A Partitioning Algorithm for Markov Decision Processes and Its Applications to Market Microstructure

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Abstract

A partitioning algorithm is proposed to solve a class of linear-quadratic Markov decision processes (MDPs) with inequality constraints and non-convex stagewise cost. Within each region of the partitioned state space, the value function and the optimal policy have analytical quadratic and linear forms, respectively. The algorithm is applied to two applications. In the main application, we present a model for limit order books with stochastic market depth to study the optimal order execution problem. Stochastic market depth is consistent with empirical studies and necessary to accommodate various order activities, such as limit order submission at and outside the best quotes and order cancellation, which may account for a large proportion of limit order activities. The optimal execution policy is solved by the algorithm and significantly outperforms that of a deterministic market depth model in numerical examples. In the second application, we use the algorithm to compute the exact optimal solution to a renewable electricity management problem; previously this problem only has an approximate solution, which may be inaccurate for some initial states.

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