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Desheng Wu

University of the Chinese Academy of Sciences, dash@risklab.ca

David L. Olson

University of Nebraska - Lincoln, dolson3@unl.edu

Alexandre Dolgui

IMT Atlantique, alexandre.dolgui@imt-atlantique.fr

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Artificial Intelligence in Engineering Risk Analytics

Desheng Wu^{a*}, David L. Olson^{b*}, Alexandre Dolgui^c

^aEconomics and Management School, University of the Chinese Academy of Sciences Beijing 100049, China and Stockholm Business School Stockholm University Stockholm 114 18, Sweden dash@risklab.ca (corresponding)

^bCollege of Business Administration University of Nebraska Lincoln, NE 68588 USA dolson3@unl.edu (corresponding)

^cIMT Atlantique, LS2N, CNRS, La Chantrerie, 4, rue Alfred Kastler - B.P. 20722, F-44307 Nantes Cedex 3, France alexandre.dolgui@imt-atlantique.fr

Introduction

Risks exist in every aspect of our lives, and can mean different things to different people. While negative in general they always cause a great deal of potential damage and inconvenience for stakeholders. Recent engineering risks include the Fukushima nuclear plant disaster from the 2011 tsunami, a year that also saw earthquakes in New Zealand, tornados in the US, and floods in both Australia and Thailand. Earthquakes, tornados (not to mention hurricanes) and floods are repetitive natural phenomenon. But the October 2011 floods in Thailand were the worst in 50 years, impacting supply chains including those of Honda, Toyota, Lenovo, Fujitsu, Nippon Steel, Tesco, and Canon. Human-induced tragedies included a clothing factory fire in Bangladesh in 2012 that left over 100 dead. Wal-Mart and Sears supply chains were downstream customers. The events of Bhopal in 1984, Chernobyl in 1986, Exxon Valdez in 1989, and the Gulf oil spill of 2010 were tragic accidents. There are also malicious events such as the Tokyo Sarin attack in

1995, The World Trade Center and Pentagon attacks in 2001, and terrorist attacks on subways in Madrid (2004), London (2005), and Moscow (2010). The news brings us reports of such events all too often. The next step up in intensity is war, which seems to always be with us in some form somewhere in the world. Complex human systems also cause problems. The financial crisis resulted in recession in all aspects of the economy. Risk and analytics has become an important topic in today's more complex, interrelated global environment, replete with threats from natural, engineering, economic, and technical sources (Olson and Wu, 2015).

Thus we need to engineer systems to reliably cope with the high levels of uncertainty induced by the complex systems we build. Using Artificial Intelligence techniques for engineering risk and analytics decisions is a fast-growing and promising multidisciplinary research area (Olson and Wu, 2017). AI techniques that are useful include, but are not limited to expert systems, artificial neural networks, support vector machines, evolutionary computations, fuzzy systems, knowledge based systems, case-based reasoning, agent-based models, and their hybrids, etc. For example, artificial intelligence models such as neural networks and support vector machines have been widely used for establishing the early warning system for monitoring a company's financial status. Agent-based theories are employed in supply chain risk management. Business intelligence models are also useful in hedging financial risks by incorporating market risks, credit risks, and operational risks. Investigation of business intelligence tools in risk management is beneficial to both practitioners and academic researchers. A new and promising approach is to hybridize AI techniques with operations research approaches (Schemeleva et al, 2012). The call for papers of this special issue asked for real world applications of risk management in engineering using artificial intelligence tools.

Artificial Intelligence in Engineering Risk Management

Since risk is inherent in human activity, risk management is needed in all aspects of human activity. This includes engineering, where catastrophes such as the Tacoma Narrows Bridge failure would be good to avoid. Artificial intelligence continues to evolve, and while some may question the ultimate limits to computer ability, others see great opportunities (Kurzweil, 2000; 2006). Conversely, artificial superintelligence could cause global catastrophe. Barrett and Baum (2017) discussed artificial superintelligence decision-making risk.

The application of artificial intelligence tools to engineering is widespread. Schneidewind (2009) reported risk management applicable to NASA Space Shuttle software risk prediction, using a cumulative failures gradient function. Wong and Qi (2009) used neural networks in program debugging to identify the exact location of program faults. Fuzzy systems have been used to create more robust wireless networks (Luo et al., 2009). More recently, systems to avert cyber intelligence threats have been developed using semantic text modeling (Qamar et al., 2017).

The energy sector involves many problems calling for risk management. Boonchuay and Ongsakul (2012) applied particle swarm optimization to assess bidding strategies for a power generation firm. Shariatinasab et al. (2014) used neural networks to replace simulation in evaluating lightning flashover outage avoidance strategies. Nuclear power risk assessment was supported by artificial intelligence models reported by Pourali (2014).

In the financial engineering domain, applications of artificial intelligence tools to improve investment risk management have existed for a long time. Mileris and Boguslauskas

(2010) reported data mining and factor analysis models for the well-studied application area of credit risk estimation. Simulated annealing was used for the same general problem by Li and Ng (2013). Chinese financial fraud risk was assessed by data mining algorithms to include neural networks by Song et al. (2014). Credit risk management practices were evaluated by Butaru et al. (2016) using machine learning.

There are many other domains of human activity where artificial intelligence risk management models have been applied. Text mining algorithms were used by Lee et al. (2013) in patent claim analysis. Ou et al. (2013) used neural networks to predict driver safety risk prediction. Zhou et al. (2016) applied Bayesian analysis models in a medical decision support system to aid expert judgment. In food security management, Chang et al. (2017) used Markov game theoretic models to avoid food contamination. Thus we see that practically every aspect of human activity involves engineering problems where artificial intelligence modeling can be fruitfully applied. Many problems requiring applications of such techniques in production systems, supply chains and logistics can be found in (Dolgui and Proth, 2010; Ivanov et al., 2017).

Journal Risk Management Applications

Engineering Applications of Artificial Intelligence has a history of publishing articles related to artificial intelligence in risk management. Fu (2011) reviewed data mining applications to time series. Wang et al. (2014) used grey models for prediction related to the largest video site in China. Sundarkumar and Ravi (2015) considered dataset balancing in customer credit card churn prediction. He et al. (2016) used fuzzy TOPSIS and rough sets for new product failure analysis.

Krishna and Ravi (2016) used evolutionary computer in support of customer relationship management. Finally, Gan et al. (2017) reported a means to improve data mining pattern recognition for time-based data.

Contents of Special Issue

This first half of this special issue includes five papers with current applications of artificial intelligence to real engineering problems. Chou applied artificial neural networks and other data mining models to deal with corrosion in concrete structures and steels in Taiwan. This is a highly nonlinear, complex problem, and a smart firefly algorithm was used with other models on two real datasets. This provides civil engineers with a superior means to schedule maintenance to reduce risk of structural failure. Datta provided a fuzzy set model to a metropolitan construction project involving an underground rail station in an Indian metro area. Pendharkar used data mining ensembles to improve posterior classification fit to real data in general. Luo applied deep belief networks to better assess credit scoring of credit default swaps. Finally, Silva, Santos, Bottura and Oleskovicz gave a neural network model to monitor voltage amplitude in an electrical distribution system in Brazil.

Thus we see a variety of useful artificial-intelligence related models being applied to real problems. This special issue includes five diverse applications utilizing a variety of artificial intelligence related tools. It is a pleasure to be able to provide readers access to these innovative and effective improvements in risk management in engineering.

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BIOS of Guest editors:

Desheng Dash Wu is a Distinguished Professor with the University of Chinese Academy of Sciences, Beijing, China, and a Professor with Stockholm University, Stockholm, Sweden. Over the past few years, he has actively participated in several research projects sponsored by both government agencies and industry. He has authored or coauthored more than 100 papers in refereed journals such as *Production and Operations Management*, *Decision Support Systems*, *Decision Sciences*, *Risk Analysis*, and the *IEEE Transactions on Cybernetics*. He is the Editor of the book series entitled *Computational Risk Management* (Springer). His research interests focus on enterprise risk management, business data mining, and performance evaluation. Prof. Wu is a member of the Professional Risk Managers' International Association Academic Advisory Committee. He is the Chair of the IEEE System Council Analytics and Risk Technical Committee. He has been an Associate Editor/Guest Editor for several journals including the *IEEE Transactions on Cybernetics*, *Annals of Operations Research*, *Computers and Operations Research*, *International Journal of Production Economics*, *Risk Analysis*, and *Omega*.

David L. Olson is the James & H. K. Stuart Professor of management information systems and the Chancellor's Professor with the University of Nebraska, Lincoln, NE, USA. From 1999 to 2001, he was a Lowry Mays Endowed Professor with Texas A&M University. His research has been published in more than 200 refereed journal papers, primarily on the topic of multiple objective decision-making and information technology. He has made more than 150 presentations at international and national conferences on research topics. He has

authored more than 20 books. Prof. Olson is a member of the Institute for Operations Research and Management Sciences and the Multiple Criteria Decision Making Society. He is a Fellow of the Decision Sciences Institute. He was named a James C. and Rhonda Seacrest Fellow from 2005 to 2006. He is the Co-Editor-in-Chief of the International Journal of Services Sciences and an Associate Editor of a number of journals. He was the recipient of the Raymond E. Miles Distinguished Scholar Award in 2002 and was named the Best Enterprise Information Systems Educator by IFIP in 2006.

Alexandre Dolgui is a Distinguished Professor, Head of Department at the IMT Atlantique (former Ecole des Mines de Nantes), France. His research focuses on manufacturing line design, production planning and supply chain optimization. He is the co-author of 5 and co-editor of 16 books, he published 194 refereed journal papers, 23 editorials and 28 book chapters as well as over 390 papers in conference proceedings. He is a Fellow of the European Academy for Industrial Management, Member of the Board of the International Foundation for Production Research, Chair of IFAC TC 5.2 on Manufacturing Modelling for Management and Control, Member of IFIP WG 5.7 on Advances in Production Management Systems and IEEE System Council Analytics and Risk Technical Committee. He is an Area Editor of Computers & Industrial Engineering, consulting Editor of the International Journal of Systems Science. He is Member of the Editorial Boards for 23 other journals, including the International Journal of Production Economics, and Risk and Decision Analysis journal. He is the Editor in Chief of the International Journal of Production Research.