Workshop on Risk Management Approaches in Engineering Applications
Gainesville, Florida-USA, October 16th-17th, 2017

ABSTRACTS

Monday, October 16th

2:00-2:30pm
Risk Management with POE, VaR, CVaR, and bPOE

Stan Uryasev, University of Florida (uryasev@ufl.edu)
Drew Kouri, Sandia National Laboratories (dpkouri@sandia.gov)

The paper compares four closely related probabilistic measures: Probability of Exceedance (POE), Value-at-Risk (VaR) which is a quantile, Conditional Value-at-Risk which is a Superquantile, and Buffered Probability of Exceedance (bPOE).

2:30-3:00pm
Application of QMU to the Design of a Nuclear Waste Storage Tank

Ari Frankel, Stanford University
David Sharp, Stanford University
Gianluca Iaccarino, Stanford University (giaccarino@gmail.com)

Defining the reliability of complex physical systems is crucial for system certification and guaranteeing safety, but is often complicated by the presence of many uncertainties and system subcomponents. One such example is the certification of the Hanford Waste Treatment Plant, where radioactive and toxic chemical waste that spontaneously generates flammable gases is stored in large tanks. We introduce the Quantification of Margins and Uncertainty (QMU) methodology to quantify the system safety of waste storage tanks in the event of a loss of tank ventilation, which poses a safety risk to workers. We also show how QMU can be used as a design tool to find operating regimes that maintain a desired confidence level. A simplified physical model is used to analyze the build-up of hydrogen gas in storage tanks and conduct an uncertainty propagation study to quantify the operating margin with respect to the flammability conditions. A demonstration problem is shown in which the radiation loading in a waste tank is iteratively modified until a desired confidence ratio is achieved. The results show that the resulting designs are sensitive to the use of interval or probabilistic QMU to achieve a desired confidence ratio, and it is not always possible to realize a design at a particular confidence ratio.

3:00-3:30pm
Conditional-Value-at-Risk estimation via Reduced-Order Models

Matthias Heinkenschloss, Rice University (heinken@rice.edu)

TBD

4:00-4:30pm
Investment Strategy for a Retirement Portfolio

George Pertaia, University of Florida (gpertaia@ufl.edu)
Morton Lane, University of Illinois at Urbana-Champaign (mnlane@illinois.edu)
Matthew Murphy, University of Illinois at Urbana- Champaign (mdmurphy@illinois.edu)
Stan Uryasev, University of Florida (uryasev@ufl.edu

A retiree with a savings account balance, but without a pension is confronted with an important investment decision that has to satisfy two conflicting objectives. Without a pension the function of the savings is to provide post-employment income to the retiree. At the same time, most retirees will want to leave an estate to their heirs. Guaranteed income can be acquired by investing in an annuity. However, that decision necessarily takes funds away from investment alternatives that might grow the estate. The decision is made even more complicated because one does not know how long one will live. A long life expectancy would suggest more annuities, and short life expectancy will immediately promote more risky investments. However there are very mixed opinions about either strategy. A framework is needed to view the consequences and the tradeoffs of alternative investment strategies. We propose a stochastic programming model to frame this very complicated problem. The objective is to maximize expected terminal net worth (the estate) subject to CVaR constraints on target income shortfalls. The wealth 'expectation' must be weighted by both probabilistic investment outcomes and mortality probabilities. The CVaR constraints must apply each year the retiree is alive; they are irrelevant after death. Investment allocations must be made immediately but can be revised annually using a prior information. We use kernel functions to build and generalize these subsequent investment strategies. They are non-linear over time.

4:30-5:00pm
On monotone portfolio selection problems and related convex functionals

Mikhail Zhitlukhin, Steklov Mathematical Institute, Moscow, Russia (mikhailzh@mi.ras.ru)

The classical Markowitz mean-variance portfolio selection approach seeks for a portfolio (in a certain class of portfolios) that maximizes the trade-off between the profit, expressed by the expected return, and the risk, expressed by the variance of the return: $M(R) := \mathrm{E}(R) - \lambda \mathrm{Var}(R)$, where R is the return of a portfolio and λ is a positive constant, risk tolerance.

It is well-known that this problem lacks monotonicity. Namely, if R^* is the return of the portfolio solving the problem, there might exist a portfolio with return R such that $R \geq R^*$ with probability 1, while $M(R) < M(R^*)$.

In the first part of the talk I will propose its modification, which satisfies a certain monotonicity property. After that in the second part I will describe a method which allows to solve the new problem in an effective way, at least numerically and, in some cases, analytically. It will be shown that in the general case the solution can be obtained by solving some two-dimensional optimization problem. In the third part I will speak about connections between the solution obtained and the buffered probability of exceedance.

5:00-5:30pm
A generalized maximin decision model for managing risk and measurable uncertainty

George G. Polak, Wright State University (george.polak@wright.edu)

We propose an innovative approach to probabilistic decision making, in which the optimal selection is made both for a decision alternative to manage risk and for a collection of measurable events to simultaneously manage uncertainty as measured by information entropy. The resulting generalized maximin model is a combinatorial optimization problem for maximizing the expected value of a random variable, defined as the minimum return in a given event, over all measurable events in a discrete sample space. The collection of measurable events and applicable probability measure are endogenously determined by a partition of the sample space and optimized for a given index that specifies the number of constituent events. The modeling approach is very general, encompassing as a special case the maximin decision criterion and providing an equivalent solution to the expected value criterion with other cases representing trade-offs between these criteria. A dynamic programming algorithm for solving the non-diversified model in polynomial time is developed. Diversification of the decisions results in a nonlinear integer optimization model that is transformed to an easily solvable mixed-integer linear model. Publicly available data of 79 investments over 10 periods are used to compare the model with meanвЂ“variance, conditional value-at-risk, and constrained maximin models.

Tuesday, October 17th

9:00-9:30am
Adapting the progressive hedging algorithm to bPOE minimization

R. Tyrell Rockafellar, University of Washington and University of Florida (rtr@uw.edu)

In problems of stochastic optimization that rely on a framework of finitely many scenarios, possibly branching over time in several periods, standard models of the past sought to minimize the expected value of some kind of "cost". A major approach to computation, called the Progressive Hedging Algorithm, was developed in order to reduce the computation iteratively to solving special subproblems, each depending only on a single scenario. Convexity was an essential ingredient in this.

Recently the Progressive Hedging Algorithm was extended to enable minimization of a risk espression like conditional value-at-risk instead of just an expected value. The question now is whether it can be further extended to minimize buffered probability of risk. There is much to build on for success in this direction, however a key issue is that bPOE doesn't fully exhibit convexity but only quasi-convexity.

9:30-10:00am
Risk-Averse Capacity Planning for Renewable Energy Production

B. Sun, University of Arizona
Pavlo Krokhmal, University of Arizona (krokhmal@email.arizona.edu)
Y. Chen, University of Arizona

This work considers the problem of capacity planning and operation of energy grids where the power demands are served from renewable energy sources, such as wind farms, and the transmission network is represented by the High- Voltage Direct Current (HVDC) lines. The principal question considered is whether a risk-averse design of the grid, including the selection of wind farm locations and assignment of power delivery from wind farms to customers, would allow for effective hedging of the risks associated with uncertainties in power demand and production of energy from renewable sources. To this end, the problem is formulated in the general context of supply chain/facility location, with both the supply and the demand being stochastic variates. Several stochastic optimization models are presented and analyzed, including the traditional risk-neutral, or expectation-based model and risk-averse models based on linear and nonlinear coherent measures of risk. Exact solutions algorithms that employ Benders decomposition and polyhedral approximations of nonlinear constraints have been proposed for the obtained linear and nonlinear mixed-integer programming problems. The conducted numerical experiments illustrate the properties of the constructed models, as well as the efficiency of the developed algorithms.

10:00-10:30am
Operations Research and Data Analytics in Defense: Basic Research Projects and Funding

Jeremy Jordan, Air Force Institute of Technology (Jeremy.Jordan@afit.edu)

Operations research and data analytics originated in the United States defense sector and are still widely used today throughout its organizations. This presentation will focus on the speakers unique experiences as an AFOSR International Program Manager for Operations Research. The goal is to give the audience a feel for defense related analysis activities, basic research interests, and various funding sources.

11:00-11:30am
Dynamic Stochastic Approximation for Multi-stage Stochastic Optimization

Guanghui Lan, Georgia Institute of Technology (george.lan@isye.gatech.edu)
Zhiqiang Zhou, Georgia Institute of Technology

In this talk, we consider multi-stage stochastic optimization problems with convex objectives and conic constraints at each stage. We present a new stochastic first-order method, namely the dynamic stochastic approximation (DSA) algorithm, for solving these types of stochastic optimization problems. We show that DSA can achieve an optimal $\mathcal{O}(1/\epsilon^4)$

rate of convergence in terms of the total number of required scenarios when applied to a three-stage stochastic optimization problem. We further show that this rate of convergence can be improved to $\mathcal{O}(1/\epsilon^2)$ when the objective function is strongly convex. We also discuss variants of DSA for solving more general multi-stage stochastic optimization problems with the number of stages $T > 3$. The developed DSA algorithms only need to go through the scenario tree once in order to compute an ϵ-solution of the multi-stage stochastic optimization problem. As a result, the memory required by DSA only grows linearly with respect to the number of stages. To the best of our knowledge, this is the first time that stochastic approximation type methods are generalized for multi-stage stochastic optimization with $T \geq 3$.

11:30am - 12:00pm
Advanced Coastal Environment Systems

Y. Peter Sheng, University of Florida (pete@coastal.ufl.edu)

Coastal inundation risk in many coastal regions of the world, including Florida, is expected to increase due to the combined effects of sea level rise and increasingly intense tropical cyclones with more precipitation due to climate change. Coastal communities in Southwest Florida is particularly vulnerable to coastal inundation due to the relatively low and flat bathymetry and topography. To enhance the resiliency of Southwest Florida communities, the Advanced Coastal Environment Systems (ACES) research group is leading a NOAA (National Oceanic and Atmospheric Administration) sponsored project to develop a web-based decision support system entitled Adaptation of Coastal Urban and Natural Ecosystems. The first part of the decision support systems will provide prediction of coastal inundation risk due to the combined effects of sea level rise and more intense tropical cyclones in the early and late 21st century. Using an integrated coastal surge-wave-inundation modeling system, probabilistic coastal inundation maps of Southwest Florida for various climate scenarios have been developed. This presentation will review the probabilistic approach of the coastal inundation mapping and preview predicted inundation elevation at selected location with return periods ranging from 10 to 1,000,000 years.

1:30 - 2:00pm
Boundary Value Problems in Uncertain Environment: Applications and Software

Greg Zrazhevsky, National University of Kyiv, Ukraine (zgrig@univ.kiev.ua)
Stan Uryasev, University of Florida (uryasev@ufl.edu)

The paper considers models described by boundary value problems for partial differential equations (PDEs) with random parameters. Our objective is to find control parameters satisfying a specified criterion. We present a numerical solution of the problem based on optimization approaches. We demonstrated effectiveness of the suggested approach.

2:00 - 2:30pm
Heavy Tails and Copulas: Limits of Diversification

Artem Prokhorov, The University of Sydney Business School (artem.b.prokhorov@gmail.com)

We show that diversification does not reduce Value-at-Risk for a large class of dependent heavy tailed risks. The class is characterized by power law marginals with tail exponent no greater than one and by a general dependence structure which includes some of the most commonly used parametric and nonparametric copulas.

2:30 - 3:00pm
On the Passage from Local to Global in Optimization: New Challenges and Risks in Theory and Practic

Panos Pardalos, University of Florida (pardalos@ufl.edu)

Large scale problems in the design of networks and energy systems, the biomedical field, finance, and engineering are modeled as optimization problems. Humans and nature are constantly optimizing to minimize costs or maximize profits, to maximize the flow in a network, or to minimize the probability of a blackout in the smart grid. Due to new algorithmic developments and the computational power of machines, optimization algorithms have been used to solve problems in a wide spectrum of applications in science and engineering. In this talk, we are going to address new challenges in the theory and practice of optimization, including exact approaches, approximation techniques, and heuristics. First, we have to reflect back a few decades to see what has been achieved and then address the new research challenges and directions.

3:00 - 3:30pm
Conservative Estimate for the Design Allowables of Composite Laminates Using Bootstrapping

Yiming Zhang, University of Florida (yimingzhang521@ufl.edu)
Nam Ho Kim, University of Florida (nkim@ufl.edu)
Raphael T. Haftka, University of Florida, (haftka@ufl.edu)

Composite laminates are being used for various mechanical systems from aircraft to bicycles. Reliable stress limits, called design allowables, are of critical interest to balance safety and economic value for the design of composite laminates. The properties of composite laminates usually suffer from significant variation due to complex manufacturing process. Estimating the design allowables is challenging because uncommon statistical distributions are occasionally encountered, that are impossible to identify from the limited number of replicates tested. We propose to enhance the conservativeness of estimated design allowables using bootstrapping. The design allowables are calculated from the bootstrapped replicates until a converged distribution is obtained. The lower 5th percentile of the distribution is used as conservative design allowables. Tests performed on composite

plates with holes are used to demonstrate the approach. The tests were performed at 12 configurations with replicates varying 2 design variables that define the size of the hole and the stiffness of the laminate. Partial replicates are adopted for evaluating the B-basis allowables, which are estimates of the 10th lower percentile with 90% confidence. The B-basis allowables from the full replicates are used as the baseline for comparison. We also explored the conservative estimation of design allowables at untested points using surrogate/regression. The replicates are bootstrapped at each configuration respectively as samples to develop surrogates. For both point-estimation and surrogate predictions, incorporating bootstrapping improves conservativeness noticeably for the same required weight, or it reduces weight for the same level of concervativeness.

4:00 - 4:30pm
Global Search for Diverse Competitive Designs

Yiming Zhou, Shanghai Electric Windpower Equipment, Shanghai, China
Raphael T. Haftka, University of Florida, (haftka@ufl.edu)
Gengdong Cheng, Dalian University of Technology, Dalian, Liaoning, China

Optimization is often performed based on incomplete knowledge of constraints and objectives. Obtaining a single optimum is risky, because this optimum may be rendered useless by refinements in models or the unrecognized performance requirements. We explore the problem formulation and solution approaches to explicitly look for diverse competitive designs using surrogate-based adaptive sampling algorithms. We also make a simplifying assumption that the simultaneous failure probability of two designs is related to their Euclidean distance in design space. In our formulation, a weighted sum of the objectives of multiple diverse competitive alternatives is selected as the objective function, two, three and four alternative designs are sought, the distance constraints for each case are set to have approximately the same probability that all of them will prove deficient when tested by a more refined model or by a required latent performance measure. Three test examples are studied. For these test problems, we find that k alternative designs could be obtained for less than a k-fold increase in computational cost. Also, it appears that as the dimensionality increases, it is easier to place well separated multiple alternatives, so that diversity becomes easier to satisfy. We found that search for the diverse designs usually finds points very close to the global optimum, so the point with the best objective may be added as another design alternative.

4:30 - 5:00pm
Generalized Conditional Value-at-Risk for High-Dimensional Statistical Learning

Hongchen Liu, University of Florida (hliu@ise.ufl.edu)
Stan Uryasev, University of Florida (uryasev@ufl.edu

Nonconvex regularization schemes for recovering sparse signals from high-dimensional data, whose dimensions are much more than the number of data entries, have become a topic of great interest in recent years. In this research, we consider a recent nonconvex regularization function called the trimmed ℓ_1-norm, which can be interpreted as a risk measure in a general form of conditional value-at-risk. In the special case of high-dimensional linear regression, we have the following two-fold results: (a) We show that a global minimal solution to the Dantzig selector with the trimmed ℓ_1-norm regularization (Trimmed ℓ_1-Dantzig selector, hereafter) yields desirable statistical performance under a much weaker condition on the design matrix than most existing schemes: The trimmed ℓ_1-Dantzig selector does not require the restricted eigenvalue condition, which is arguably the weakest condition required for the many high-dimensional statistical learning approaches to perform properly. (b) We further show that, in spite of the nonconvexity introduced by the trimmed ℓ_1-norm, globally solving the Trimmed ℓ_1-Dantzig selector may not be necessary for statistical applications. More specifically, certain polynomial-time achievable feasible solutions are good enough to ensure sound statistical performance. To our knowledge, those are the first set of findings concerning the theoretical advantages of the trimmed ℓ_1-norm in high-dimensional learning. Numerical results based on simulated data are consistent with our theoretical findings.