Qingtao Cao

Sociotechnical Systems Modeling| Data Science | Network Science| Artificial Intelligence
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ABOUT ME

I am a Sixth-year Ph.D. student in Industrial Engineering at Northeastern University, working with Professor Babak Heydari. As a research assistant in applied disciplines, I am a fast learner, a questions riser, and a solid problem solver with a track record in interdisciplinary research at the cross-section of complex systems modeling, data science, and network science. I like to ask and solve the questions not only about 'HOW to make it works', but also 'WHY it works' to deeply understand the interior logic behind the nonlinear emergence in sociotechnical systems. My vision is to become a scholar in modeling, design, and policy making of complex sociotechnical systems.

EDUCATION

Northeastern University (USA), College of Engineering

- Ph.D. Candidate in Industrial Engineering, MAGICS Lab — GPA: 3.92/4 — 2017 – Current (Expected Apr 2023)
  Advisor: Prof. Babak Heydari
- M.S in Operations Research — 2014 – 2015

South China Normal University (CHN), College of Science

- B.S in Applied Mathematics — 2008 – 2012

RESEARCH PROJECTS

Mobility Networks and Pandemic Analytics (Sponsored by IAPRA) — 2021 – Current

- Used detailed mobility data from SafeGraph/Cuebiq to describe the mobility flow over multi-level networks and analyzed the change of the mobility pattern overtime.
- Predicted the further mobility flow on networks by the Dyadic Regression model and the Graph Neural Network model with demographic data.
- With the addition of the mobility and related network data, the accuracy of the prediction of the weekly Covid confirmed cases is increased by 10% using the multivariate linear regression model.
- Computer Software Applied: *Python, SQL, AWS, Discovery (Neu Cloud computational system)*

Learning Platforms: Adaptive Competition using Deep Reinforcement Learning (Sponsored by NSF) — 2021 – 2022

- Used the Deep learning Approach to solve the new challenge of the platform's governance caused by multi-level interactions between agents in the experimental complex ecosystem.
- By using Deep Reinforcement Learning (DRL), the AI platform can learn a high-performance dynamic adaptive policy to compete with another platform in a multi-sided market.
- By modularizing the strategy action space, the learned policy by DRL revealed the interpretability and, furtherly, be inferred to enhance performance of the heuristic policy of humans by 30%.
- Computer Software Applied: *Python, Pytorch*

Micro-level Social Contact Structures and the Success of COVID-19 National Policies — 2020 – 2021

- Created an explainable epidemic model based on a new algorithm that transforms national-average data on micro-level social interaction into a small-scale social network.
- Integrated top-down (National Policies) and bottom-up (Micro-level Social Contact) factors to show how the interaction of these two factors leads to the differences in the success rate of containing the pandemic between countries by the simulation model.
- Apart from the explainability, our model showed a high predictive power with a below 10 % average error of 10 target countries only using a few national-average, un-calibrated data.
- Using national-average, un-calibrated data made our model computationally more efficient, thus our model is suitable to be used in counterfactual analysis and policy scenario studies.
- Computer Software Applied: *Python, R, Discovery (Neu Cloud computational system)*

Modeling Competition between multi-sided platforms with bounded-rational users (Sponsored by NSF) — 2018 – 2021

- Combined customers' behavior theories (e.g., bounded rationality) and the dynamic game theory to mathematically model the price competition between platforms on a multi-sided market.
- We proved that even in the presence of cross-sided network effects, the "winner-takes-all" nature of multi-sided platforms can be replaced by the possibility of multiple equilibria.
- Figured out the structure of the platform's local optimal price, consisting of the magnitude of the network effect and the customers' rationality level, in the equilibrium of the competition.
- Computer Software Applied: *Python*

JOURNAL PUBLICATIONS

1. **Cao, Q.**, & Heydari, B. (2022). Micro-level social structures and the success of COVID-19 national policies. ***Nature Computational Science***, 2(9), 595-604.
   Press Coverage by *Nature News & Views*, *MedicalXpress*, and *Northeastern News*
2. Chou, C. A., **Cao, Q.**, Weng, S. J., & Tsai, C. H. (2020). Mixed-integer optimization approach to learning association rules for unplanned ICU transfer. *Artificial Intelligence in Medicine*, 103, 101806
3. **Cao, Q.**, & Heydari, B. Mobility Networks and Pandemic Analytics: How much can we gain by using complex network models? Manuscript submitted to *Scientific Report.*
4. **Cao, Q.**, Chen, Q., Heydari, B. Adaptive Recommender Systems for Competing Platforms: Incorporating Consumers' Behavioral Response Using Deep Reinforcement Learning. Manuscript submitted to *IEEE Transactions on Engineering Management.*
5. Chatterjee, A., **Cao, Q.**, Sajadi, A., & Ravandi, B. From NetLogo Modeling of Deterministic Random Walk to the Identification of Asymmetric Saturation Time in Erdos-Renyi Graphs. Manuscript submitted to *Applied Network Science*.
6. **Cao, Q.**, Heydari, B., Lorè, N. Breaking the Myth of Natural Monopoly: Platform Competition with Myopic Behavior. Working paper— manuscript available per request.
7. **Cao, Q.**, Heydari, B. How openness the platform needs to be? Innovation and Competition in the multi-sided platform. Working paper— manuscript available per request.

PEER-REVIEWED CONFERENCE PRESENTATIONS

- **Cao, Q.**, & Heydari, B. Micro-level Social Structures and the Success of COVID-19 National Policies. 8th International Conference on Computational Social Science (*IC2S2, 2022*). Chicago, IL.
  (The acceptance rate for the oral presentation is ~ 20%)
- Qu, H., **Cao, Q.**, Gong, M., Heydari, B. Platform Jumping: Network Analysis of How Political Memes Seeded on Reddit Diffuse to Twitter. 8th International Conference on Computational Social Science (*IC2S2, 2022*). Chicago, IL.
- **Cao, Q.**, Chen, Q., Heydari, B. Learning Platforms: Adaptive Competition Using Deep Reinforcement Learning. 8th International Engineering Systems Symposium (*CESUN, 2021*). Charlottesville, VL.
  (The acceptance rate for the oral presentation is ~ 25%).
- **Cao, Q.**, & Heydari, B. Design and Governance of Platform Systems. *CESUN 2021 Virtual Staying in Touch Event*, online

INDUSTRY EXPERIENCE

Operations Coordinator, 4Excelsior Inc, Los Angeles, USA — 2016 – 2017

- Managed the inventory to satisfy the demand for manufacturing and operation activities.
- Reported directly to the COO for daily operations and assisted the COO to design the standard of process in the warehouse.

Financial Analyst Assistant (Internship), E Fund Management Co., Ltd. Guangzhou, China — Summer 2015

- Collected the information and data of the domestic market and the global stock market, and then reported it to the senior financial analysts.
- Assisted senior financial analysts to predict the stock price by the regression model.

RESEARCH FOCUS AND SKILLS

- **Research Focus**: Complex Sociotechnical Systems Modeling and Simulation (Multi-sided platforms System, Sharing Economy, and Epidemiology), Data Science, Network Science and Artificial Intelligence
- **Analytical Skills:** Complex System Modeling (Epidemic, Economic and Human-Behavior), Mathematical closed-form solving, Data Analysis, Generalized Linear Models, Machine Learning, Network Analysis, Multi-Agents Simulation, Bayesian Inference, Deep Reinforcement Learning and Optimization
- **Computer software**: Python, PyTorch, R, SQL, AWS, NetLogo and AMPL
- **Language:** English (fluent), Cantonese (native), Mandarin (native)

HONORS AND AWARDS

- Outstanding Graduate Research Award, College of Engineering, Northeastern University, 2022