# Xinyu Wu

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## EDUCATION

**Massachusetts Institute of Technology, Laboratory of Information and Decision System (LIDS)** Sep. 2018-Present

- **Ph.D. in Aeronautics and Astronautics & Interdisciplinary Doctoral Program in Statistics (IDPS)**
- **Ph.D. Advisor:** Eytan Modiano **GPA**: 5.0/5.0
- **Research Interest:** Network Robustness, Control, and Optimization
- **Courses:** Introduction to Linear Programming; Data Networks; Inference and Information; Statistical Communication and Localization Theory; Fundamentals of Probability; Statistical Learning Theory and Applications; Reinforcement Learning: Foundations and Methods; Mathematical Statistics; Introduction to Functional Analysis

**Shanghai Jiao Tong University, Electronic Engineering** (GPA**:** 93.0/100, Rank 1/168) Sep. 2014-Jun. 2018

- **Courses:** C++ Programming (99); Data Structure (95); Algorithm & Complexity (94); Wireless Communication & Mobile Networks (99); ARM Embedded System & its Experiments (94)
- **Thesis**: Theoretical Analysis and Algorithm Design for Social Network De-anonymization (A+, Outstanding Thesis, top 1%)

**Shanghai Jiao Tong University, Mathematics (minor)** (GPA**:** 95.4/100, Rank 1/26) Feb. 2016-Jun. 2018

- **Courses:** Advanced Algebra (98); Probability and Statistics (99); Stochastic Process (93); Numerical Analysis (93); Ordinary Differential Equation (99); Real Analysis (96)
- **Thesis**: Study of Planar Interpolation Polynomial (A)

## PUBLICATIONS

- **Xinyu Wu**, Dan Wu, Eytan Modiano, "Overload Balancing in Switched Networks with Finite Buffers", submitted to *IEEE International Conference on Computer Communications (INFOCOM) 2022*.
- **Xinyu Wu**, Dan Wu, Eytan Modiano, "An Ordinary Differential Equation Framework for Stability Analysis of Networks with Finite Buffers", submitted to *IEEE 60$^{th}$ Conference on Decision and Control (CDC)*.
- **Xinyu Wu**, Dan Wu, Eytan Modiano, "Predicting Failure Cascades in Large Scale Power Systems via the Influence Model Framework", *IEEE Transactions on Power Systems*, vol. 36, no. 5, pp. 4778-4790, 2021.
- **Xinyu Wu**, Dan Wu, Eytan Modiano, "An Influence Model Approach to Failure Cascade Prediction in Large Scale Power Systems", *the 2020 American Control Conference (ACC)*, Denver, USA, Jul. 1$^{st}$-3$^{rd}$, 2020.
- **Xinyu Wu**, Xiaohua Tian, Xinbing Wang, "Large-scale Wireless Fingerprints Prediction for Cellular Network Positioning'', *IEEE International Conference on Computer Communications (INFOCOM)*, Honolulu, USA, Apr. 15$^{th}$-19$^{th}$, 2018.
- Xiaohua Tian, **Xinyu Wu**, Hao Li, Xinbing Wang, "RF Fingerprints Prediction for Cellular Network Positioning: A Subspace Identification Approach'', *IEEE Transactions on Mobile Computing*, vol. 19, no. 2, pp. 450-465, 2019.
- **Xinyu Wu**, Zhongzhao Hu, Xinzhe Fu, Luoyi Fu, Xinbing Wang, Songwu Lu, "Social Network De-Anonymization with Overlapping Communities: Analysis, Algorithm, and Experiments", *IEEE International Conference on Computer Communications (INFOCOM)*, Honolulu, USA, Apr. 15$^{th}$-19$^{th}$, 2018.

## RESEARCH EXPERIENCES

**Overload Balancing in Switched Networks with Finite Buffers | MIT** Oct. 2020 – Jul. 2021

- We showed that the backpressure policy, which is known to achieve the most balanced queue overloading for networks with unbounded buffers, does not balance the overload in networks with finite buffers.
- We proved that a policy combining maxweight scheduling with backpressure can achieve the most balanced overloading in switched networks, with either sufficient and limited transmission capacity, through a new quadratic optimization framework to capture overload balancing and a novel differentiable characterization of the policy.
- We verified by simulation that the proposed policy is effective in overload balancing under stochastic packet arrival.

**Queue Overloading Prevention in Finite-Buffer Communication Systems | MIT** Sep. 2019 – Sep. 2020

- We proved a sufficient condition for local transmission policy to avoid queue overloading in single-commodity finite-buffer network systems, based on an ordinary differential equation (ODE) model to characterize the queuing dynamics.
- We showed that the above condition can be served as a general criterion to propose policies to avoid queue overloading, for example: policy based on backpressure; policy based on buffer occupancy.
- We extended the sufficient condition to multi-commodity systems with either sliced or shared queue buffers, and further

quantified the negative effect of finite buffer over queue overloading prevention over single-hop networks.

**Failure Cascade Prediction and Analysis in Network Systems | MIT** Nov. 2018 - Sep. 2019

- We characterized the failure cascade process in power systems by the influence model (IM), and proposed a hybrid learning scheme to train IM. First, we applied a Monte-Carlo approach to quickly acquire the pairwise influence between any two transmission links; Then we formulated a quadratic programming to obtain the weights of each pairwise influence; Finally we proposed an adaptive threshold estimation and selection scheme to better predict cascade processes.
- We tested our prediction mechanism based on the 1354-bus, 2383-bus, and 3012-bus systems provided by IEEE in Matlab MATPOWER Toolbox, under DC and AC flow. Our mechanism could predict the final state of each link within 10% error rate, final failure size within 7% error rate, and failure time within 2 time units generally, with at most 3.4% of all possible initial link contingencies as training samples and two magnitudes faster in prediction than the flow calculation method.
- We proposed an efficient way to identify the most critical initial contingency that can lead to large failure range based on the learned influence model with $O(n^2)$ time in a parallelable way, where prior works cost at least $O(n^{2.373})$..
- We implemented Logistic Regression (LR) in Matlab and LSTM by Tensorflow for comparison, and showed prediction accuracy: LSTM > IM≈LR, while our IM-based approach was much more efficient and could further unveil useful network properties, including remote failure propagation and critical transmission links in the systems, compared with LR and LSTM.
- Python Code for LSTM: https://github.com/xinyuwusjtu/FailureCascadePredictionLSTM.

**Social Network De-Anonymization | SJTU** Mar. 2017 - May. 2018

- We intended to identify anonymized users by another correlated public social networks, based on the Minimum Mean Square Error criterion. We showed its NP-hardness, and then derived an approximated alternative to this problem via the restriction by Sequence Inequality, with the approximation ratio at most 2. We then proposed a convex-concave based algorithm to solve the problem, and showed that overlapping communities in social networks can enhance de-anonymization accuracy.
- We further unveiled that the network symmetry, including intra-network and inter-network symmetry, fundamentally determines the de-anonymizability. We further derived the de-anonymizable region for Erdos-Renyi model, Power Law model, and Stochastic Block model, mainly by probability and matrix theory. Results of all cases echoed our claim based on the Microsoft Academic Graphs with at most 2000 nodes.

**Large-Scale Wireless Fingerprinting Prediction and Localization | SJTU** Sep. 2016 - Mar. 2017

- We intended to do outdoor localization based on limited samples of wireless signal strength from different base stations, termed as ‘fingerprints’. We modeled the fingerprint prediction as a matrix completion problem, and proposed a Stiefel-manifold based algorithm for prediction based on Singular Value Decomposition and QR Decomposition.
- We further designed a sliding-window mechanism to overcome the sparsity of fingerprints that solely gathered on main roads in real situations, by means of firstly applying our method in small windows around main roads, and gradually percolating to the whole region with larger windows as more fingerprints had been predicted.
- We reconstructed the fingerprints in a $69.8km^2$ region in Ningbo, China, and showed that 71% and 98% users can respectively be localized within an error of 100m and 300m, triumphing over the accuracy of Cell-ID and Gaussian Mixture Model approaches, and achieving E911’s requirements: “within 100m for 67% and 300m for 90%.”

## HONORS & AWARDS

- MIT AeroAstro MathWorks Fellowship, awarded to students with strong experiences with MathWorks products 2021
- Oge Ho-Ching and Han-Ching Fund Award Fellowship, MIT 2021
- Outstanding Bachelor’s Thesis Award, top 1%, highest honor of undergraduate thesis in SJTU 2018
- Outstanding Winner (INFORMS Award), Mathematical Contest of Modeling (Problem C), only 1 in all 4748 teams 2018
- Shanghai Honorable Graduate, ~10% of all senior students in SJTU 2018
- IEEE INFOCOM Travel Grant, only for student presenters in INFOCOM 2018

## COURSE PROJECT

**Cipher Breaking using Markov Chain Monte Carlo**, Course 6.437: Inference and Information, MIT. Apr. 2019

- I implemented Metropolis-Hasting MCMC algorithm to identify the cipher function over 28 characters (a-z, space, comma), and tested on the ciphertext with length more than 10,000 characters.
- I utilized the bisection method and examined the abrupt drop of likelihood function to identify the possible breakpoint, at which the cipher function changed, in the ciphertext.
- Python Code and Technical Report: https://github.com/xinyuwusjtu/MCMC_decipher

## TEACHING EXPERIENCE

**Teaching Assistant**, Course 16.36/16.363: Communication Systems & Networks, MIT. Spring 2020

- I constructed problem sets including modulation, channel coding, ARQ, CSMA, etc., and exams.

**Teaching Assistant**, Course CS214: Algorithm and Complexity, SJTU. Spring 2018

- I formulated problem sets for Greedy Algorithm, Amortized Analysis, Graph Algorithm, Turing Machine, and Approximation Algorithm, and exams.
- I prepared course slides about Linear Programming and Simplex Algorithm.
- Course Website: http://anl.sjtu.edu.cn/gao-xf/course/CS214-2018

## ACADEMIC SERVICES & ACTIVITIES

- Reviewer
  - *Discrete Mathematics, Algorithms and Applications (DMAA)*
- External Reviewer
  - *IEEE/ACM Transactions on Networking (ToN)*
  - *IEEE Transactions on Network Science and Engineering (TNSE)*
  - *IEEE International Conference on Computer Communications (INFOCOM)*