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Constant Depth Decision Rules for multistage optimization under uncertainty

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In this paper, we introduce a new class of decision rules, referred to as Constant Depth Decision Rules (CDDRs), for multistage optimization under linear constraints with uncertainty-affected right-hand sides. We consider two uncertainty classes: discrete uncertainties which can take at each stage at most a fixed number d of different values, and polytopic uncertainties which, at each stage, are elements of a convex hull of at most d points. Given the depth mu of the decision rule, the decision at stage t is expressed as the sum of t functions of mu consecutive values of the underlying uncertain parameters. These functions are arbitrary in the case of discrete uncertainties and are poly-affine in the case of polytopic uncertainties. For these uncertainty classes, we show that when the uncertain right-hand sides of the constraints of the multistage problem are of the same additive structure as the decision rules, these constraints can be reformulated as a system of linear inequality constraints where the numbers of variables and constraints is O(1)(n+m)d^mu N^2 with n the maximal dimension of control variables, m the maximal number of inequality constraints at each stage, and N the number of stages. As an illustration, we discuss an application of the proposed approach to a Multistage Stochastic Program arising in the problem of hydro-thermal production planning with interstage dependent inflows. For problems with a small number of stages, we present the results of a numerical study in which optimal CDDRs show similar performance, in terms of optimization objective, to that of Stochastic Dual Dynamic Programming (SDDP) policies, often at much smaller computational cost.

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