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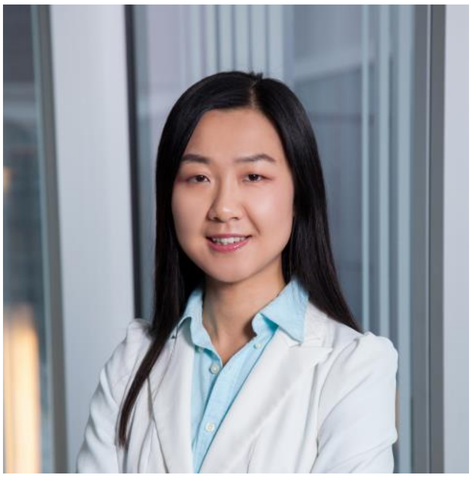
Data-Driven Dynamic Robust Resource Allocation: Application to Efficient Transportation



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Abstract:

With the development of sensing technologies, modern cities have brought to life unprecedented opportunities and challenges for allocating limited resources in a data-driven way. Intelligent transportation system is one emerging research area. However, greedy or matching algorithms that only deal with known requests in transportation systems are far from efficient without considering future demand information provided by data. In this talk, we develop a data-driven robust resource allocation framework to consider predicted demand and demand uncertainties, motivated by the problem of efficient dispatch of taxis or autonomous vehicles. We first present a receding horizon control (RHC) framework to incorporate both information from historical record data and real-time GPS location and occupancy status data. The objectives of improving efficiency include reducing total idle driving distance of all vehicles and matching demand and supply ratio spatial-temporally for service quality. We then present robust optimization and distributionally robust resource allocation methods to consider spatial-temporally correlated demand model uncertainties. Uncertainty sets of demand are constructed from data to provide a desired probabilistic guarantee or minimize the anticipated cost for the performance of dispatch solutions. An efficient algorithm that compatible with various demand prediction methods for building demand uncertainty sets is developed. We prove equivalent computationally tractable, or convex forms of the robust and distributionally robust resource allocation problems. Finally, analysis with real taxi operational record data of San Francisco shows that the RHC framework reduces the average total idle distance of taxis by 52%; evaluations with over 100GB of New York City taxi trip data show that the robust and distributionally robust dispatch methods reduce the average total idle distance by 10% more compared with non-robust solutions.

Biography:

Fei Miao received the B.Sc. degree in Automation from Shanghai Jiao Tong University, Shanghai, China, in 2010. She received the M.A. degree in Statistics from the dual degree program of Wharton, in 2015 and the Ph.D. degree in Electrical and Systems Engineering in 2016, both from the University of Pennsylvania. Currently, she is a postdoc researcher at the Department of Electrical and Systems Engineering, University of Pennsylvania. Her research interests focus on the control aspect of Cyber-Physical Systems (CPS), include data-driven control frameworks of large-scale CPSs under model uncertainties, attack detection and resilient control approaches to address security issues of CPSs. Dr. Miao was a Best Paper Award Finalist at the 6th ACM/IEEE International Conference on Cyber-Physical Systems (ICCPS), CPSWeek, in 2015.