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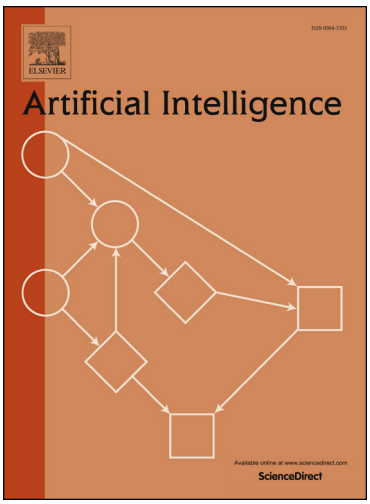

Online spatio-temporal matching in stochastic and dynamic domains

Meghna Lowalekar, Pradeep Varakantham, Patrick Jaillet

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Online Spatio-Temporal Matching in Stochastic and Dynamic Domains[1]

Meghna Lowalekar, Pradeep Varakantham, Patrick Jaillet†

School of Information Systems, Singapore Management University
† Department of Electrical Engineering and Computer Science, Massachussets Institute of Technology
meghnal.2015@phdis.smu.edu.sg, pradeepv@smu.edu.sg, jaillet@mit.edu

Abstract

Online spatio-temporal matching of servers/services to customers is a problem that arises at a large scale in many domains associated with shared transportation (e.g., taxis, ride sharing, super shuttles, etc.) and delivery services (e.g., food, equipment, clothing, home fuel, etc.). A key characteristic of these problems is that the matching of servers/services to customers in one stage has a direct impact on the matching in the next stage. For instance, it is efficient for taxis to pick up customers closer to the drop off point of the customer from the first stage of matching. Traditionally, greedy/myopic approaches have been adopted to address such large scale online matching problems. While they provide solutions in a scalable manner, due to their myopic nature, the quality of matching obtained can be improved significantly (demonstrated in our experimental results). In this paper, we present a multi-stage stochastic optimization formulation to consider potential future demand scenarios (obtained from past data). We then provide an enhancement to solve large scale problems more effectively and efficiently online. We also provide the worst-case theoretical bounds on the performance of different approaches. Finally, we demonstrate the significant improvement provided by our techniques over myopic approaches and two other multi-stage approaches from literature (Approximate Dynamic Programming and Hybrid Multi-Stage Stochastic optimization formulation) on three real world taxi data sets.

Keywords: Online Matching, Online Linear Programming, Stochastic Optimization, MDPs

[1]This paper is an extension of our earlier paper at AAAI 2016 [1]. We have extended the paper in the following ways: (a) The earlier paper focused on an approach that considers only two stages. We have now extended it to consider multiple stages; (b) We have added theoretical results on the hardness of offline and online spatio-temporal matching problems; (c) We have proved *a priori* bounds for the algorithms in multi-stage matching problems; (d) We have extended our experimental results to consider our updated approach and also generated results on synthetic data sets to better understand where our approach works well and where it does not work well; (e) We have also provided the results on a new dataset (from New York) that is publicly available and also compare against two other multi-stage approaches from literature (Approximate Dynamic Programming and Hybrid Multi-Stage Stochastic optimization formulation.)