

Dynamic Causal Mediation Analysis for Micro-Randomized Trials

Fall 2026 Departmental Seminar

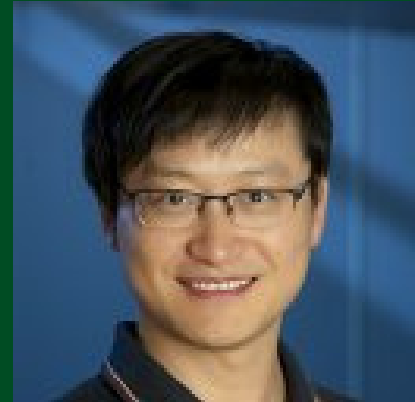
Thursday, October 15th

9:00 am

Engineering Rm E105

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Abstract

Mobile health (mHealth) interventions aim to deliver real-time, personalized behavioral support based on the premise that prompts lead to short-term behavior changes, which in turn drive long-term health benefits. Verifying this premise empirically requires causal mediation analysis, but applying it to micro-randomized trials (MRTs), where individuals are randomized hundreds of times, poses two key challenges: (1) many treatment occasions (e.g., 210 decision points in the HeartSteps MRT with only 37 participants), making it difficult to define and model causal effects on an end-of-study outcome; and (2) many potential mediators, since a single treatment may influence the outcome through all future mediators, complicating the decomposition into interpretable pathways. We address these challenges by introducing natural direct and indirect excursion effects, which use marginal contrasts to define the causal effect of each treatment occasion on a distal outcome and focus mediation on the most immediate mediator following each treatment time. This captures the most scientifically meaningful pathways in mHealth (prompt $\rightarrow$ immediate behavioral target $\rightarrow$ long-term health goal) while improving the plausibility of causal identification assumptions. We derive efficient influence functions and propose a multiply robust estimator that accommodates flexible modeling and is doubly robust in the MRT context. Applied to the HeartSteps MRT, our analysis reveals that early direct effects of activity suggestions are large but decline rapidly, while the indirect effects, mediated through increased immediate walking, are more stable and persistent throughout the intervention..