Games and Decisions in Reliability and Risk Workshop
May 16-20, 2016
SPEAKER TITLES/ABSTRACTS

David Banks
Duke University

"Adversarial Risk Analysis"

Adversarial Risk Analysis (ARA) is a Bayesian approach to strategic decsion-making. One builds a model of one's opponents, expressing subjective uncertainty about the solution concept each opponent uses, as well as their utilities, probabilities, and capabilities. Within that framework, the decision-maker makes the choice that maximizes expected utility. ARA allows the opponent to seek a Nash equilibrium solution, or a mirroring equilibrium, or to use level-k thinking, or prospect theory, and so forth, and it allows the decision-maker to relax the common-knowledge assumption that arises in classical game theory. The methodology applies to corporate competition and counterterrorism. The main ideas are illustrated in the context of auctions, the Borel game La Relance, and a toy counterterrorism example.

Melike Baykal-Gursoy
Rugers University

"Incomplete Information Protection Games"

We use a robust approach to model the infrastructure protection game as a non-zero sum non-cooperative game between an adversary and a defender. We develop a distribution-free model of incomplete-information games, both with and without private information, in which the players use a robust optimization approach to contend with payoff uncertainty. Depending on the objective of the adversary and existence of private information, three models are presented for this game. Existence and uniqueness of the Nash equilibrium is proved for the first two models and the shape of the Nash equilibrium is characterized for the third model. We present a numerical example in which the proposed approach is applied to the real data.

Philippe Delquié
George Washington University

"Elicitation of an Individual's Risk Tolerance: Theory and some Experimental Evidence"

An individual's risk attitude may be measured by eliciting his/her preferences over gambles, then estimating model parameters that provide best fit to the responses. The results of such experiments are notoriously vagarious, as documented in the behavioral decision research literature, due to bias, error, and cognitive limitations. This presentation will review some quick methods, classic and newer, for estimating the risk tolerance coefficient of the exponential utility function, a utility form widely used in Decision Analysis. Experimental evidence comparing the alternative methods will be presented, highlighting the relative merits of different approaches.

Johan van Dorp
George Washington University

"Decision Analysis Introduction"

The domain of decision making under uncertainty shall be introduced interactively by presenting the participants with a variety of decision problems involving coin-toss examples. Any decision analysis involves the construction of a model as an abstraction of reality. By drawing analogies between these coin-toss examples and the practical decision context in the field of maritime risk management the importance is presented of: (1) making reasonable assumptions rather than worst case assumptions, (2) identifying the fundamental objective(s), (3) how to evaluate the objectives and (4) developing an attractive graphical means to communicate the analysis results. During the second part of the course, we introduce influence diagrams and decision trees as two visual means to organize the identified elements of decision problems (i.e. values and objectives, decisions, uncertain events and consequences) in a single graphical representation.

Kathy Ensor

"Risk Based Decisions Based on a Class of Stochastic Volatility Models with Intractable Likelihoods"

We introduce a new approach to latent state filtering and parameter estimation for a class of stochastic volatility models for which the likelihood function is unknown. The alpha-stable stochastic volatility model provides a flexible framework for capturing asymmetry and heavy tails, which is useful when modeling financial returns. However, the -stable distribution lacks a closed form for the probability density function, which prevents the direct application of standard filtering and estimation techniques such as sequential Monte Carlo (SMC) and Markov chain Monte Carlo (MCMC). We highlight the necessity for modeling asymmetric alpha-stable SVMs through an application to propane weekly spot prices and model based investment decisions.

Authors: Emilian Vankov, Michele Guindani and Katherine B. Ensor (presenter)

Joseph Halpern
Cornell University

"Actual Causality: A Survey"

What does it mean that an event C ``actually caused" event E? The problem of defining actual causation goes beyond mere philosophical speculation. For example, in many legal arguments, it is precisely what needs to be established in order to determine responsibility. (What exactly was the actual cause of the car accident or the medical problem?) The philosophy literature has been struggling with the problem of defining causality since the days of Hume, in the 1700s. Many of the definitions have been couched in terms of counterfactuals. (C is a cause of E if, had C not happened, then E would not have happened.) In 2001, Judea Pearl and I introduced a new definition of actual cause, using Pearl's notion of structural equations to model counterfactuals. The definition has been revised twice since then, extended to deal with notions like "responsibility" and "blame", and applied in databases and program verification. I survey the last 15 years of work here, including joint work with Judea Pearl, Hana Chockler, and Chris Hitchcock. The talk will be completely self-contained.

Aparna Huzurbazar
Los Alamos National Laboratory

"Adversarial Scenarios in Safety and Security"

Adversarial scenarios of interest to the defense and intelligence communities, such as attacks on guarded facilities, involve multiple autonomous actors operating concurrently and interactively. These scenarios cannot be modeled realistically with methods such as Markov processes, stochastic game theory, event graphs, or Bayesian networks, which assume sequential actions, serialized sample paths, or situations static in time. Petri nets, originally developed to model parallelism and concurrency in computer architectures, offer a powerful graphic tool for eliciting scenarios from experts, as well as a basis for simulating scenario outcomes. We will describe how stochastic Petri nets can be used for deriving statistical properties of dynamic scenarios involving any number of concurrent actors. We illustrate with an application to site security, implemented using a framework for stochastic Petri net simulation developed using the statistical computing language R.

Lurdes Inoue
University of Washington

"Bayesian Joint Longitudinal-Discrete Time Competing Risks Survival Model: Evaluating biopsy protocols in an Active-Surveillance Study"

Active surveillance is an approach for avoiding overtreatment of low-risk prostate cancers. Knowing the rate at which disease progresses under active surveillance is critical for establishing an optimal frequency of surveillance testing which typically includes serial biopsies in addition to tests for the serum biomarker prostate-specific antigen (PSA). A number of active surveillance studies are ongoing, but the observed cumulative incidence of biopsy-based disease progression differs markedly across cohorts. It is unclear whether this is due to true differences in disease natural history or to other factors specific to the studies, such as differential rates of dropout to treatment in the absence of progression. In this talk we consider treatment without progression, as a competing risk and focus on estimating the posterior predictive distribution of the time to progression in the absence of treatment. Recognizing that both progression and the competing risk depend on prostate-specific antigen (PSA) growth we develop a Bayesian joint longitudinal-discrete time survival model for competing risks events data. We apply our model to a large contemporary active surveillance cohort and use the results to determine the consequences of more versus less frequent surveillance biopsies. We conclude that annual surveillance is unnecessary and that biopsying every other year will likely provide equivalent benefits but should greatly reduce harm.

Janne Kettunen
George Washington University

"Project Portfolio Risk Analysis"

We investigate trade-offs between risk and return in multi-period new product development (NPD) portfolio selection problems, where new development projects become periodically available. Our analytical and computational results show that, paradoxically, a risk-neutral NPD portfolio selection approach provides higher return and lower risk than a risk-averse selection approach. This result can explain why leading innovators tend to employ a risk-neutral NPD selection approach. The risk of the NPD portfolio can be mitigated by (i) reviewing portfolios more frequently and (ii) increasing the proportion of derivative products instead of platform products. Our results show that it is beneficial for

NPD organizations, regardless of decision makers risk aversion attitude, to foster an environment that (i) elicits as many vetted new development proposals as possible, (ii) encourages generation of high risk projects, and (iii) incubates a large variety of development projects.

Thomas Mazzuchi
George Washington University

"Risk in Engineering, Finance, Health, and Environmental Sciences"

This will be a short course intended to introduce students to the exciting field of Risk Analysis. We will begin with an overview several diverse application areas and then discuss in tern the main phases of a risk analysis namely, problem formulation, data gathering, various quantitative and qualitative modeling techniques, the use of objective and subjective data for populating the models, and developing an presenting findings from the risk analysis.

Jason Merrick
Virginia Commonwealth University

"Risk in Engineering, Finance, Health, and Environmental Sciences"

This will be a short course intended to introduce students to the exciting field of Risk Analysis. We will begin with an overview several diverse application areas and then discuss in turn the main phases of a risk analysis namely, problem formulation, data gathering, various quantitative and qualitative modeling techniques, the use of objective and subjective data for populating the models, and developing and presenting findings from the risk analysis.

Suleyman Ozekici
Koc University

"Risk Sensitive Inventory Management with Financial Hedging"

We consider a risk sensitive inventory management problem where, unlike most models in the literature, the inventory manager is sensitive to risk. The main sources of risk in inventory management are uncertainties in demand, supply as well as stochastic price fluctuations. We further consider the case where these uncertainties are correlated with the financial markets. This correlation makes it possible to hedge the risks by investing in a portfolio composed of various financial instruments. The problem therefore includes both the determination of the optimal ordering policy and the selection of the optimal portfolio. We investigate the impact of financial hedging and provide characterizations on the structure of the optimal policy. We also present numerical examples to illustrate the effects of risk-aversion on the optimal ordering policy and the effects of financial hedging on risk reduction.

Tao Pang
North Carolina State University

"Parametric and Semi-Parametric Approaches for Credit Value Adjustment Calculation"

Credit value adjustment known as CVA is an adjustment added to the fair value of an over-the-counter trade due to the risk of counterparty defaults. When the exposure to the counterparty and counterparty default risk change in the same direction, the so-called wrong-way risk (WWR) must be taken into account. The right-way risk (RWR) takes place when the two factors move in the opposite directions.

These two effects are also called directional-way risk (DWR). A lot of efforts have been made to reduce the computational burden to calculate CVA with DWR. In this paper, we start with a parametric model and get some analytical results with some simplified assumptions, which can be relaxed safely. The CVA DWR ratio is then decomposed into two factors, a robust correlation and a profile multiplier. With the decomposition, further economic insight into the CVA DWR are made. The work in this paper builds a bridge between different types of models. Thus it provides better understanding and implementation of different models.

Nicholas Polson
University of Chicago

"Deep Learning in Finance"

We explore the use of deep learning hierarchical models for problems in financial prediction and classification. Financial prediction problems -- such as those presented in designing and pricing securities, constructing portfolios, and risk management -- often involve large data sets with complex data interactions that currently are difficult or impossible to specify in a full economic model. Applying deep learning methods to these problems can produce more useful results than standard methods in finance. In particular, deep learning can detect and exploit interactions in the data that are, at least currently, invisible to any existing financial economic theory.

Authors: J. B. Heaton, N. G. Polson, J. H. Witte
(Submitted on 21 Feb 2016 (v1), last revised 23 Feb 2016 (this version, v2))

Nalini Ravishanker
University of Connecticut

"Semi-parametric Modeling of Inter-Event Durations in High-Frequency Financial Transactions Data"

Accurate modeling of patterns in inter-event durations is important in understanding and controlling risk in several applications. This talk will discuss a semi-parametric approach for modeling, in the context of high-frequency transaction level financial data. Several classes of parametric models for durations have been developed since the Autoregressive Conditional Duration (ACD) model was first proposed by Engel and Russell. Developing fast and accurate methods for estimation based on long duration series is an ongoing research problem. The framework of martingale estimating functions provides an optimal approach for developing inference for linear and nonlinear time series based on information on the first few conditional moments of the observed process. Model parameter estimation via solution of nonlinear equations, and by using recursive formulas based on linearizing the nonlinear estimating functions will be described. The recursive formulas permit fast, online estimation of parameters with large data sets. Since the accuracy of the solutions to the nonlinear equations or recursive formulas benefits immensely from good starting values of the parameters, a time-series context-specific approach for determining such starting values will be a useful topic for discussion. Extensive simulation studies enable us to assess the accuracy and speed of the approaches, and a real data example provides a practical illustration. Extensions to other classes of nonlinear time series models, as well as comparisons to other approaches such as particle filtering will be discussed. An open topic for useful discussion at the workshop will be how to implement subsequent optimal decision-making in the context of stock portfolio allocation/selection.

Allison Reilly
University of Michigan

"Games and Risk - a foundational perspective"

There has been a substantial increase in game theory among risk analysts in the past decade. Why? What does game theory have to offer the risk analyst that other approaches do not? What are the fundamental assumptions made in using standard game theoretic methods in risk analysis? What are some of the research needs as the field makes progress?

David Rios
ICMAT

"Introduction to Game Theory"

I shall provide an introduction and critical assessment of basic concepts in game theory, with a hint to computational issues and applications to security and social robotics.

- Games and Decisions: Basic Concepts. Multi-agent influence diagrams.
- Games in Normal Form. Nash equilibria.
- Games in Extensive Form. Subgame perfect equilibria.
- Games of Incomplete Information. Bayes-Nash equilibria.
- A critical assessment.
- Bayesian approaches to non-cooperative games.
- Bargaining.

Fabrizio Ruggeri
Consiglio Nazionale delle Ricerche

"Tutorial on Reliability"

The short course will introduce the basic notions in reliability and will focus mostly on repairable system, illustrating case studies representative of modeling, inference (mostly Bayesian) and decision, namely gas escapes in a city network, doors' failures in subway trains and software reliability.

Kimberly Sellers
Georgetown University

"A Generalized Statistical Control Chart for Dispersed Count Data"

The Poisson distribution is a popular distribution used to describe count information, from which control charts involving count data have been established. Several works recognize the need for a generalized control chart to allow for data over-dispersion; however, analogous arguments can also be made to account for potential under-dispersion. The Conway–Maxwell–Poisson (COM-Poisson) distribution is a general count distribution that relaxes the equi-dispersion assumption of the Poisson distribution, and in fact encompasses the special cases of the Poisson, geometric, and Bernoulli distributions. Accordingly, a flexible control chart is developed that encompasses the classical Shewart charts based on the Poisson, Bernoulli (or binomial), and geometric (or negative binomial) distributions.

Ehsan Soofi
University of Wisconsin-Milwaukee

"Jensen-Shannon Information of the Coherent System Lifetime"

The signature of a coherent system with n components is an n-dimensional vector whose i-th element is the probability that the i-th failure of the components is fatal to the system. The signature depends only on the system design and provides useful tools for comparison of systems. We propose the Jensen-Shannon information (JS) criteria for comparison of systems, which is a scalar function of the signature and ranks systems based on their designs. The JS of a system is interpreted in terms of the remaining uncertainty about the system lifetime, dependence between the lifetime and the number of failures of components fatal to the system, and the Bayesian decision theory. The JS is non-negative and its minimum is attained by k-out-of-n systems, which are the least complex systems. This property offers JS as a measure of complexity of a system. Effects of expansion of a system on JS are studied. Application examples include comparisons of various sets of new systems and used but still working systems discussed in the literature. We also give an upper bound for the JS at the general level and compare it with a known upper bound for the mixture distributions.

Refik Soyer
George Washington University

"Decision Analysis in Reliability"

In this course we consider decision problems that arise in reliability analysis and discuss how these problems can be represented in a decision theoretic framework and how they can be solved using decision analysis methods. Our discussion will consider both single-stage and multi stage decision problems as well as use of computational methods for solution including Monte Carlo techniques. Decision problems will include optimal replacement strategies, design of life tests, optimal stopping as well as recent work in adversarial life testing.

Canan Ulu
Georgetown University

"Risk Aversion, Information Acquisition, and Technology Adoption"

We use a dynamic programming model to study the impacts of risk aversion on information acquisition in technology adoption decisions. In this model, the benefit of the technology is uncertain and, in each period, the decision maker (DM) may adopt the technology, reject the technology, or pay to acquire a signal about the benefit of the technology. The dynamic programming state variables are the DM's wealth and a probability distribution that describes the DM's beliefs about the benefit of the technology; these distributions are updated over time using Bayes' rule. If the signal generating process satisfies the monotone-likelihood ratio property and the DM is risk-neutral, the value functions and policies satisfy natural monotonicity properties: a likelihood-ratio improvement in the distribution on benefits leads to an increase in the value function and moves the DM away from rejection and towards adoption. With risk aversion, the value functions (now representing expected utilities) will be monotonic, but the policies need not be monotonic, even with reasonable utility functions. However, if we assume the DM exhibits decreasing absolute risk aversion and is not "too risk averse," the policies can be shown to be monotonic. Establishing these structural properties requires the use of some novel proof techniques that may prove useful in other contexts. We also study the impact of changing risk attitudes on the optimal policy.

Mike West
Duke University

"Portfolio Decisions and Dynamic Bayesian Forecasting Models for Portfolio Risk Characterization"

I discuss some of the basics of Bayesian portfolio decision analysis and the use of dynamic Bayesian forecasting of multivariate financial time series that drive such decisions. I highlight recent developments aiming to scale Bayesian methods to higher dimensions while improving characterization of risk via novel multivariate stochastic volatility models. The latter are fundamental to evaluating the balance of risk & return in Bayesian portfolio decision analysis. Examples using simultaneous graphical dynamic models reflect some recent developments and open questions, and give connections to broader questions of measuring and characterizing risk in global financial and economic systems.

Simon Wilson
Trinity College Dublin

“Risk Elicitation in Complex Systems: application to spacecraft re-entry”

We discuss approaches to risk assessment in complex systems where there is lots of dispersed background information across many experts about different aspects of it, but little prospect of much data, either for reasons of the cost of testing or observation, or because the risk event in question is infrequent. To elicit all aspects of the system in detail is impractical. We investigate the use of analytic hierarchy process to simplify the elicitation process on different aspects of the system, which is then combined to a system risk assessment using standard methodology such as fault trees. We also how look at how observations of the system under different conditions, that affect the risk, might be incorporated.

This procedure is illustrated with an example from the space industry, where interest is in assessing the risk of an explosion during re-entry of a spacecraft that is being intentionally de-orbited to burn up in the atmosphere. This strategy is increasingly used to remove decommissioned spacecraft from orbit so as to reduce the problem of space junk. Such an explosion could cause parts of the spacecraft to land on inhabited areas of the ground, and so quantifying the risk of this event is of interest.

Most unmanned space missions in low Earth orbit end up with a destructive atmospheric re-entry as a way of reducing the amount of space junk. From ten to forty percent of a re-entering satellite's mass may impact the Earth's surface, representing a hazard to people and assets.

Many tools have been designed in order to assess the risk linked to the surviving fragments, but none of them include a model devised for the cases, not so rare, in which the vehicle explodes during the re-entry. This can be due to a variety of causes such as fuel left in tanks and over-heating batteries.

For this reason we want to propose a statistical tool able to ll this gap. Our tool includes an explosive hazard assessment model and a fragmentation model. In this talk we focus on the first one, predicting which kind of fragmentation events occur through the combination of failure models in a Bayesian network framework.

It has been built relying on data coming from the ESA/NASA Automated Transfer Vehicle Jules Verne re-entry airborne observation campaign. Bayesian inference methods are very suitable, this being a

problem where data are scarce but expert knowledge is large. Indeed the incorporation of expert opinion was crucial, as well as the strategies developed to deal with the incompleteness of data sources.

Emmanuel Yashchin
IBM Research

"Decision-Making in Systems for Monitoring Reliability of Mass-Produced Items"

Modern early warning systems are based on a decision-making process that assesses the state of monitored processes and produces signals that are communicated to users. Some of the signals are related to detected unfavorable process conditions, others might signify model adequacy issues or opportunities for process improvement. In this talk we discuss factors influencing decision-making in large-scale reliability monitoring systems. We also discuss examples related to systems for warranty data analysis.

Jun Zhuang
University at Buffalo

"Validating Models of Adversary Behavior"

Hundreds of billions of dollars have been spent on homeland security since September 11, 2001, and numerous models have been developed to study the strategic interactions between defenders and adversaries (e.g., attackers or terrorists). Unfortunately, few if any models have yet been validated using empirical data, limiting the application of those models in practice. We will discuss various methods on validating models of adversary behavior, examples, challenges, and future research directions.