing physics-based information
- Enable diagnostics of predictions (i.e., the higher the residual flows, the less credible the prediction is.)

# Results – Total Travel Time Prediction

## Conventional NN

## Proposed PINN

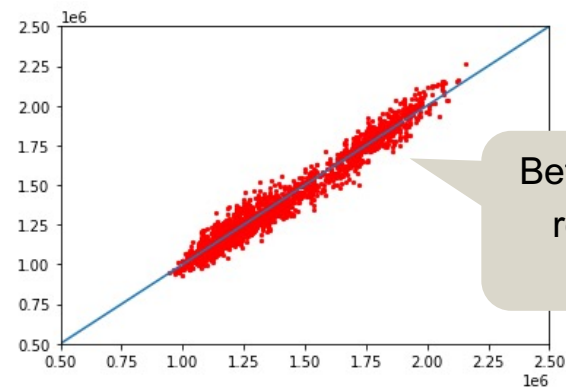
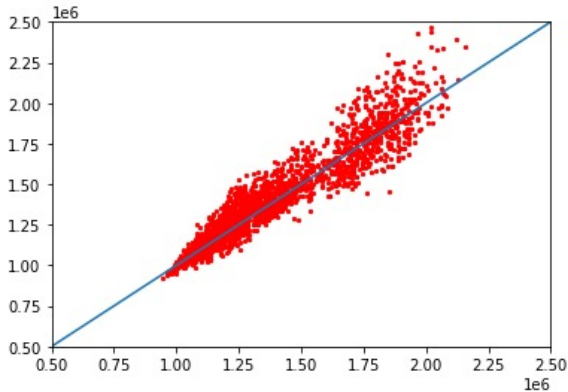
Train



Pred.

True

Test



Better predictions on regions with less training data