Fang Liu

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Education

Aug. 2014 - 2019 (Expected)	Ph.D. in Electrical and Computer Engineering at The Ohio State University, Columbus, OH, 43202, USA **Overall GPA:** 4.0/4.0
Sep. 2010 - Jul. 2014	B.S. in Information Engineering at Dept. of Electronic Engineering Shanghai Jiao Tong University (SJTU), P. R. of China **Overall GPA:** 92/100 **Major GPA:** 94/100 **Rank:** 3/223

Research Interests

I am interested in **statistics** and **machine learning**, with a focus on **online learning**. In particular, I have studied several variants of the **Multi-Armed Bandit** model, a fundamental framework to describe sequential resource allocation tasks. I adopt the "theory-based design" approach to strive for solutions, with provable performance guarantees, to the real world applications, including recommendation systems, online advertising and energy-efficient systems.

Publications

- **Fang Liu**, Zizhan Zheng, Ness Shroff, "Analysis of Thompson Sampling for Graphical Bandits Without the Graphs", *The Thirty-Fourth Conference on Uncertainty in Artificial Intelligence (UAI)*, 2018.
- **Fang Liu**, Sinong Wang, Swapna Buccapatnam, Ness Shroff, "UCBoost: A Boosting Approach to Tame Complexity and Optimality for Stochastic Bandits," *The Twenty-Seventh International Joint Conference on Artificial Intelligence (IJCAI)*, 2018.
- **Fang Liu**, Swapna Buccapatnam, Ness Shroff, "Information Directed Sampling for Stochastic Bandits with Graph Feedback," *The Thirty-Second AAAI Conference on Artificial Intelligence (AAAI)*, 2018.
- **Fang Liu**, Joohyun Lee, Ness Shroff, "A Change-Detection based Framework for Piecewise-stationary Multi-Armed Bandit Problem," *The Thirty-Second AAAI Conference on Artificial Intelligence (AAAI)*, 2018.
- Joohyun Lee, **Fang Liu**, Ness Shroff, "iMUTE: Energy-optimal Update Policy for Perishable Mobile Contents," *The 25-th IEEE International Conference on Network Protocols (ICNP)*, 2017.
- Sinong Wang, **Fang Liu**, Ness Shroff, "Non-additive Security Games," *The Thirty-First AAAI Conference on Artificial Intelligence (AAAI)*, 2017.
- Swapna Buccapatnam, **Fang Liu**, Atilla Eryilmaz, Ness Shroff, "Reward Maximization Under Uncertainty: Leveraging Side-Observations on Networks," *Journal of Machine Learning Research (JMLR)*, 2018.
- **Fang Liu**, Zhiyong Chen, Bin Xia, "V2V Data Dissemination with Network Coding in Two-Way Road Networks," *IEEE Transactions on Vehicular Technology (TVT)*, 2016.

Research Activities

Information Processing Systems Lab (IPS), OSU Aug. 2014 - Present

Research topic: **Multi-armed Bandit, Online Learning**
Advisors: ***Prof. Zizhan Zheng and Prof. Ness Shroff***
Jan. 2018 - Mar. 2018 **Sampling for Bandits on Graphs**

- Considered stochastic multi-armed bandit problems with graph feedback, where the decision maker is allowed to observe the neighboring actions of the chosen action. We allowed the graph structure to vary with time and the graph structure is never fully revealed to the decision maker.
- Presented a novel analysis of Thompson Sampling that leads to tighter performance bound than our preliminary work. We established a Bayesian regret bound for TS that scales with the independence number of the graph instead of the number of actions if the graphs are undirected.
- Proposed new variant of Thompson Sampling that actively explores the graph structure. Even in the directed graphs, we established a Bayesian regret bound for the proposed policy that scales with the independence number of the graph instead of the number of actions.

Accepted for publication in UAI 2018.

Research topic: **Multi-armed Bandit, Boosting**
Advisors: ***Dr. Swapna Buccapatnam and Prof. Ness Shroff***
Jul. 2017 - Jan. 2018 **Boosting for Bandits**

- Considered the open problem of finding low-complexity and near-optimal multi-armed bandit algorithms for sequential decision making problems. We proposed a boosting approach to Upper Confidence Bound based algorithms for stochastic bandits, that we call UCBoost.
- Proposed one type of UCBoost algorithm that ensembles a finite number of UCB algorithms, called UCBoost(D). We showed that UCBoost(D) enjoys $O(1)$ complexity for each arm per round as well as regret guarantee that is $1/e$-close to the optimal lower bound.
- Proposed another type of UCBoost algorithm that ensembles an infinite number of UCB algorithms, called UCBoost(ϵ). We showed that UCBoost(ϵ) enjoys $O(\log 1/\epsilon)$ complexity for each arm per round as well as regret guarantee that is ϵ-close to the optimal lower bound.

Accepted for publication in IJCAI 2018.

Research topic: **Multi-armed Bandit, Online Learning**
Advisors: ***Dr. Swapna Buccapatnam and Prof. Ness Shroff***
Aug. 2016 - Jun. 2017 **Sampling for Bandits on Graphs**

- Considered stochastic multi-armed bandit problems with graph feedback, where the decision maker is allowed to observe the neighboring actions of the chosen action. We allowed the graph structure to vary with time and consider both deterministic and Erdős-Rényi random graph models. For such a graph feedback model, we first presented a novel analysis of Thompson sampling that leads to tighter performance bound than existing work.
- Proposed new Information Directed Sampling based policies that are graph-aware in their decision making. Under the deterministic graph case, we established a Bayesian regret bound for the proposed policies

that scales with the clique number of the graph instead of the number of actions.
- Under the random graph case, we provided a Bayesian regret bound for the proposed policies that scales with the ratio of the number of actions over the expected number of observations per iteration.

Accepted for publication in AAAI 2018.

Research topic: **Change Detection, Online Learning**
Advisors: ***Dr. Joohyun Lee and Prof. Ness Shroff***
Aug. 2015 - Jan. 2017 **Algorithms for Non-stationary Bandits**

- Considered piecewise-stationary multi-armed bandit problems, where the distributions of the actions may change over time. We proposed a change-detection based framework, which uses the change detection algorithms to monitor the actions and restart the bandit algorithm once there are alarms. We provided theoretical guarantees for regret performance of the framework with any change detection algorithms.
- We studied CUSUM algorithm, an optimal change detection algorithm, and modified it for the bandit setting. Then, we proposed CUSUM-UCB, with the best known regret performance guarantee in the state of the art.
- Under experiments on both synthetic data and real world data, our algorithm CUSUM-UCB outperforms all the existing algorithms.

Accepted for publication in AAAI 2018.

Research topic: **Markov Decision Process, Data-driven Optimization**
Advisors: ***Dr. Joohyun Lee and Prof. Ness Shroff***
Aug. 2015 - Jan. 2017 **Optimal Updates for Social Apps**

- Mobile applications that provide ever-changing information such as social media and news feeds applications are designed to consistently update their contents in the background. However, such updates often result in the unwanted side-effect of draining the battery of mobile devices.
- We developed an optimal strategy to update the contents in the background under a given energy constraint. The key challenge is to predict when the user will access the contents in a probabilistic manner from the statistics of the accessed patterns in the past. We proved that our iMUTE algorithm converges superlinearly to the optimal solution of the constrained Markov decision process under a mild condition.
- We also experimentally verified that iMUTE outperforms the periodic policy as well as the additive and multiplicative increase policies that are adopted in the Doze mode of Android systems and HUSH, in terms of user experience and energy saving.

Accepted for publication in ICNP 2017.

Research topic: **Game Theory**
Advisor: ***Prof. Ness Shroff***
Co-Author: ***Sinong Wang***
Aug. 2015 - Aug. 2016 **Non-additive Security Games**

- Investigated a general security game where the utility function is defined on a collection of subsets of all targets, and provided a novel theoretical framework to show how to compactly represent such a game, efficiently compute the optimal (minimax) strategies, and characterize the complexity of this problem.
- Appiled our theoretical framework to the network security game. We characterized settings under which we find a polynomial time algorithm for computing optimal strategies. In other settings we prove the problem is NP-hard and provide an approximation algorithm.

Accepted for publication in AAAI 2017.

Research topic: **Multi-armed Bandit, Online Social Networks**
Advisors: ***Dr. Swapna Buccapatnam and Prof. Ness Shroff***
Aug. 2014 - Aug. 2016 **Stochastic Multi-armed Bandit with Side Observations**

- Generalized a framework for stochastic multi-armed bandit problem with side observations. The structure of the side observations can be described by a general bipartite graph between actions and base-arms.
- Proposed a general version of epsilon-greedy algorithm, epsilon-LP, for the bandit problem. Analyzed the expected performance upper bound of the algorithm.
- Proposed a general version of Upper Confidence Bound, UCB-like algorithm, that is UCB-LP, for the bandit problem. Analyzed the expected performance upper bound of the algorithm.

Accepted for publication in JMLR.

Selected Honors

Scholarships

- UAI-18 Scholarship 2018
- AAAI-18 Scholarship 2018
- Litton Fellowship 2014
- First Prize of SCSK Corporation Scholarship (Top 4%) 2013
- Academic Excellence Scholarship of SJTU (Top 5%) 2012, 2013
- Dongshi Dongfang Scholarship (Top 2%) 2012
- National Scholarship (**Highest Scholarship Honor**) (Top 1%) 2011

Awards

- Merit Student of Shanghai Jiao Tong University 2013
- First Prize of Physics Olympic Contest in China 2011

Skills

Program languages: C/C++, JAVA, XML, MATLAB, VHDL, LabVIEW, Python
Developing experience: Android with Eclipse, Xilinx Spartan3E, Digilent Nexys3 with ISE, EDA with MAX+Plus II, NI MyDAQ with LabVIEW, ARM Cortex M3, ad hoc network on Linux.

The above lists the developing experience for my undergraduate study. Since 2014, I have been using MATLAB and Python for my research.