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RBSDP as a Modified form of SDP for Reservoir Hydropower Optimization

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Abstract

Conventional Stochastic Dynamic Programming (SDP) has some drawbacks. The most important of them is "curse of dimensionality". This phenomenon indicates that for increasing the accuracy of solution, the intensity of discretization should be increased**.** Unfortunately by increasing the number of discretized segments or clusters in each stage of solution in dynamic programming, burden of calculation increases exponentially. Second drawback of SDP is that, we have no control to define constraints in each stage of solution. This fact causes some values of interval indices in discretization to be physically useless. Third drawback is that some combinations of values of interval indices from current stage to next stage to be impossible to adopt and these combinations provide no satisfactory answer to the problem. This paper presents a new developed method called reliability-based stochastic dynamic programming (RBSDP) to handle disadvantages mentioned above. The result compared to SDP indicates promising methodology for performing better operation in reservoir hydropower system.
Keywords: RBSDP, SDP, Optimization, GAMS.

1. INTRODUCTION

Many decision making problems in real world have to be solved at different stages of time and levels. These problems are called sequential decision problems. They are also referred to as multistage decision problems. One of the best techniques available for solving these problems is Dynamic Programming (DP) developed by Richard Bellman in 1950. DP, if applicable, can decompose a multistage decision problem to a number of single-stage decision problems. Generally, solving N subproblems is easier than challenging with a large size problem. Optimal solution of main problem can be obtained using answers of N subproblems. Solving subproblems can be done by any optimization method from nonlinear programming to a simple enumeration process.

DP on the other hand can be used for solving problems containing discrete variables, nonconvex, noncontinuous and nondifferentiable objective functions. Despite of these advantages, DP suffers from a major drawback known as "Curse of Dimensionality". Incorporation of stochasticity in DP (called SDP) is relatively simple by some modifications in its structure.

As one of the earliest studies on SDP, Karamouz and Houck [1] compared two algorithms of Dynamic Program and Regression (DPR) and SDP to generate monthly reservoir operating rules for single reservoir sites. DPR model consist of an algorithm that cycles through three components: a dynamic programming, a regression analysis and a simulation model. They concluded that SDP model performed better than DPR model for small reservoirs (capacity of 20 percent of mean annual flow), but for larger reservoirs (capacities exceeding 50 percent of the mean annual flow), the DPR performed more efficiently. They pointed out that behavior of SDP is highly related to number of state variables.

In recent years, many efforts have been devoted to improve conventional SDP. Mousavi et al. [2] developed a SDP model with fuzzy storage states for optimizing the operation of a reservoir system. An Interval transition between storage volumes in this method is possible by considering discretized storage space as fuzzy numbers whereas in conventional SDP, point-to-point transition is applied. Interval transitions in the fuzzy SDP are performed using the rules, which define algebraic operations with fuzzy numbers. Simulation using optimal release policies derived from two methods indicates that a fuzzy SDP with coarse partitions of storage space performs as well as a crisp SDP with finer partitions of this variable. Also it was found that fuzzy SDP is not so sensitive to the level of discretization and this fact justify using it in multireservoir problems where less computational effort is desired.