

Tractable Robust Markov Decision Processes

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In this talk we investigate the tractability of robust Markov Decision Processes (RMDPs) under various structural assumptions on the uncertainty set. Surprisingly, we show that in all generality (i.e. without any assumption on the instantaneous rewards), s-rectangular and sa-rectangular uncertainty sets are the only models of uncertainty that are tractable. Our analysis also shows that existing non-rectangular models, including r-rectangular uncertainty and new generalizations, are only weakly tractable. In that they require an additional structural assumption that the instantaneous rewards do not depend on the next state, and in this case they are equivalent to rectangular models, which severely undermines their significance and usefulness. Interestingly, our proof techniques rely on identifying a novel simultaneous solvability property, which we show is at the heart of several important properties of RMDPs, including the existence of stationary optimal policies and dynamic programming-based formulations. The simultaneous solvability property enables a unified approach to studying the tractability of all existing models of uncertainty, rectangular and non-rectangular alike.

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