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A General Framework for Learning-Augmented Online Allocation

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Ilan Cohen and Debmalya Panigrahi

Abstract: Online allocation is a broad class of problems where items arriving online have to be allocated to agents who have a fixed utility/cost for each assigned item so to maximize/minimize some objective. This framework captures a broad range of fundamental problems such as the Santa Claus problem (maximizing minimum utility), Nash welfare maximization (maximizing geometric mean of utilities), makespan minimization (minimizing maximum cost), minimization of ℓ_p-norms, and so on. We focus on divisible items (i.e., fractional allocations) in this paper. Even for divisible items, these problems are characterized by strong super-constant lower bounds in the classical worst-case online model.

In this paper, we study online allocations in the learning-augmented setting, i.e., where the algorithm has access to some additional (machine-learned) information about the problem instance. We introduce a universal algorithmic framework for learning-augmented online allocation that produces nearly optimal solutions for this broad range of maximization and minimization objectives using only a single learned parameter for every agent. As corollaries of our general framework, we improve prior results of Lattanzi et al. (SODA 2020) and Li and Xian (ICML 2021) for learning-augmented makespan minimization, and obtain the first learning-augmented nearly-optimal algorithms for the other objectives such as Santa Claus, Nash welfare, ℓ_p-minimization, etc. We also give tight bounds on the resilience of our algorithms to errors in the learned parameters, and study the learnability of these parameters.

Presenter: PANIGRAHI, Debmalya

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