07-1585 Proposal Summary

Renewal Status New

Title Robust Analysis of Large-scale Combinatorial Applications

Investment Area

Investment Area/Focus Area	
Enable Predictive Simulation * Enable Predictive Simulation Focus	

Principal Investigator HART,WILLIAM E., 01415

Project Manager HERMINA,WAHID L., 01510

Additional Team Members HART,WILLIAM E., 01415
CARR,ROBERT D., 01415

Breakdown by Center:

Center #	Total Funding Requested $K	Manpower (FTE)
01400	$99K	.30
Totals:	$99K	.30

Outyear Funding Requested:

	Funding Requested in $K

Abstract

This project will develop risk-based optimization strategies for applications with discrete decision parameters. Discrete optimization problems arise in many application areas like infrastructure surety, military inventory and transportation logistics, production planning and scheduling, and computational biology. However, discrete models of large, complex systems like national infrastructures and complex logistics frameworks naturally incorporate many modeling uncertainties. Model factors like transportation times and demands in water networks are inherently variable. Further, other information like logistical costs and infrastructure capacity limitations may only be known at a coarse, aggregate level of precision. Consequently, model predictions made with average or estimated data will often fail to reflect the risks associated with these modeling uncertainties.

A key limitation of existing discrete optimization methods is that they cannot effectively assess the risks associated with modeling uncertainties. Although a variety of discrete risk models have been developed in the literature, the application of these methods to large-scale applications remains a challenge. This project will focus on the conditional value-at-risk (CVaR) metric for characterizing the robustness of solutions. CVaR can be used to minimize the risk in severe circumstances, and this risk measure has been widely used in the finance community. The technical focus will be on (1) developing CVaR formulations that can be effectively analyzed, and (2) developing strategies for analyzing the trade-off between performance and risk in discrete models.

This project will focus on integer programming models, which can be widely applied to solve discrete optimization applications. Two particular applications will be used to assess these robust optimization strategies: sensor placement for water security and testing coverage assessment for integrated stockpile evaluation. Further, this project will involve academic collaborators who are experts in robust discrete optimization.

Proposed Work

The principle goal of this project will be to enable risk-constrained optimization strategies for large-scale applications. We will leverage and generalize discrete formulations for conditional value at risk (CVaR) that we have previously developed. These formulations have proven computationally expensive in real-world water security applications. We will analyze the mathematical structure of this risk metric and develop alternative formulations that are easier to solve. For example, we will consider approximations to CVaR that are easier to optimize but which compute a similar measure of risk.

Further, we will develop methods for computing the trade-offs curve between a discrete optimization objective and solution risk. This curve can be computed by independently solving for different trade-offs. However, we have observed that weakly constrained robust formulations can be used to seed the computation of more tightly constrained formulations. This observation will be used to develop iterative methods that can efficiently enumerate a set of alternative trade-offs.

The following milestones will be completed:

1. Develop and analyze discrete formulations of risk related to CVaR.

2. Develop iterative methods for enumerating performance/risk tradeoffs.

3. Assess robust optimization on two real-world applications: sensor placement for water security and test coverage analysis for integrated stockpile evaluation.

Tie To DOE

This project will develop new capabilities for formulating and analyzing discrete optimization problems. Discrete optimization problems arise in many application areas like infrastructure surety, military inventory and transportation logistics, production planning and scheduling, and computational biology. This project will specifically enable the analysis of modeling and data uncertainties that frequently arise in large discrete applications.