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A multi-agent system for web-based risk management in small and medium business

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ABSTRACT

Business Intelligence has gained relevance during the last years to improve business decision making. However, there is still a growing need of developing innovative tools that can help small to medium sized enterprises to predict risky situations and manage inefficient activities. This article present a multi-agent system especially created to detect risky situations and provide recommendations to the internal auditors of SMEs. The core of the multi-agent system is a type of agent with advanced capacities for reasoning to make predictions based on previous experiences. This agent type is used to implement a evaluator agent specialized in detect risky situations and an advisor agent aimed at providing decision support facilities. Both agents incorporate innovative techniques in the stages of the CBR system. An initial prototype was developed and the results obtained related to small and medium enterprises in a real scenario are presented.

1. Introduction

In the present financial context, it is relevant to provide innovative tools and decision support systems that can help the small-medium enterprises (SMEs) to improve their functioning (Khashman, 2009; Sun & Li, 2009a, 2009b). These tools and methods can contribute to improve the existing business control mechanisms, reducing the risk by predicting undesirable situations and providing recommendations based on previous experiences (Chi-Jie, Tian-Shyug, & Chih-Chou, 2009; Li & Sun, 2008; Sun & Li, 2008a, 2008b). As a consequence of this, the need of periodic internal audits has arisen. However, evaluating and predicting the evolution of these types of business entities, which are characterized by their great dynamism, tends to be a complicated process. It is necessary to construct models that facilitate the analysis of the work carried out in changing environments such as finance. The processes carried out inside a company are grouped into functional areas (Corchado, Díaz, Borrajo, & Fdez-Riverola, 2000) denominated "Functions". A Function is a group of coordinated and related activities that are systematically and iteratively carried out during the process of reaching the company's objectives (Li & Sun, 2009). The functions that are usually carried out within a company, as studied within the framework of this research, are: Purchases, Cash Management, Sales, Information Technology, Fixed Assets Management, Compliance to Legal Norms and Human Resources. Each one of these functions is broken down into a series of activities. For example, the Information Technology function is divided into the following activities: Computer Plan Development, Study of Systems, Installation of Systems, Treatment of Information Flows, and Security Management.

This article proposes an innovative approach, based on multi-agent systems (Bajo, De Paz, De Paz, & Corchado, 2009), to propose a model for risk management and prediction in SMEs. Multi-agent systems are the most prevalent solution to construct Artificial Intelligence distributed systems. Agents are computational entities that can be characterized through their capacities in areas such as autonomy, reactivity, pro-activity, social abilities, reasoning, learning and mobility (Bajo et al., 2009). These capacities make the multi-agent systems very appropriate for constructing intelligent environments. An agent can act as an interface between the user and the rest of the elements of the intelligent environment. Moreover, intelligent agents can incorporate advanced artificial intelligence models to predict risky situations. In this study we propose a distributed approach where the components of a SME are modelled as intelligent agents that collaborate to create models that can evolve over the time and adapt to the changing conditions of the environment. Thus, making possible to detect risky situations for the SMEs and providing suggestions and recommendations that

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can help to avoid possible undesirable situations. The core of the multi-agent system are the evaluator and advisor agents, that incorporate new techniques to analyze the data from enterprises, extract the relevant information, and detect possible failures or inefficiencies in the operation processes.

The evaluator and advisor agents are CBR-BDI agents (Corchado & Laza, 2003) that make use to past experiences to resolve new problems. CBR (Case-Based Reasoning) which uses past experiences to solve new problems (Kolodner, 1983), as such, it is perfectly suited for solving the problem at hand. In addition, CBR makes it possible to incorporate the various stages of expression analysis into the reasoning cycle of the CBR, thus facilitating the creation of strategies similar to the processes followed in small and medium enterprises. On one hand the evaluator agent is specialized in detecting risky situations. The recovery of information from previous experiences simplifies the prediction process by detecting and eliminating relevant and irrelevant patterns detected in previous analyses. The retrieve phase of the hybrid neural intelligent system incorporates the Expectation Maximization clustering technique (Dellaert, 2002). The reuse stage incorporates an innovative mixture of experts that makes use of multilayer perceptron, support vector regression and radial basis function neural network. The revise and retain stages implement a decision support system for experts. Moreover, the knowledge obtained during the prediction process is of great importance for subsequent predictions. On the other hand, the advisor agent is specialized in providing recommendations to avoid risky situations and improving the overall functioning of the SME. The retrieve phase recovers similar cases and their corresponding solutions. The reuse phase incorporates a novel approach based on decision trees and probabilistic gain functions to assess efficient and inefficient tasks. The revise and retain stages also implement a decision support system for experts. There are various artificial intelligence techniques such as artificial neural networks (Bianchia, Calogero, & Tirozzi, 2007; Sawa & Ohno-Machado, 2003), Bayesian networks (Baladandayuthapani, Ray, & Mallick, 2005), and fuzzy logic (Avogadri & Valentini, 2009) which have been applied to business failure prediction. While these techniques can be applied to failure detection and prediction, the knowledge obtained cannot be incorporated into successive tests and included in subsequent analyses. This article presents a hybrid neural intelligent system based on mixtures of experts and decision trees that have the ability to adapt to changes in the environment making use of past experiences. In this way, this article proposes an innovative approach where the knowledge acquired when resolving new problems is used for future situations.

The approach presented in this article is an evolution of our previous works and proposes an innovative perspective (Borrajo, Corchado, Yanez, Fdez-Riverola, & Diaz, 2005; Corchado, Borrajo, Pellicer, & Yanez, 2005). The new approach proposes a multi-agent system to model the organizational structure of a SME. Moreover, the core of the system is a CBR-BDI agent type with the ability to adapt to the changes in the environment. In Borrajo et al. (2005), we presented a system composed of two case-based reasoning systems to detect the associate risk in the activities of SMEs in the textile sector and generate recommendations to improve the erroneous processes. In Corchado et al. (2005), we presented a decision support tool based on a case-based reasoning system that automates the internal control processes of a SME. The new approach proposes new methods for the retrieval stage of the CBR systems, as the Expectation Maximization clustering that notably improves the case's recovery reducing the final quantity of cases retrieved and making it easier to recover the most similar cases to the problem introduced. Moreover, the approach proposes very innovative reuse mechanisms, based on mixture of experts and probabilistic decision trees.

The article is structured as follows: the next section briefly introduces the problem that motivates this research. Section 3 presents the multi-agent system for managing small and medium enterprises. Section 4 describes the implementation of the multi-agent system, focusing on the internal structure of the Evaluator and Advisor agents. Section 5 and 6 presents the results obtained after testing the system and the conclusions of this study.

2. Enterprise risk management

"Risk Management" is a broad term for the business discipline that protects the assets and profits of an organization by reducing the potential for risks before it occurs, mitigating the impact of a loss if it occurs, and executing a swift recovery after a loss occurs. It involves a series of steps that include risk identification, the measurement and evaluation of exposures, exposure reduction or elimination, risk reporting, and risk transfer and/or financing for losses that may occur. All organizations practice risk management in multiple forms, depending on the exposure being addressed (Calderon & Cheh, 2002).

The economic environment has increased the pressure on all companies to address risks at the highest levels of the organization. Companies that incorporate a strategic approach to risk management use specialized tools and have more structured and frequent reporting on risk management. As such, they are in a better position to ensure that risk management provides relevant and applicable information that meets the needs of the organization and executive team. But no matter what an organization's approach is, the tools used must be backed up by solid, actionable reporting addressed (Calderon & Cheh, 2002). It is not always necessary for the risk managers to be conducting their own studies for their voices to be heard. Forging a strong relationship with internal auditors and other departments can allow risk practitioners to supplement their reports with the risk manager's own analysis (Colbert, 1995).

Enterprise Risk Management (ERM) is defined as "a process, effected by an entity's board of directors, management and other personnel, applied in strategy-setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives" (COSO, 2009).

The managing of risks and uncertainties is central to the survival and performance of organizations. Enterprise risk management (ERM) is an emerging approach to managing risks across different business functions in an organisation that represents a paradigm shift from specialized approaches in managing specific risks (Ding, Song, & Zen, 2008; Huang, Tsai, Yen, & Cheng, 2008; Li & Sun, 2009; Lin, Wang, Wu, & Chuang, 2009; Ramamoorti, Bailey, & Traver, 1999). This paper provides a web intelligent model to ERM, which will subsequently lead to better organisational performance.

ERM represents a revolutionary change in an organization's approach to risk. ERM broadens the scope of risk management behaviours to include every significant business risk of the organization, comprehensively and systemically. It requires that all of these risks be considered in relation to each other to create a consolidated risk profile. It expands the scope of risk management practices beyond the physical and financial exposures to include issues such as long-term strategy, competitor response, human capital, and operational exposures, to name a few. In addition, ERM encompasses all aspects of an organization in managing risks and seizing opportunities related to the achievement of the organization's objectives, not only for protection against losses, but for reducing uncertainties, thus enabling better performance against the organization's objectives (Calderon & Cheh, 2002).