
Principal Investigator: Shapiro, Alexander

Organization: GA Tech Res Corp - GIT

Submitted By:
Shapiro, Alexander - Principal Investigator

Title:
Multistage Stochastic Convex Optimization

Project Participants

Senior Personnel
Name: Shapiro, Alexander
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kleywegt, Anton
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student
Name: Narayanan, Vijay
Worked for more than 160 Hours: Yes
Contribution to Project:
Started his Ph.D. research and was supported for one semester

Name: Chun, So Yeon
Worked for more than 160 Hours: Yes
Contribution to Project:

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:


Findings: (See PDF version submitted by PI at the end of the report)
There are many issues associated with the use of multistage stochastic programs to model and solve applied problems, including computational complexity, and the determination of a good model to use, including selection of input parameter values for the stochastic program. We study the use of stochastic programs with modeling error and estimation of input parameter values, in the context of a revenue management problem. Recently it has been proposed to control a revenue management process by solving a certain multistage stochastic program. There are strong reasons to suspect that the proposed stochastic program has modeling errors. In addition, the probabilities associated with the scenario tree have to be chosen, presumably estimated based on observed data. We study the dynamic behavior of a process consisting of a sequence of estimated scenario trees and the associated optimal solutions, in the presence of modeling error. This is ongoing work with Vijay Narayanan, who was supported with this grant.
We studied problems involving a seller and buyers who are formulating and solving stochastic programs. The buyers do not know the input parameters of the stochastic programs, such as the probability distributions of future prices, or the probabilities that products will be available for purchase in future time periods. The buyers estimate these input parameters using observed data. However, the observed data are affected by the previous decisions of the buyers, which in turn depended on the previous estimates. We study the convergence of the estimates and chosen decisions, and compare the outcomes with settings in which the correct models are known.

This work was presented (by A. Kleywegt) at the 11th International Conference on Stochastic Programming in Vienna in August 2007.

**Training and Development:**

Two graduate students were trained in stochastic optimization.

**Outreach Activities:**

Not yet.

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**Journal Publications**


Books or Other One-time Publications

Web/Internet Site

URL(s):
http://www2.isye.gatech.edu/people/faculty/Alex_Shapiro/SPbook.pdf

Description:
This is a (downloadable) preliminary version of the monograph "Lectures on Stochastic Programming" by A. Shapiro and A. Ruszczynski. We have worked on that monograph for several years. Currently we negotiate with the SIAM publisher for publication of this monograph.

Other Specific Products

Contributions within Discipline:
In many situations there is a need to make, hopefully an optimal, decision under conditions of uncertainty. Everybody would agree with this statement. There is a disagreement, however, with how to deal with such situations. Uncertainty can come in many different forms, and hence there are various ways how it can be modelled. In a mathematical programming approach one formulates an objective function which should be optimized (say minimized) subject to specified constraints. Typically the objective function is subject to an error (say a round-off error) or, even worse, is uncertain. In
such cases fixing the involved parameters to a nominal value and then solving the corresponding optimization problem, could lead to a poor solution. The classical approach to dealing with such uncertain optimization problems is suggested by stochastic programming where the objective is optimized on average. Recently results related to computational complexity and risk averse approaches to stochastic programming were developed. This may have a significant impact on practical ways of dealing with optimization under uncertainty.

Contributions to Other Disciplines:
Not yet,

Contributions to Human Resource Development:
Not yet.

Contributions to Resources for Research and Education:
Not yet.

Contributions Beyond Science and Engineering:
Not yet.

Conference Proceedings

Categories for which nothing is reported:
Organizational Partners
Any Book
Any Product
Any Conference
Discrete Choice Models with Multistage Decision Making

In classical discrete choice models, one considers a population of decision makers who have to choose among a discrete set of alternatives. Each decision maker \( n \) considers a set \( A_n \) of alternatives and chooses alternative \( a_n \in A_n \). The random utility model of decision making supposes that each decision maker \( n \) associates a utility \( U_{an} \) with each alternative \( a \in A_n \), and chooses the alternative \( a_n \in A_n \) with the largest utility, that is, the chosen alternative \( a_n \) satisfies \( U_{a_n,n} \geq U_{an} \) for all \( a \in A_n \). We would like to model the decisions made as a function of the attributes of the alternatives and the decision makers. Let \( x_{an} \) denote a vector of attribute values of alternative \( a \) and decision maker \( n \), let \( \theta \) denote a vector of parameters to be estimated with data, let \( \xi_{an} \) denote an unobservable part of \( U_{an} \), and let \( f(x, \theta, \xi) \) denote a chosen function. A popular choice is \( f(x, \theta, \xi) = \theta^T x + \xi \). If \( \theta \) is the same for all decision makers and alternatives, and \( \xi \) has a distribution over the population of decision makers independent of \( x \), then based on the distribution of \( \xi \) one can consider the probability that a decision maker, or the fraction of decision makers who, if presented with a set \( A' \) of alternatives, with attribute vector \( x_a \) for each \( a \in A' \), will choose alternative \( a' \in A' \), that is, \( P[U_{a'} \geq U_{a} \text{ for all } a \in A'] = P[f(x_{a'}, \theta, \xi_{a'}) \geq f(x_a, \theta, \xi_a) \text{ for all } a \in A'] \). Given a set of observed choices, one can consider the problem of choosing a value of the parameter \( \theta \) that best fits the data. Similar models in which \( \theta \) has a distribution over the population of decision makers can also be considered. Discrete choice models of the type above have been thoroughly studied in the literature, and have been widely applied.

The classical discrete choice model described above assumes that decision maker \( n \) knows the values of \( x_{an} \) for each \( a \in A_n \), of \( \theta \) (or \( \theta_n \)), and of \( \xi_{an} \). However, often alternatives have attribute values that are not known by decision makers at the time the decision is made. Such a situation is typical in multistage decision problems. We are interested in developing discrete choice models that incorporate multistage decision making.

Our current project in this line of research is to consider settings in which decision makers have to either choose an alternative that is currently available, or to postpone a decision, anticipating a set of alternatives to choose from later. Some attribute values of the future alternatives are not known when the initial decision is made, and are forecasted by the decision makers based on historical data. The parameter \( \theta \) includes both parameters that enter into the utility function, as well as parameters of the forecasting method.