Enterprises Monitoring for Crisis Preventing Based on Knowledge Engineering

Nafisa I. Yusupova, Gyuzel R. Shakhmametova, and Elmira Kh. Dusalina

Computer Science & Robotics Dept.
Ufa State Aviation Technical University, Russia
yussupova@ugatu.ac.ru,
shakhgouzel@mail.ru,
dusalina.elmira@gmail.com

Abstract. Decision support system (DSS) for enterprises monitoring on the base of knowledge engineering is considered. The technologies of expert systems and data mining are used for DSS. The developed system assumes continuous monitoring of the enterprises indicators and consists of three modules. The expert systems technology forms the basis of the two modules of the DSS – the first module is to classify enterprises depending on the level of crisis states risk, and the second one is to identify the signs of a false crisis states (fraudulent bankruptcy) on the base of forecasted indicators. The data mining module is to forecast the financial indicators of the enterprise. The decision maker using the DSS may be the top manager or supervisory authority. It is possible for users of the system to monitor the major trends in the economic processes of the enterprise. This approach has been used on the example of state monitoring of number of industrial and agro-industrial enterprises of Republic Bashkortostan. The practical application of the DSS prototype, allowing realizing approach suggested, is considered.

Keywords: Enterprise monitoring, crisis preventing, bankruptcy, decision support system, expert system technology, data mining.

1 Introduction

Enterprises monitoring is a management process component, which represents an enterprise activity continuous observation and analysis with a changes dynamics tracking. Monitoring of enterprises is important for identification of possible signs of crisis states, its preventing and enterprises safety. Enterprises crisis states include its insolvency, an inability to pay debts and a bankruptcy. Quickly estimation of the changes in the financial state of the enterprise allows to realize management decisions at the early stage of the crisis and to avoid the negative consequences for enterprise. One of the main enterprise crises is a bankruptcy. The researches in the field of bankruptcy monitoring have been carried on for a long time and can be found in the papers of many scientists, as well as in the IT-decisions. These problems are considered in detail in [6]. In the article the decision support system (DSS) for enterprises

G.L. Kovács and D. Kochan (Eds.): NEW PROLAMAT 2013, IFIP AICT 411, pp. 343–353, 2013.

monitoring on the base of knowledge engineering is proposed. The second section describes state of art in enterprise bankruptcy forecasting, third one – the problem statement. The decision support system (DSS) for enterprises monitoring is considered in forth section. The fifth section is devoted to DSS modules in details and in sixth section DSS implementation efficiency analysis is presented.

2 State of Art

There are two main approaches to enterprise bankruptcy forecasting in modern business and financial performance practice [1]. Quantitative methods are based on financial data and include the following coefficients: Altman Z-coefficient (the USA); Taffler coefficient (Great Britain); two-factor model (the USA); Beaver metrics system and the others. A qualitative approach to enterprise bankruptcy forecasting relies on the comparison of the financial data of the enterprise under review with the data of the bankrupt business (Argenti A-account, Scone method). Integrated points-based system used for the comprehensive evaluation of business solvency includes the characteristics of both quantitative and qualitative approaches. An apparent advantage of the methods consists in their system and complex approach to the forecasting of signs of crisis development, their weaknesses lie in the fact that the models are quite complicated in making decisions in case of a multi-criteria problem, it is also worth mentioning that the taken forecasting decision is more subjective.

The carried-out analysis of methods of enterprises bankruptcy predicting and the analysis of possibilities of well known IT-decisions in this field showed that the development of a decision support system for bankruptcies monitoring is needed [6]. The data required for anti-crisis management are semi-structured data in the majority of cases and therefore the application of intelligent information technologies is necessary [3, 5].

Financial and economic application software that is available on the market nowadays is quite varied and heterogeneous. The necessity to develop such software products is dictated by the need of enterprises to promptly receive management data in due time and to forecast the signs of crisis development. To one extent or another, tools for anti-crisis management are available in a number of ready-made IT-decisions [6]. But the data analysis in many software products actually consists in providing the necessary strategic materials, while software products should meet the increasing needs such as analysis and forecasting enterprise financial performance in the next period of report.

The distinguishing feature of presenting research is the possibility of fraudulent bankruptcy indications forecasting at its early stages when it is possible to take preventive measures.

3 Problem Statement

Enterprises monitoring involves an enterprise activity observation, works on adverse effects timely detection and assessment and includes a creation and an

implementation of modern techniques providing a data collection and transmission automation. Enterprises monitoring goal is an early crisis (bankruptcy) signs detection, warning and prevention based on enterprise financial indicators analysis.

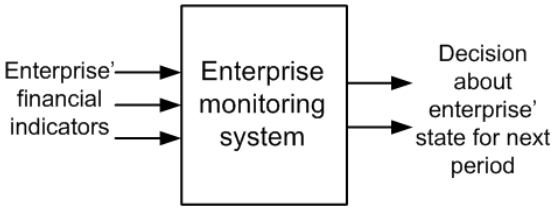

Fig. 1. Enterprise monitoring system

Enterprises monitoring allows a bankruptcy process information transparency organizing, an enterprise economic component subjectivity assessment reducing and a decision maker early warning in case of a false bankruptcy signs presence.

Data required for enterprises monitoring are both structured (characterized by a large volume and represent diverse information that contains hidden patterns) and semi structured, that creates an information processing problem. Therefore, it's not always possible to solve a problem of a decision making support without an intelligent information technology application.

The authors of the study aim to develop models and algorithms based on intelligent technologies for the detection of the crisis state of the enterprise while still in its early stages for the timely changes of the development strategy of the enterprise, which will increase stability and economic independence of the enterprise, as well as reduce the impact of the human (subjective) factor on making important management decisions. Decision support system for crisis management is discussed in this article on the example of monitoring bankruptcies.

4 Decision Support System for Monitoring Bankruptcy

The major aspect of the bankruptcy monitoring problem is the analysis and identification in good time of the signs of fraudulent bankruptcies [1]. The basis of the whole complex of techniques for the decision support system (DSS) is legally approved methodical instructions on accounting and analysis of enterprise' financial position and solvency so as to group the enterprises depending on the level of risk of bankruptcy, as well as techniques for the identification of the signs of fictitious and deliberate bankruptcy. These techniques are currently used by auditors and arbitration managers. To develop the decision support system for monitoring enterprise bankruptcy the authors propose the following general scheme of DSS (Figure 2) and used knowledge engineering, expert system (ES) technology [3] and data mining (DM) technology [2].

The expert system technology underlies two modules of DSS in bankruptcy monitoring [7]:

- module for grouping companies depending on the level of risk of bankruptcy (module1);
- module for the identification of the signs of illegal bankruptcy (module 2).

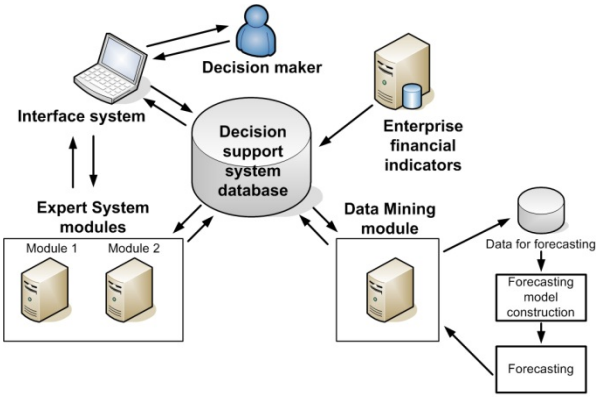

Fig. 2. The general scheme of the DSS in monitoring enterprise bankruptcy

Another module of the DSS is a data mining module. This module helps to solve problems which include cleaning the data for qualitative forecasting and predicting financial indicators of the enterprise with the use of several prognostic model-building mechanisms, including self-teaching algorithms. The objective of this module is to identify negative trends in changing financial indicators as well as possible signs of fraudulent bankruptcy based on the comparative analysis of the current financial indicators and financial indicators forecasted by the data mining module.

Primary, intermediate and resulting data are stored in the main decision support database organized according to the relational model. To keep the decision support system operating the primary data on the company is imported in the system either automatically or manually. Interaction between the DSS and the user is carried out by means of an interface subsystem.

In the first phase of the DSS the enterprise is classified according to the degree of the threat of bankruptcy by means of module 1 of the expert system (Figure 3).

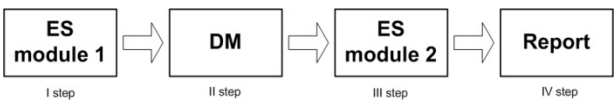

Fig. 3. The steps of the DSS modules using

Depending on the results, the enterprise is either checked for signs of fraudulent bankruptcy (I step, module 1 of the expert system), or financial performance is forecasted using the data mining technology (II step, DM module). In the third phase on the basis of the forecasted values the signs of the deliberate bankruptcy are identified (III step, module 2 of expert system). On the IV step a report is made for the decision maker.

5 DSS Modules

5.1 Expert System Modules

ES module 1 for an enterprises grouping in accordance with a bankruptcy threat degree involves an enterprises classification on the basis of its financial indicators into five groups:

- group 1 – solvent enterprises, that have an ability to pay fully and within the prescribed period their current obligations at the expense of their current economic activity or liquid assets (G1);
- group 2 – enterprises without a sufficient financial resources to ensure their solvency (G2);
- group 3 – enterprises with established by law bankruptcy signs (G3);
- group 4 – enterprises, that have a direct threat of the bankruptcy proceedings institution (G4);
- group 5 – enterprises, in respect of which an arbitral tribunal accepted for consideration an application for recognition of the enterprise as a bankrupt (G5).

This grouping allows determining an enterprise that should be analyzed for potential signs of a deliberate bankruptcy and an enterprise, in respect of which bankruptcy proceedings have already been entered, that should be analyzed for potential signs of a fictitious bankruptcy. Knowledge representation production model is applied for the knowledge base development (table 1).

Table 1. Expert system module 1- knowledge base fragment

№	Rules of production
Rule 1	If K1 ≤ 6, Then G1
Rule 2	If K1 > 6 And K2 ≥ 1, Then G1
Rule 3	If K1 > 6 And K2 < 1, Then G2
Rule 4	If K3 = 1, Then G3
…	…
Rule11	If K10 = 1, Then G5
…	…

ES module 2 for a false bankruptcy signs detecting, based on the financial coefficients analysis, determines a false bankruptcy presence. Financial coefficients (debtor obligations provision by assets, net assets value, long-term investments share in assets, creditor debts share in liabilities, etc.) are calculated on the basis of enterprise financial indicators. Table 2 shows expert system module operational rules to detect a false bankruptcy signs presence.

Table 2. Expert system module 2 - knowledge base fragment

№	Rules of production
Rule 1	X1 : If K1(tj+Δt)<K1(tj), Then R1, Or X2
Rule 2	X2 : If K2(tj+Δt)<K2(tj), Then R1, Or X3
Rule 3	X3 : If K3(tj+Δt)<K3(tj), Then R1, Or X4
Rule 4	X4 : If K4(tj+Δt)<K4(tj), Then R2, Or X5
Rule 5	X5 : If K5(tj+Δt)≥K5(tj), Then R2, Or X6
Rule 6	X6 : If K6(tj+Δt)=K6(tj), Then X7, Or X8
Rule 7	X7 : If K7(tj+Δt)<K7(tj), Then R1, Or R4
Rule 8	X8 : If K6(tj+Δt)>K6(tj), Then X9, Or R3
Rule 9	X9 : If K7(tj+Δt)≤K7(tj), Then R5, Or R4
…	…

Where R1 – false bankruptcy signs are present; R2 – false bankruptcy signs are present, fixed assets can be withdrawn from an enterprise; R3 – false bankruptcy signs are absent, an enterprise pays out compulsory payments; R4 – false bankruptcy signs are absent, an enterprise is in a difficult financial situation; R5 – false bankruptcy signs are present, a deliberate debts accumulation for subsequent cancellation is taking place.

5.2 Data Mining Module

The problem which is solved by the data mining module in DSS in monitoring enterprise bankruptcy is the problem of forecasting financial indicators of the enterprise (company) and is considered in detail in [9]. This problem can be seen as a problem of forecasting the time series, as the data for the prediction of financial indicators are presented in the form of measurement sequences, collated at non-random moments of time.

The dynamics of lots of financial and economic indicators has a stable fluctuation constituent. In order to obtain accurate predictive estimates it is necessary to represent correctly not only the trend but the seasonal components as well. The use of data mining methods in time series forecasting makes the solution of the given task possible. These methods have a number of benefits: possibility to process large volumes of data; possibility to discover hidden patterns; use of neural networks in forecasting allows obtaining the result of the required accuracy without determining the precise mathematical dependence.

There are a lot of other benefits of data mining such as basic data pre-processing, their storage and transformation, batch processing, importing and exporting of large

volumes of data, availability of data pre-processing units as well as ample opportunities for data analysis and forecasting. The algorithm for forecasting the companies' financial indicators has been developed (Figure 4).

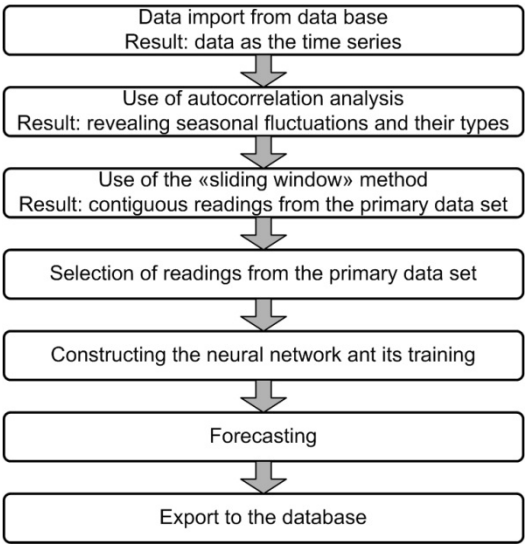

Fig. 4. Main stages of the data mining module

Forecasting of enterprise financial indicators in the DSS can be performed by means of a number of DM techniques such as partial and complex data preprocessing, autocorrelation analysis, the method of "sliding window" and neural networks. In solving the problem of forecasting the time series with the aid of a neural net it is required to input the values of several adjacent counts from the initial set of data into the analyzer. This method of data sampling is called "sliding window" (window – because only a certain area of data is highlighted, sliding – because this window "moves" across the whole data set). Transformation of the sliding window has the parameter "depth of plunging" – the number of the "past" counts in the window.

The software implementation of the data mining module to forecast the financial indicators of the enterprise is performed by means of the analytical platform [8]. As it was mentioned above, the data mining module is realized by the following main steps: primary data input; using of "sliding window"; neural network programming – constructing and teaching; forecasting.

Each of the financial indicators has its own prediction algorithm that includes the size of the step of the sliding window, neural network (NN) structure, the form of the activation function and its value (Table 3). These parameters are defined for each enterprise individually.

Table 3. Algorithms of data mining application to forecast enterprise's financial indicators

Financial indicators	Depth of "sliding window"	Activation function		NN struc ture
		form	value	
fictitious assets	5	sigma form	0.80	5-3-1
fixed assets	5	sigma form	1.30	5-4-3-2-1
long-term financial invest ments	3	sigma form	0.95	3-2-1
total of non-working assets	5	hyper tan gent form	1.05	5-3-2-1
…	…	…	…	…
reserves of forth-coming expenses and pay ments	5	arc tan gent form	1.25	5-2-1
liabilities balance	5	hyper tan gent form	0.85	5-2-1

6 DSS Implementation Efficiency Analysis

DSS has been used in state monitoring of a number of industrial and agro-industrial enterprises of Republic Bashkortostan (Russia) (Table 4).

ES module 1 for an enterprises grouping in accordance with a bankruptcy threat degree has correctly determined an enterprises specific group membership in all cases. For a proposed decision making support system efficiency analysis a comparative analysis of the DSS results with classical methods results was conducted. Thus, according to classical methods, enterprise 1 is unprofitable, that confirms decision support system application results. Enterprise 4 is effectively functioning, that also confirms decision support system application results. Enterprise 2 and enterprise 3 were identified by classical methods as effectively functioning, but this conclusion wasn't confirmed by real data, namely enterprises accounting balance analysis results. This situation demonstrates a high efficiency of a system application. Therefore, a proposed decision making support system diagnoses an enterprises financial condition more accurately.

Table 4. The enterprises characteristics

Enterprise' name	Organizational and legal form	Ownership type	Occupation	Employees number
Enterprise 1	public company	private	livestock breeding and fruits, vegetables production	150
Enterprise 2	open joint stock company	mixed	production of bread and non-durable pastry goods	700
Enterprise 3	state unitary enterprise	state	production of bakery products and confectionery, pasta, breadcrumbs, the selling of its own products	150
Enterprise 4	limited liability company	private	wholesale trade in petroleum products	60

The analysis of the effectiveness of the data mining module is based on the comparative analysis of the financial indicators for the same period of time, obtained directly from the enterprise and forecasted through data mining. The fragment of the analysis of the effectiveness of data mining with deviation of the forecasted values of the financial indicators from the actual data is presented in Table 5.

Analysis of the effectiveness of data mining for values forecasting showed that the deviations of the forecasted values from the real data are in the range from 1,35% to 8,74%. The average deviation is about 6,5 %, which is quite a good result for forecasting.

Table 5. Deviations of forecasted values from actual data, in percentage

Financial indicators of the enterprises	Enterprise' name			
	1	2	3	4
fixed assets	3.57	4.28	4.86	5.05
long-term investments	4.62	1.45	5.61	6.63
total non-current assets	4.89	4.22	3.77	3.25
…	…	…	…	…
result of short-term liabilities	6.83	5.88	6.24	8.67
balance of liabilities	2.42	4.47	8.45	3.57
revenue for the period under review	5.87	3.55	5.62	1.52

ES module 2 for a false bankruptcy signs detecting analysis also showed a high efficiency of a system application. This conclusion is confirmed by an analysis of the table 6.

Thus, it may be concluded about an adequacy of considered informational support methods for a complex decision making support system designed to prevent crises in an enterprises monitoring.

Table 6. Comparative analysis of the ES - module 2 application results

Enter prise	DSS result	Real situation
1	false bankruptcy signs are present, fixed assets can be withdrawn from an enterprise	investigating authorities initiated verification
2	false bankruptcy signs are absent, an enterprise is in a difficult financial situation	enterprise continues working, compulsory payments debts increase
3	false bankruptcy signs are present	enterprise continues working, enterprise obligations constitute 95%

7 Conclusions

The decision support system for bankruptcy monitoring including the data mining module is developed. The decision maker using the DSS may be the top manager or supervisory authority. It is possible for users of the system to monitor the major trends in the economic processes of the enterprise. With the help of the expert system the enterprise is classified according to the degree of the bankruptcy threat Then with the help of data mining means, neural networks in particular, the enterprise financial indicators can be forecasted for the definite period of time (for example for 3 months). The aim of the neural network at this stage is to catch the regularities of the financial indicators changes and detect them. And then on the basis of the forecasted indicators with the help of the expert system the signs of the enterprise illegal bankruptcy are identified. The condition of the enterprise is defined not for present moment but for the definite time period (for example for 3 months). It gives an opportunity to take

measures preventing the enterprise from fraudulent bankruptcy. The efficiency analysis reveals good results of DSS implementation for bankruptcy monitoring.

This research has been supported by grants № 11-07-00687-a, № 12-07-00377-a of the Russian Foundation for Basic Research and grant "The development of tools to support decision making in different types of management activities in industry with semi-structured data based on the technology of distributed artificial intelligence" of the Ministry of Education of the Russian Federation.

References

1. Belyaev, Korotkov, E.: Anti-Crisis Management. UNITI-DANA, Moscow (2011)
2. Senthil Kumar, A.V.: Knowledge Discovery Practices and Emerging Application of Data Mining: Trends and New Domains. Information Science Reference, Hershey (2011)
3. Jackson, P.: Introduction to Expert Systems. Williams, Moscow (2001)
4. Barsegyan, Kupriyanov, M., Stepanenko, V., Kholod, I.: Technologies of Data Analysis: Data Mining, Visual Mining, Text Mining, OLAP. Sec. ed. BHV-Petersburg, Saint-Petersburg (2007)
5. Duk, V., Samoilenko, A.: Data Mining. Peter, Saint-Petersburg (2001)
6. Yusupova, N., Shakhmametova, G.: Intelligent Information Technologies in the Decision Support System for Enterprises Bankruptcy Monitoring. UNC RAN, Ufa (2010)
7. Shakhmametova, G., Amineva, D., Dolzhenko, V.: Expert System for Decision Support in Anti-Crisis Monitoring. In: Proc. of the 13th International Workshop on Computer Science and Information Technologies, Garmisch-Partenkirchen, Germany, vol. 1, pp. 151–155 (2011)
8. http://www.basegroup.ru (June 20, 2012)
9. Yusupova, N., Shakhmametova, G.: Data Mining Application for Anti-Crisis Management. In: Proc. of the Second International Conference on Advances in Information Mining and Management, IMMM 2012, Venice, Italy, pp. 68–74 (2012)