

Interdisciplinary Research

Computational Engineering in CEE



Xinyu Chen

Postdoc, MIT (now)

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

Interests

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

PhD (ML for Transportation)

- **Traffic imputation** w/ tensor decomposition
[Chen et al.'19](#); [Chen et al.'21](#) in TR-C (cited 300+)
[Chen et al.'22](#) in IEEE TITS (cited 100+)
- **Time series imputation** w/ Laplacian convolution
[Chen et al.'24](#) in IEEE TKDE
- **Mobility prediction** w/ Bayesian optimization
[Chen & Sun'22](#) in IEEE TPAMI (cited 250+)
- **Traffic prediction** w/ Hankel factorization
[Chen et al.'24](#) in IJOC
- **Dynamic climate pattern discovery**
[Chen et al.'24](#) in IEEE TKDE

Postdoc (ML + Optimization for Spatiotemporal Data)

- **Tensor decomposition for ML**
[Chen et al.'24](#), major revision in IEEE TPAMI
- **Causal inference from climate systems**
[Chen et al.'24](#), 2nd-round review in IEEE TKDE
- **Mobility periodicity quantification w/ MIP**

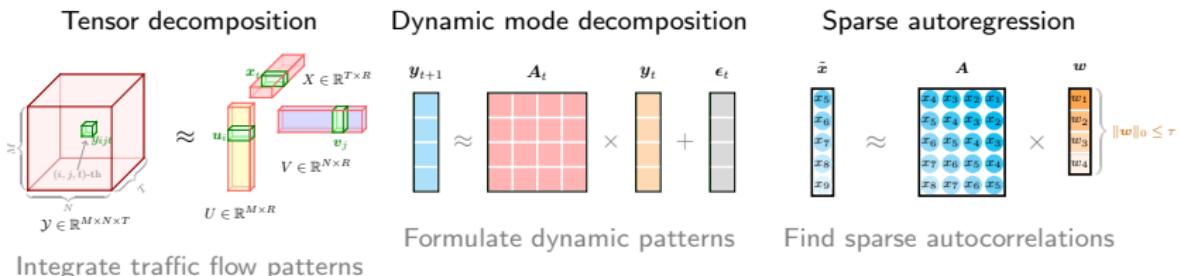


Research Contributions

- Formulating challenging engineering problems



- Advancing ML development with methodological contributions



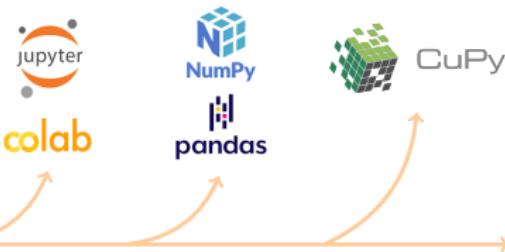
Reproducible Research for Engineering

- 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>



Tensor Decomposition for ML

(ML initiative)

Math & ML Tutorials

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



Spatiotemporal data modeling

(Data science initiative)

Model Development of ML & Data Science

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

Building Research Impact at Vanderbilt

- CEE collaboration
- Initiatives at Vanderbilt
- College of Connected Computing
- Collaboration & possible contributions

Improve I-24 Motion data quality with imputation

Teaching & Grant

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

Figure 2 shows taxi pickup and dropoff trips (2023) on 77 community areas in the City of Chicago. Note that the average trip duration is 1207.75 seconds and the average trip distance is 6.16 miles.



Figure 3 shows taxi pickup and dropoff trips (2019) in the City of Chicago, USA. There are 4,783,661 remaining trips after the data processing.

For comparison, Figure 3 shows taxi pickup and dropoff trips (2019) on 77 community areas in the City of Chicago. Note that the average trip duration is 918.62 seconds and the average trip distance is 3.93 miles.



Figure 3. Taxi pickup and dropoff trips (2019) in the City of Chicago, USA. There are 12,464,672 remaining trips after the data processing. See the data processing codes.

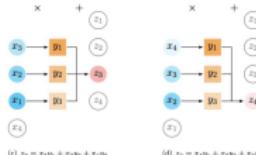
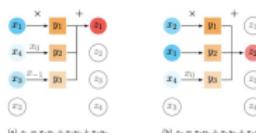
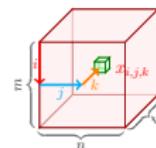
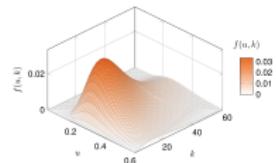


Figure 2. Illustration of the circular convolution between $x = (x_1, x_2, x_3, x_4)^T$ and $y = (y_1, y_2, y_3)^T$.
.. (a) Computing z_1 involves $x_0 = x_4$ and $x_{-1} = x_3$; (b) Computing z_2 involves $x_0 = x_4$. The figure inspired by Prince (2023).



Data-Driven Transportation Analytics

Advanced Computing for CEE

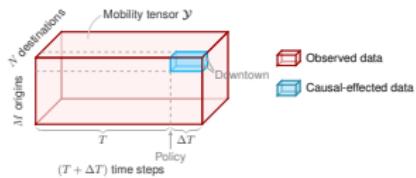
Spatiotemporal Modeling in CEE

- Grant & Funding



Transit-Centric Smart Mobility System with ML

(PI: Jinhua Zhao. Role: Senior Researcher)



Causal inference for congestion pricing (NSF, submitted)

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