Risk Intelligence in Big Data Era: A Review and Introduction to Special Issue

Desheng Wu and John R. Birge

Abstract—**Risks exist in every aspect of our lives, and can mean different things to different people, while negatively in general they always cause a great deal of potential damage and inconvenience for the enterprise stakeholders. Investigation of risk analytics tools in today's big data era is beneficial to both practitioners and academic researchers from industrial systems. The current special issue provides some view of how risk-based business intelligence can be applied to industrial systems faced with big data issues.**

Index Terms—**Big data, risk intelligence, risk management.**

I. Introduction

TODAY'S modern economy and contemporary business are growing faster and in ways unrivalled throughout history, this has led to that industrial systems are facing increasingly complex uncertainties and more difficult challenges in their decision making to manage risks. On the other hand, the business environment is featured with massive volumes of structured and unstructured data. For example, a consumer brand strengthens its reputation by monitoring social media data, a hospital improves patient safety based on health records or a bank fights fraud by analyzing time-series trades [6].

We are very pleased to see completion of this special issue of IEEE Transactions on Cybernetics: Risk Intelligence in Big Data Era. In the following section we will present a review of risks while the one after next introduces contents in the special issue.

II. Risks

Risks negatively in general cause a great deal of potential damage and inconvenience for the stakeholders of industrial systems. Disaster risks include terrorism leading to the gassing of the Japanese subway system, to 9/11/2001, to bombings of Spanish and British transportation systems, and the SARS virus disrupting public and business activities, particularly in Asia. The financial crisis has resulted in recession in all aspects of the economy [4].

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However, risk does not necessarily always mean damage. Businesses in industrial systems exist to cope with risks since risks exist in every aspect of our business environment [5]. In the U.S., genetic management is generally viewed as a way to obtain better and more productive sources of food more reliably. However, there are strong objections to bioengineered food in Europe and Asia.

Different disciplines have different ways of classifying risks. In order to explain the risk management lessons from the Credit Crisis, Jorion [2] classified risks into: 1) known known; 2) known unknowns; and 3) unknown unknowns. This is actually based on the degree of risks and is similar to what Olson and Wu [4] discussed. We propose the following general classification of risks: 1) field-based and 2) property-based.

A. Field-Based Classification

Risks based on field study includes both financial and nonfinancial types. The first type basically includes all risks from either financial sectors or financial issues in other sectors. Typical risks, for example, include market risk, credit risk, operational risk, operational risk, and liquidity risk. Nonfinancial risks indicate risks from sources that are not related to finance. Examples of these include, but are not restricted to, political risks, reputational risks, bioengineering risks, and disaster risks.

B. Property-Based Classification

We extend three risk properties (i.e., probability, dynamics, and dependence) in [3] to consider five risk properties: 1) probability; 2) dynamics; 3) dependence; 4) conflict; and 5) complexity. The first two properties have been widely recognized in intertemporal models from the behavioral decision and behavioral economics areas [1]; the last three properties are well studied in finance discipline, game theory discipline and artificial intelligence discipline, respectively.

Risk probability applies probability theory and various distributions to model risks. This approach can be dated back to the 1700s, leading to Bernoulli, Poisson, and Gaussian models of events and general Pareto distributions and general extreme value distributions to model extreme events. Dynamics of risks mainly uses stochastic process theory in risk management. This can be dated back to 1930s where Markov processes, Brownian motion, and Levy processes were developed. Dependence of risks deals with correlation among risk factors. Various copula functions are built and Fourier transformations are also used. Conflict of risks mainly considers comprehensively assess risk factors that are in conflict with each other. Complexity of risks handles situations where risk properties are basically not from the above four cases. This can be due to the fact that multiple above-mentioned properties take place, or because more complex risk factors happen.

Risk analytics has become especially important in industrial systems during the last decade. Risk analytics technology in industrial systems such as operations management systems enables users to capture, extract and analyze data and deliver risk intelligence that helps improve decision making strategy, operations, and performance. New risk analytics approaches such as enterprise risk management (ERM) has emerged as a systematic and integrated approach to manage risks facing an organization. ERM seeks the most effective ways to deal with financial and operations systems risks in the big data era. It has become a vital topic in both academia and practice during the past several decades. Data oriented risk analytics has recently received widespread attention from both the business and academic community—it is now emerging as a new discipline in systems science and engineering.

III. Issue Contents

The papers in this section include five modeling risk intelligence papers in the big data era: one for risk intelligence system for biodiversity enterprises which depend on a supply of endangered species for their revenue, one for systems reliability as an effective systems risk management tool in the big data era, one for mobile systems facing a number of application vulnerabilities, one for performance-based control design problem for double-layer networked industrial processes, and one for an intelligent carpool system where an automated service process assists carpool participants in determining routes and matches. This set of risk management papers cover major typical topics: agent/individual-based economic-ecological model applied to the case of South African rhinos, optimal biobjective redundancy allocation for systems reliability risk management, risk assessment for mobile systems through a multilayered hierarchical Bayesian network, performance-based adaptive fuzzy tracking control for networked industrial processes, and stochastic particle swarm optimization (PSO) based on local exploration for solving the carpool service problem (CSP).

Haas and Ferreira developed a risk intelligence system for biodiversity enterprises which depend on a supply of endangered species for their revenue. Many of these enterprises cannot purchase a supply of this resource and are largely unable to secure the resource against theft in the form of poaching. Authors developed an agent/individual-based economic-ecological model that captures these effects and apply it to the case of South African rhinos. The developed model uses observed rhino dynamics and poaching statistics. Govindan *et al.* presented systems reliability as an effective systems risk management tool in the big data era. Authors developed a multiobjective approach, with hybridization of a known algorithm called NSGA-II and an adaptive population-based simulated annealing method solve the systems reliability optimization problems. In the first step, to create a good algorithm, authors use a coevolutionary strategy. Li *et al.* studied mobile systems facing a number of application vulnerabilities that can be combined together and utilized to penetrate systems with devastating impact. When assessing the overall security of a mobile system, it is important to assess the security risks posed by each mobile applications (apps), thus gaining a stronger understanding of any vulnerabilities present. Authors developed a three-layer framework that assesses the potential risks which apps introduce within the Android mobile systems. Wang *et al.* investigated the performance-based control design problem for double-layer networked industrial processes. The prescribed performance functions are first given to describe the output tracking performance, and then by using backstepping technique, new adaptive fuzzy controllers are designed to guarantee the tracking performance under the effects of input dead-zone and the constraint of prescribed tracking performance functions. Chou *et al.* examined an intelligent carpool system where an automated service process assists carpool participants in determining routes and matches. It is a discrete optimization problem that involves a system-wide condition as well as participants' expectations. Authors solved the CSP to provide satisfactory ride matches. They developed a particle swarm carpool algorithm based on stochastic set-based PSO.

IV. Conclusion

Amongst applications of system engineering and expert systems, IEEE Cybernetes also considered risk and risk management at its core. Risk-based decision support system is critically important in big data era. This special issue presents five papers reflecting current research applying a variety of data analytics models to risk management support. We hope that this carefully selected set of papers are useful to both practitioners and academia.

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