

Interdisciplinary Research

Computational Engineering in CEE



Xinyu Chen

Postdoc, MIT (now)

Advisor: Prof. Jinhua Zhao

PhD, University of Montreal ('23)
Civil Engineering (Transportation)

Interests

- Advanced computing for engineering
- Urban system & human mobility
- Data-driven traffic flow modeling
- Climate system monitoring
- Machine learning & data science
- Optimization & math programming

Collaboration w/ CEE, EECS, Stat, Math

PhD (ML for Transportation)

- **Traffic imputation** w/ tensor decomposition
[Chen et al.'19](#); [Chen et al.'21](#) in *Transportation Research Part C* (cited 300+)
- [Chen et al.'22](#) in *IEEE Transactions Intelligent Transportation Systems* (cited 100+)
- [Chen et al.'24](#) in *IEEE Transactions on Knowledge and Data Engineering* (TKDE)
- **Mobility prediction** w/ nonconvex optimization
[Chen & Sun'22](#) in *IEEE Transactions on Pattern Analysis and Machine Intelligence* (TPAMI) (cited 250+)
- [Chen et al.'24](#) in *INFORMS Journal on Computing* (IJOC)
- [Chen et al.'25](#), accepted in *Transportation Science*
- **Dynamic climate pattern discovery**
[Chen et al.'24](#) in TKDE

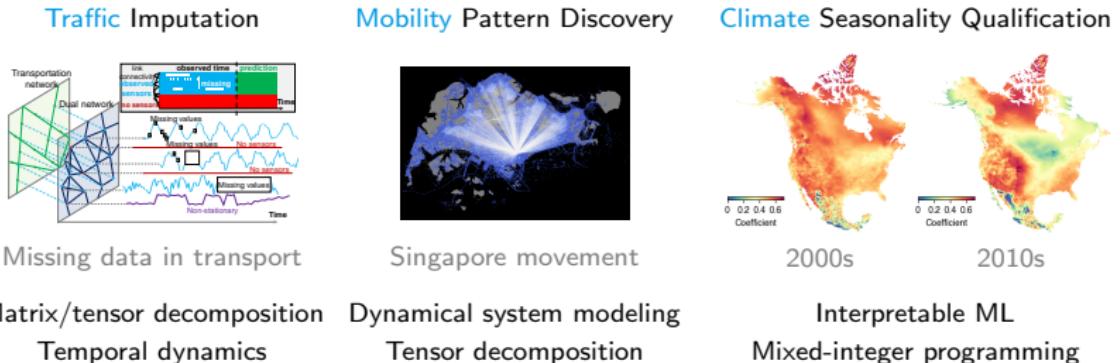
Postdoc (ML + Optimization for Spatiotemporal Data)

- **Tensor decomposition for ML**
[Chen et al.'25](#), major revision in TPAMI
- **Causal inference from climate systems**
[Chen et al.'25](#), 2nd-round review in TKDE
- **Mobility periodicity quantification**
Ready for submission to IJOC

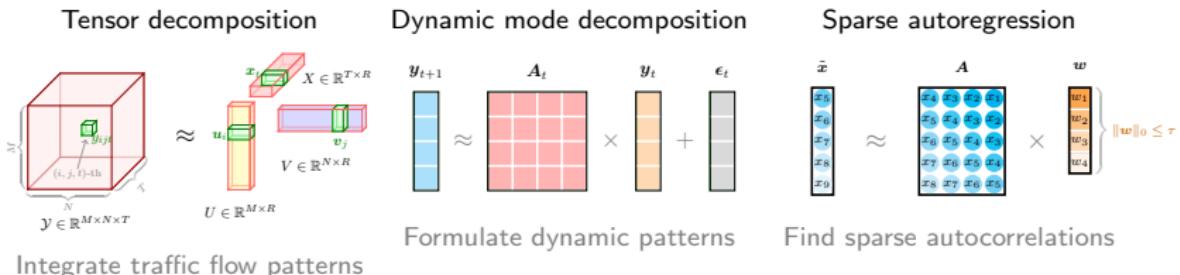


Research Contributions

- Formulating challenging engineering problems (w/ practical contributions)



- Advancing ML development (w/ methodological contributions)



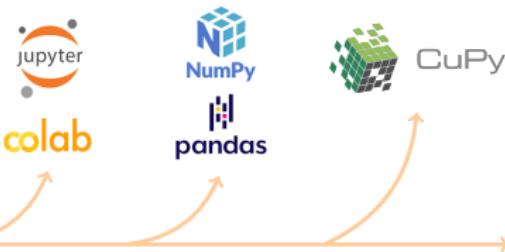
Reproducible Research for Engineering

- The last mile of AI for computational engineering

Human mobility & smart cities
Data-driven transport analytics
Spatiotemporal data modeling
Interpretable ML for causal inference
Tensor decomposition for ML

...

Directions & Topics



Reproducible Research

- Advancing ML development with open-source research



transdim

(1,200+ GitHub stars)

ML for Transport Data Imputation

<https://github.com/xinychen/transdim>

The screenshot shows a search result for 'Tensor Decomposition for Machine Learning' on the MIT Tensor4ML website. The page title is 'Tensor Decomposition for Machine Learning' by Xinyi Chen, Sheng Dongyu, Jiebo Zhou (2021). A brief description follows: 'An overview of the development of tensor decomposition models and algorithms, along with columns on tasks and tensor interpretations, and an tensor decomposition techniques across a wide range of scientific areas and applications.'

Tensor Decomposition for ML

(ML initiative)

Math & ML Tutorials

<https://sites.mit.edu/tensor4ml>



Spatiotemporal Data Modeling

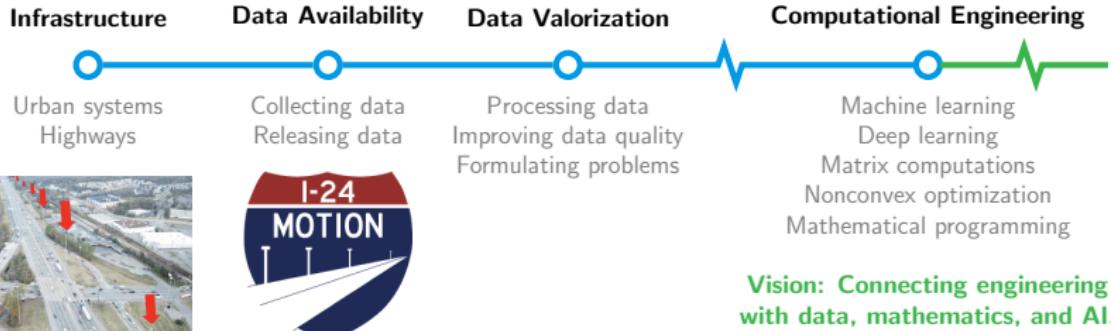
(Data valorization initiative)

Model Development of ML & Data Science

<https://spatiotemporal-data.github.io>

Building Research Impact at Vanderbilt University

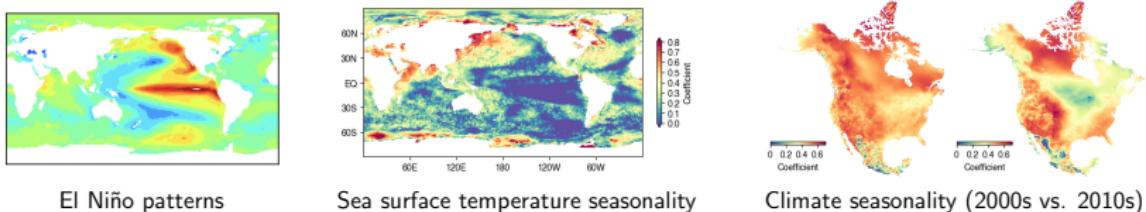
- Contributing to CEE, College of Connected Computing & Data Science Institute



(Source: [arXiv:2311.10888](https://arxiv.org/abs/2311.10888))

Vehicle trajectory

- Contributing to Vanderbilt Center for Sustainability, Energy and Climate



El Niño patterns

Sea surface temperature seasonality

Climate seasonality (2000s vs. 2010s)

- Supervising students: Undergraduate Summer Research Program; Immersion VU; Experience Vanderbilt; Serving for PhD committee
- Research group: Developing ML and optimization in transportation & mobility analytics; Developing innovative AI tools for computational engineering.

Teaching & Grant

• Teaching Interests & Plan at Vanderbilt University

- Formats: Tutorial, data example, LaTeX graphic, Python code, GitHub repository, and course website

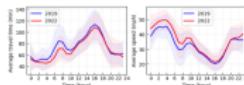


Figure 6. Average travel time and speed from area 32 (i.e., Downtown) to area 76 (i.e., Airport) in both 2019 and 2022.

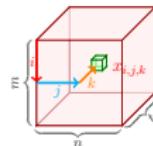
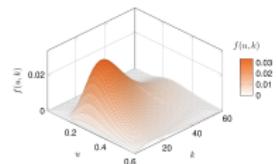
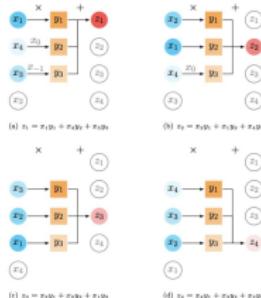
```
import numpy as np
import networkx as nx
import matplotlib.pyplot as plt

# Create a directed graph G
G = nx.DiGraph()
G.add_node('A', pos=(0, 0))
G.add_node('B', pos=(1, 0))
G.add_node('C', pos=(2, 0))
G.add_node('D', pos=(3, 0))
G.add_node('E', pos=(0, 1))
G.add_node('F', pos=(1, 1))
G.add_node('G', pos=(2, 1))
G.add_node('H', pos=(3, 1))
G.add_node('I', pos=(0, 2))
G.add_node('J', pos=(1, 2))
G.add_node('K', pos=(2, 2))
G.add_node('L', pos=(3, 2))

# Add edges with weights
G.add_edge('A', 'B', weight=1)
G.add_edge('B', 'C', weight=1)
G.add_edge('C', 'D', weight=1)
G.add_edge('A', 'E', weight=1)
G.add_edge('E', 'F', weight=1)
G.add_edge('F', 'G', weight=1)
G.add_edge('G', 'H', weight=1)
G.add_edge('A', 'I', weight=1)
G.add_edge('I', 'J', weight=1)
G.add_edge('J', 'K', weight=1)
G.add_edge('K', 'L', weight=1)

# Compute shortest path distances
nx.all_pairs_shortest_path_length(G, weight='weight')

# Print the shortest path between A and L
print(nx.shortest_path(G, 'A', 'L'))
```



Data-Driven Transportation Analytics

Computing Fundamentals in CEE

Spatiotemporal Modeling in CEE

• Grant & Funding



Transit-Centric Smart Mobility System with ML (DOE)

(PI: Jinhua Zhao. Role: Senior Researcher)



Causal inference for congestion pricing (NSF, submitted)

(PI: Jinhua Zhao; Co-PI: Ankur Moitra. Role: Senior Researcher)

