Optimal Model Selection for Conformalized Contextual Robust Optimization

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摘要：

In decision-making under uncertainty, contextual robust optimization (CRO) ensures reliable performance by minimizing the worst-case decision cost in a prediction set to hedge against variability of labels. While recent advances leverage conformal prediction to construct prediction sets for machine learning models, downstream decision outcomes critically depend on the choice of these models—a factor often overlooked in practice. This paper introduces an optimal model selection framework in CRO problem that unifies the robustness control and efficiency maximization. In general decision setting, we propose the Conformalized Robust Optimization with Model Selection method that automatically selects the model by minimizing the average decision loss of CRO's solution, while maintaining valid marginal coverage and robustness guarantee in finite samples. In individual decision setting, we propose the Conformalized Robust Optimization with Individualized Model Selection method that tailors the selection procedure to the context of test data, which achieves asymptotic individual robustness and optimality conditional on test data under mild conditions. This also enriches the scope of model selection in existing conformal prediction works. Numerical experiments across diverse synthetic and real-world applications show significant improvements in decision efficiency and robustness satisfaction compared to baseline approaches.

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