CAREER: Reliable Machine Learning and Decision-Making in Feedback Systems

Sarah Dean

Overview

Machine learning (ML)-enabled algorithms play an important role in social and economic life. In settings ranging from social media to music and video streaming, ML is pushed beyond the paradigm of static prediction towards dynamical and interactive decision-making problems. It is crucial to consider the emergent effects of feedback between ML, decisions, and the broader world; both to mitigate unintended consequences and to achieve better performance.

Social, behavioral, and economic dynamics are not easily described by universally accepted models. To some extent, this challenge can be addressed by the use of data and ML. However, advances are necessary to apply tools from areas like control theory, system identification, and reinforcement learning. At the lowest level, individual decisions must be made on the timescale of seconds despite high dimensional feature and decision spaces (e.g. ranking). Here, the dynamics are largely driven by the stochasticity of user populations. On longer timescales, feedback effects become more prevalent, for example due to strategic behaviors or opinion formation. This proposal introduces a plan for grappling with the challenge of dynamics on both timescales: developing theory and algorithms for ML and decision-making interactive and feedback-laden settings.

Intellectual Merit

The proposed work will grapple with these challenges along two fronts:

1. Low-level control algorithms for high dimensional feature and decision spaces (e.g. ranking). Leverage the approximate stationarity, but incorporating long term objectives. Paradigm of online optimization and bandit algorithms.
2. Detecting and steering long term dynamics and feedback effects. Leverage longer timescales and lower dimensional abstractions for system identification and causal inference, to learn dynamics, and simple planning algorithms, to achieve overall platform goals.

Developing low level control algorithms will require intellectual contributions on bandit and online optimization algorithms in realistic settings; on developing a general constraints/optimization framework for fairness and bias; on advancing and applying bandit and other online algorithms to real problems and datasets; drawing connections between feedback control like PID and the systems that we study. Especially robust, uncertain, and adaptive control.

For the high level, system identification with finite sample guarantees and nonlinear systems is an active area of research; most works are focused on physical systems where there is considerable controllability and few constraints on choosing inputs to excite the system; in contrast many online platforms make small only perturbations and perform binary A/B tests. Consequently is is likely that it will not be possible to identify full parameters of models; on a spectrum with the other end being estimating a causal effect and effect size.

Broader Impacts

Many real platforms in different domains from music to news to social media. Also electricity, mobility. Currently many algorithms operate out of control. Better serve long term needs of users and other stakeholders. Ethics and bias. Coupled with a broadening participation initative designed to make algorithmic decisions, in appications like personalized recommendation, more broadly accessible to community members and groups. K-12 education and undergraduate research.