

Online Mechanism Design with Predictions

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Aiming to overcome some of the limitations of worst-case analysis, the recently proposed framework of “algorithms with predictions” allows algorithms to be augmented with a (possibly erroneous) machine-learned prediction that they can use as a guide. In this framework, the goal is to obtain improved guarantees when the prediction is correct, which is called *consistency*, while simultaneously guaranteeing some worst-case bounds even when the prediction is arbitrarily wrong, which is called *robustness*. The vast majority of the work on this framework has focused on a refined analysis of online algorithms augmented with predictions regarding the future input. A subsequent line of work has also successfully adapted this framework to mechanism design, where the prediction is regarding the private information of strategic agents. In this paper, we initiate the study of online mechanism design with predictions, which combines the challenges of online algorithms with predictions and mechanism design with predictions.

We consider the well-studied problem of designing a revenue-maximizing auction to sell a single item to strategic bidders who arrive and depart over time, each with an unknown, private, value for the item. We study the learning-augmented version of this problem where the auction designer is given a prediction regarding the maximum value over all agents. Our main result is a strategyproof mechanism whose revenue guarantees are α -consistent with respect to the highest value and $(1 - \alpha^2)/4$ -robust with respect to the second-highest value, for $\alpha \in [0, 1]$. We extend our mechanism to also obtain expected revenue that is proportional to the prediction quality. We complement our positive results with impossibility results. For the original setting without predictions, we prove that the best-known competitive ratio of $1/4$ is optimal for a large family of auctions whose pricing rule can be an arbitrary function of the values observed in the past, but no more than the maximum seen so far. The proof relies on an LP formulation of the revenue maximization problem and duality. For the learning-augmented setting, we prove that the robustness-consistency trade-off achieved by our auction is optimal within a class of learning-augmented online auctions.

A full version of this paper can be found at <https://arxiv.org/abs/2310.02879>.

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