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ACCEPTED MANUSCRIPT

A scenario decomposition algorithm for 0-1 stochastic programs

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Abstract

We propose a scenario decomposition algorithm for stochastic 0-1 programs. The algorithm recovers an optimal solution by iteratively exploring and cutting-off candidate solutions obtained from solving scenario subproblems. The scheme is applicable to quite general problem structures and can be implemented in a distributed framework. Illustrative computational results on standard two-stage stochastic integer programming and nonlinear stochastic integer programming test problems are presented.

Keywords: 0-1 stochastic programs; scenario/dual decomposition; parallel computation.

1 Introduction

We consider stochastic programs of the following form

$$\min\{\mathbb{E}[f(x,\boldsymbol{\xi})] :\ x \in X \subseteq \{0,1\}^n\}, \tag{1}$$

where $\boldsymbol{\xi}$ is a random vector with support Ξ and known distribution P, and the expectation in (1) is with respect to P. An important example of (1) is the class of two-stage stochastic programs with 0-1 first stage variables with

$$f(x,\xi) = c^\top x + \min\{\phi(y(\xi),\xi) :\ y(\xi) \in Y(\xi,x)\}$$

where, for realization ξ of $\boldsymbol{\xi}$, $y(\xi)$ is the second stage decision vector, $\phi(\cdot,\xi)$ is the second stage objective function, and $Y(\xi,x)$ is the second stage constraint system depending on the first stage decision vector x. We assume that the random vector $\boldsymbol{\xi}$ has a finite support, i.e. $\Xi = \{\xi^1,\ldots,\xi^N\}$, where each ξ^i for $i \in \{1,\ldots,N\}$ is referred to as a scenario. We can then rewrite (1) as

$$\min\left\{\sum_{i=1}^N f_i(x) :\ x \in X \subseteq \{0,1\}^n\right\}, \tag{2}$$

where $f_i(x) = p_i f(x,\xi^i)$ and p_i is the probability mass associated with scenario i.

A popular approach for solving (2) is the so-called scenario or dual decomposition method. By making copies of the decision variables x, problem (2) can be reformulated as

$$\min\left\{\sum_{i=1}^N f_i(x^i) :\ x^i \in X\ \forall\, i, \sum_{i=1}^N A_i x^i = h\right\}$$

where the equations $\sum_{i=1}^N A_i x^i = h$ enforce the nonanticipativity constraints $x^1 = \cdots = x^N$. The Lagrangian dual problem by dualizing these nonanticipativity constraints take the form

$$\max_\lambda\left\{v(\lambda) := \sum_{i=1}^N \min\left\{f_i(x^i) + \lambda^\top A_i x^i :\ x^i \in X\right\} - \lambda^\top h\right\}, \tag{3}$$

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