Workshop Program

Risk Management Approaches in Engineering Applications

Venue: University of Florida, Gainesville FL

Dates: November 14 and November 17

Publication: selected papers will be reviewed and published in a Special Issue of the "Annals of Operations Research"

Organizer: Stan Uryasev

Day 1. November 14, Friday. Location: Weil Hall 300, Conference Room, Deans Office of College of Engineering.

Period 3. 9:35-10:25

Johannes Royset
Naval Postgraduate School, Monterey CA, joroyset@nps.edu

Risk, Estimation, and Optimization

Quantification of risk is an integral part of optimization in the presence of uncertainty. The connections between risk and statistical estimation, however, have only recently come to the forefront. Estimation is a prerequisite for risk quantification as probability distributions are rarely known and must be estimated from data. But connections exist also on a more fundamental level as revealed through quadrangles of risk that link measures of risk, error, regret, and deviation. The presentation gives an overview of these connections and, in particular, discusses first- and second-order superquantiles, also called conditional values-at-risk (CVaR). We show that the connections lead to an extension of classical least-squares and quantile regression centered on superquantiles and the CVaR risk measures.

Period 4. 10:40-11:30

Mattias Heinkenscloss
Rice University, Houston TX, heinken@rice.edu

Adaptive stochastic collocation for PDE optimization under uncertainty

The numerical solution of optimization problems governed by partial differential equations (PDEs) with uncertain parameters requires some sort of sampling to capture the impact of the uncertain parameters on the solution of the optimization problem. If these sampling methods are applied naively, a huge number of PDEs would need to be solved, which is infeasible in practice.

In this talk I use stochastic collocation methods to sample uncertain parameters, and I describe an approach to reduce the number of PDE solves and/or the cost of a PDE solve so that sampling methods become feasible. The samples and the quality of the PDE solves at these samples determine the approximation of the objective function and its gradient in the PDE constrained optimization problem. The basic idea is to allow coarse approximations of function and of gradient evaluations when the optimization algorithm is away from the solution. The quality of the function and gradient approximation is controlled by a trust-region approach. The novelty of the presented trust-region approach is that is only needs error estimates for function and gradient approximations to guarantee convergence, and not exact bounds of these errors, as required by previous approaches. The stochastic collocation provides an adaptive sampling approach to estimate errors in function and gradient evaluation. This framework allows to dramatically reduce the number of samples that are required to carry out the optimization and to replace high fidelity PDE solvers with reduced order models. As a result, PDE constrained optimization problems that previously could only be solved within a day on supercomputers can now be solved in the same time on workstations.

This talk is based on joint work with D. P. Kouri, C. Maguder, D. Ridzal, and B. van Bloemen Waanders.

Periods 5,6. 11:45-13:40

Lunch at Arredondo Room 4th floor Reiz Union

Period 7. 13:55-14:45

Junya Gotoh
Chuo University, Japan, jgoto@indsys.chuo-u.ac.jp
Stan Uryasev
University of Florida, Gainesville FL, uryasev@ufl.edu

Support Vector Machines Based on Convex Risk Functional and General Norms

We revisit the formulations of support vector machines (SVMs) for binary classification on the basis of convex analysis. Interpretability of dual formulations is related to properties of the convex empirical risk functionals. Besides, we demonstrate how robust optimization modelings are easily incorporated. With regularizers based on new families of polyhedral norms (in place of the lp-norms), regularizer tuning can be efficiently incorporated via (possibly, parametric) linear programming.

Period 8.

15:00-15:25

Alexander Mafusalov , Stan Uryasev
University of Florida, Gainesville FL, mafusalov@ufl.edu, uryasev@ufl.edu

Buffered Probability of Exceedance: Mathematical Properties and Optimization Algorithms

This paper introduces a new probabilistic characteristic called buffered probability of exceedance (bPOE). This characteristic is an extension of so-called buffered probability of failure and it is equal to one minus super-distribution function introduced by Rockafellar and Royset. Paper provides efficient calculation formulas for bPOE. The bPOE function is a quasi-convex function of random variable w.r.t. the regular addition operation and a concave function w.r.t. the mixture operation and it is a monotonic function of random variable. bPOE is a strictly decreasing function of the parameter on the interval between the mathematical expectation and the essential supremum. Multiplicative inverse of the bPOE is a convex function of parameter, and a piecewise-linear function for discretely distributed random variable. Minimization of the bPOE can be reduced to a convex program for a convex feasible region and to LP for a polyhedral feasible region. A family of bPOE minimization problems and a family of the corresponding CVaR minimization problems share the same frontier of optimal solutions and optimal values.

15:25-15:50

Matt Norton, Stan Uryasev
University of Florida, Gainesville FL, mdnorton@ufl.edu , uryasev@ufl.edu

Maximization of AUC and Buffered AUC for Classification

We present an alternative to the Area Under the Receiver Operating Characteristic Curve (AUC) performance metric called Buffered AUC (bAUC). We show that bAUC is an intuitive counterpart to AUC. We then show that bAUC, compared to AUC, is a more informative measure of a classifiers ranking quality. In addition, we show that bAUC is much easier to handle in optimization frameworks than AUC, specifically reducing to convex and linear programming. We use these friendly optimization properties to present the bAUC Efficiency Frontier, a concept that serves to partially resolve the 'incoherency' that arises when misclassification costs need be considered.

Period 9. 16:05-16:55

Nathaniel Price, Raphael T. Haftka, and Nam H. Kim
University of Florida, Gainesville FL, NatBPrice@gmail.com , haftka@ufl.edu , nkim@ufl.edu

Designers Redesign for Safety, but Structural Redesign for Performance is Better Long Term

At the initial design phase, high epistemic uncertainty in models may exact significant performance penalties if incorporated into a reliability based design optimization framework. In practice, this epistemic uncertainty is typically reduced as new information becomes available in the future. This reduction in epistemic uncertainty can be leveraged through redesign to improve the design performance or reliability. However, redesign is often undesired due to associated delays or costs. For a fixed risk of redesign, designers face a dilemma in whether to start with a more conservative design and risk having to redesign to improve performance or start with a more ambitious design and risk having to redesign to improve safety. In this study we show that the average design performance will be better when starting with a more conservative initial design, but also reveal a conflict between companies and designers in that designers may prefer the benefits of redesign for safety.

18:00-21:00 Dinner in Uryasev's house

Address: 4014 SW 98th Ter., Gainesville, FL 32608

Google Maps link:

https://www.google.com/maps/place/4014+SW+98th+Terrace,+Gainesville,+FL+32608/@29.617869,-82.4472849,17z/data=!3m1!4b1!4m2!3m1!1s0x88e8bdb3710e77b1:0x5fb57e9f5621ceda

Day 2. November 15, Saturday.

10:00-12:00. Socializing and kayaking at the lake Wauburg (University of Florida recreational facility), Northern Entrance.

Google Maps link: **http://www.recsports.ufl.edu/lake-wauburg**

Day 3. November 16, Sunday.

Recreational activities: TBD

Day 4. November 17, Monday. Location: Weil Hall 303, Conference Room.

Period 3. 9:35-10:25

R.Tyrrell Rockafellar
University of Washington and University of Florida, rtr@math.washington.edu

Approaching the Risk Quadrangle Through Generalized Utility Preferences

The idea that preferences in financial optimization may, in particular, be developed in terms of a utility function for money has been developed extensively. Special classes of one-dimensional utility functions for this purpose have been explored for their properties of comparative insensitivity to the choice of a benchmark. However, when a random variable like an index underlies the benchmark something more is needed.

Additional directions of development are suggested from economics, which after all was the original source of the utility concept. Economists have been interested in combining expected utility with stochastic ambiguity in the sense that the probability distribution with respect to which the expectation is taken may not really be known. Worst case analysis in this setting has led them to derive preference axioms beyond those of Von Neumann and Morgenstern which correspond to that rather than simple expected utility.

These approaches can be combined in a framework in which they yield general measures of relative utility that, in the fundamental quadrangle of risk, are the counterparts of measures of regret and therefore automatically generate associated measures of risk, deviation and error.

In this way the prospect emerges of thinking of each instance of the risk quadrangle as coming from some instance of preferences based on utility in a general sense and perhaps open to axiomaticization and testing from that angle.

Period 4. 10:40-11:30

Drew Philip Kouri
Sandia National Laboratories, Albuquerque NM, dpkouri@sandia.gov

Risk-Averse PDE-Constrained Optimization using the Conditional Value-at-Risk

Uncertainty is inevitable when solving science and engineering optimization problems. In many applications, it is essential that one determines robust or risk-averse solutions in the face of this uncertainty. The conditional value-at-risk (CVaR) provides a natural framework to handle such risk.

In this talk I discuss primal and dual approaches for minimizing CVaR with application to a class of optimization problems governed by partial differential equations (PDEs) with uncertain coefficients. For the primal problem, I introduce a smooth approximation of CVaR which facilitates the use of derivative-based optimization algorithms. Moreover, the additional regularity of the objective function leads to rapid convergence of quadrature-based discretizations. I prove consistency of this approximation and provide explicit error bounds for the optimal controls. For the dual approach, I regularize the inner maximization problem and rigorously derive first-order optimality conditions. Using the specific form of the optimality system, I propose a simple fixed-point iteration which provides a means to calculate worst-case probability distributions. Such distributions provide insight on the uncertain PDE parameters and can be used to reduce computational cost of solving subsequent optimization problems. I conclude with numerical results demonstrating the primal and dual approaches applied to multiple PDE-constrained optimization problems.

This talk is based on joint work with T. M. Surowiec, M. Heinkenschloss, D. Ridzal, and B. G. van Bloemen Waanders.

Periods 5,6. 11:45-13:40

Lunch

Period 7.

13:55-14:20

Konstantin Pavlikov
Air Force Research Laboratory, Destin FL, pavlikoff.ko@gmail.com

Minimum Risk Network Coverage Problem

The network maximum expected coverage problem under uncertainty is considered. In this problem, network vertices are assumed to cover their adjacent nodes with some probability, independently of each other. The emphasis is put on minimizing the risk of losing coverage in the presence of random failures of "covering" components. We formalize the stochastic coverage problem, formulate and further investigate the corresponding combinatorial optimization problems.

14:20-14:45

Value-at-Risk Support Vector Machine (Var-SVM): MIP Representation and Equivalence of Formulations.

Victoria Zdanovskaya,
University of Florida, Gainesville FL, ladyvi@ufl.edu
Konstantin Pavlikov
Air Force Research Laboratory, Destin FL, pavlikoff.ko@gmail.com
Stan Uryasev
University of Florida, Gainesville FL, uryasev@ufl.edu

Support Vector Machines (SVMs) is one of the most widely used data classification techniques in machine learning. A class of Var-SVMs is known to be robust to the outliers in the training dataset. Unfortunately Var-SVM is a nonconvex optimization problem. In this talk we consider Mixed Integer Programming (MIP) representation of Var-SVM that can be solved by standard Brach and Bound algorithm. We also show an equivalence of geometric margin maximization and structural risk minimization formulations of Var-SVMs in L1-norm (a result previously known for L2-norm), which is due to the positive homogeneity of Value-at-Risk (VaR) risk measure.

Period 8.

15:00-15:25

Detecting Robust Cliques in Graphs Subject to Uncertain Edge Failures

Vladimir L. Boginski
University of Florida, Gainesville FL, boginski@reef.ufl.edu

Joint work with O. Yezerska and S. Butenko (Texas A&M University)

We develop and compare several heuristic approaches, as well as an exact combinatorial branch-and-bound algorithm, for detecting maximum robust cliques in graphs subjected to multiple uncertain edge failures. The desired robustness properties are enforced using Conditional Value-at-Risk (CVaR) risk measure. The results of computational experiments on DIMACS graph instances are reported.

15:25-15:50

Justin R. Davis, Stan Uryasev
University of Florida, Gainesville FL, justin.r.davis@essie.ufl.edu , uryasev@ufl.edu

Analysis of Tropical Storm Damage using Buffered Probability of Exceedance

Relying solely on probability of exceedance (POE) or in combination with other statistical measures such as mean or standard deviation does not always give a clear picture of data which have heavy tailed distributions. In this paper, the new concept of buffered probability of exceedance (bPOE) is explained, reduced to a simple algorithmic form, and then applied to a set of normalized economic loss data for tropical storms that made landfall (average loss $6.961 billion). Through averaging of data in the tail, bPOE combines the elements of both probability as well as density of heavy tailed distributions into a single statistic. Using the bPOE analysis applied to a $50 billion threshold in the loss data shows the POE is 4.2% while the bPOE if 9.7%. Consistent with analysis of data in other fields, the risk observed by bPOE is more than double that of POE. Thus, the storm data can be equivalently “packed” into a discretion distribution with two atoms: a lower tail expected loss ($2.311 billion*0.903=$2.087 billion) and an upper tail expected loss ($50 billion*0.097=$4.875 billion). For a 25% probability, the value-at-risk (quantile) determined using POE is $4.875 billion, while the conditional-value-at-risk (average of damage in excess of the quantile) determined by the bPOE is $25.176 billion. For a fixed probability, this $20.301 billion difference between the damage associated with POE and bPOE is referred to as “excess loss” and represents the damage above the value-at-risk. Subdividing the historical data by landfall state, at the 50% probability level, FL, the state most often hit by tropical storms has the highest value for excess loss at $16.157 billion.