CPS:CAREER: Co-Design of Information and Incentives in Societal-Scale Cyber-Physical Systems

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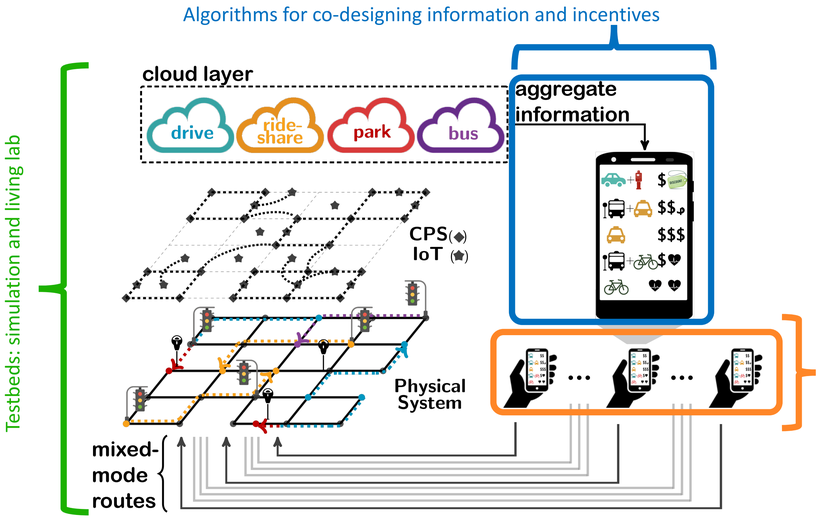
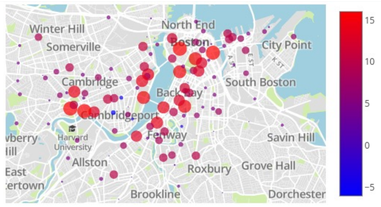


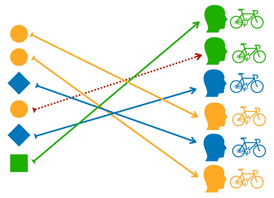
Aim 1: Algorithms for Learning in SCPS.

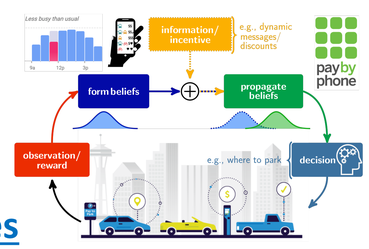
Objective: develop foundational models, and algorithms to learn them, that capture the decision-making processes of humans in the SCPS loop.

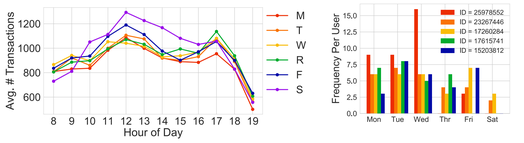
Challenge: human decision makers are integral parts of SCPS. Their decision-making processes are dynamic and depend on external inputs. Humans are also not completely rational. Fairness and bias mitigation are important aspects to consider but challenging to address.

Current work: Introduction of a novel differential approach to bounded rationality which is amenable to computation [1]. Develop platform for experimentally validating bounded rationality models. Undergraduate researchers are working on the data and platform management including IRB status.









Aim 2: Co-Design of Information & Incentives

Objective: algorithmic mechanisms for shaping information and objectives of decision-makers with the goal improving performance while avoiding unexpected outcomes.

Challenge: information asymmetries, modeling and predicting unintended consequences, developing measurable fairness and efficiency criteria.

Current work: regret guarantees for algorithmic incentive design with budget constraints and bandit feedback and where agents' types are dynamic and depend on the actions taken (i.e. incentives offered).

Selected Results:

- **Adaptive Incentive Design with Budget Constraints.** Regret guarantees for online incentive design under bandit feedback for matching budget constrained incentives to users with testing on bike-share supply and demand matching, and algorithms for online ranking [2,3].
- **Active Learning:** algorithms with theoretical regret guarantees and which can be leveraged for determining the most informative locations to sample groundtruth data given budget constraints[5]
- **Provable Convergence Guarantees for learning in competitive settings:** first global convergence guarantees to game theoretically meaningful equilibria in nonconvex-PL zero-sum games, and local convergence in general nonconvex zero-sum games [6,7]

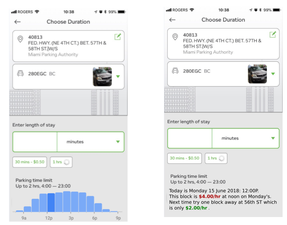


Fig. user behavior is context dependent, e.g., time of day or day of week [4]; can use this in contextual bandit algorithms for exploration of space of "information messages"

Aim 3: Simulations & Living Labs

Objective: validation and testing via three tiered approach: (Tb.1) high-fidelity simulation environment built on data-informed models, (Tb.2) interactive lab constructed on top of the simulation platform for assessing policy performance, and (Tb.3) living labs (UW campus and in the city of Seattle).

Current work: with industry partner (IDAX) and Seattle DoT, designing experiments to test active learning algorithms for conducting targeted studies to estimate on-street parking occupancy in Seattle; building simulation environments based on data from city and industry partners to test incentive and information mechanisms, as well as simulate policy changes.

Impact: SDOT has now adopted a data-informed model-based (e.g.,[4]) for occupancy which it uses to set parking policy including prices as opposed to basing decisions based on single-day samples once per year.

Undergraduate Research

- Development of an experimental platform for assessing bounded rationality models;
- Data visualization tools to help SDOT and other transportation authorities visualize parking and bus data

Broader Impact: Girls in Research Labs

Starting with the development of modules for the Early Engineering Institute at UW, this project seeks to develop an intensive project-driven summer program for middle/rising high school girls. UW STARS (program for under-represented students in CoE) will act as mentors.

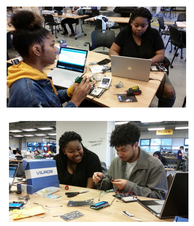


Fig. UW STARS students Kiana Peterson, Grace Kariuki, Teven Stanley

Selected Products

[1] Chasnov, B., Fiez, T., Ratliff, L.J. Opponent Anticipation via Conjectural Variations. NeuRIPs Workshop, 2019.

[2] Fiez, T., Sekar, S., Zheng, L., Ratliff, L. Combinatorial Bandits for Incentivizing Agents with Dynamic Preferences, UAI, 2018.

[3] Fiez, T. Shah, N, Ratliff, L. A SUPER* Algorithm to Determine Orderings of Items to Show Users, UAI 2020

[4] Fiez, T., Ratliff, L.J. Data-Driven Spatio-Temporal Analysis of Curbside Parking Demand, IEEE Transactions on Intelligent Transportation Systems, 2019.

[5] Fiez, T., Jain, L., Jamieson, K., Ratliff, L. Sequential Experimental Design for Transductive Linear bandits, NeurIPS 2019

[6] Fiez, T. Ratliff, L.J., Mazumdar, E., Narang, A. Faulkner, E. Global Convergence to Minmax Equilibria in Nonconvex Zero-Sum games, under review NeurIPS 2021

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