Numerical Techniques for Stochastic Optimization


Abstract

This is a comprehensive and timely overview of the numerical techniques that have been developed to solve stochastic programming problems. After a brief introduction to the field, where accent is laid on modeling questions, the next few chapters lay out the challenges that must be met in this area. They also provide the background for the description of the computer implementations given in the third part of the book. Selected applications are described next. Some of these have directly motivated the development of the methods described in the earlier chapters. They include problems that come from facilities location, exploration investments, control of ecological systems, energy distribution and generation. Test problems are collected in the last chapter.

This is the first book devoted to this subject. It comprehensively covers all major advances in the field (both Western and Soviet). It is only because of the recent developments in computer technology, that we have now reached a point where our computing power matches the inherent size requirements faced in this area. The book demonstrates that a large class of stochastic programming problems are now in the range of our numerical capacities.

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Classical optimization techniques must compute this sum in its entirety for each evaluation of the objective, respectively its gradient. As available data sets grow ever larger, such “batch” optimizers therefore become increasingly inefficient. They are also ill-suited for the online (incremental) setting, where partial data must be modeled as it arrives. A stochastic optimization problem analogous to the above can be defined by the data-dependent objective: 

$$f(\theta, X) = \frac{1}{2} \sum_{i} (\theta_i - \theta^*)^2$$

Numerical Optimization. Springer Series in Operations Research. Springer, 1999. Deterministic global optimization methods are developed for both cases, while a stochastic version of the method is also proposed for large instances of the latter case. Numerical results show the effectiveness and efficiency of the proposed methods. Key words: Planar covering with ellipses, deterministic global optimization, algorithms.

1 Introduction. In this work, a covering problem on the plane is considered. A finite set of demand points is given and the problem consists on covering the most valuable subset of demand points using at most $k$ or exactly $k$ ellipses from a set of $m$ given ellipses. The stochastic optimization approach usually involves the assumption that the probability distribution of the unknown outcome is known. However, in practice, the probability distribution is usually not known. One way to deal with this situation is to estimate a distribution from data, assuming that the data is relevant for the decision problem, and then to use the estimated distribution in the stochastic optimization problem. There are several approaches to estimate probability distributions from data: the infinitesimal perturbation analysis technique for gradient estimation, to the optimization of the steady state means of single server queues were studied by Chong and Ramadge (1992) and L'Ecuyer and Glynn. (1994).