NEURAL NETWORK BASED APPROACH FOR DEVELOPING THE ENTERPRISE STRATEGY

Todorka Kovacheva, Daniela Toshkova

Abstract: Modern enterprises work in highly dynamic environment. Thus, the developing of company strategy is of crucial importance. It determines the surviving of the enterprise and its evolution. Adapting the desired management goal in accordance with the environment changes is a complex problem. In the present paper, an approach for solving this problem is suggested. It is based on predictive control philosophy. The enterprise is modelled as a cybernetic system and the future plant response is predicted by a neural network model. The predictions are passed to an optimization routine, which attempts to minimize the quadratic performance criterion.

Keywords: enterprise strategy, model predictive control, neural network, black-box modeling, business trends.

ACM Classification Keywords: I.2.6 Artificial Intelligence: Neural nets; I.6.3 Simulation and Modeling: Applications

Introduction

In the present paper, a Generalized Strategy Development (GSD) approach is suggested. Designing of the enterprise strategy is a very complicated process. It depends on many factors, which require a lot of variables to be taken into account. The relationships between them are complex and non-linear.

In the decision making process the managers need to know the environment characteristics in order to adapt the developed strategy. Therefore, the predictions of the environment changes are needed. They enable businesses make better strategic decisions and manage their activity more efficiently. It can also identify new opportunities for increased revenues and entering new markets. The prediction of the environment changes is a very difficult task. Price, advertising, goods seasonality, customers and competitors behaviour, global economic trends etc. are all factors that influence the overall performance of the enterprise.

Traditional forecasting methods such as regression and data reduction models are limited in their effectiveness as they make assumptions about the distribution of the underlying data, and often fail to recognize the inter-relatedness of variables. Now, a new forecasting tool is available – artificial neural networks (ANN). They are a form of artificial intelligence, which provide significant potential in economic applications by increasing the flexibility and effectiveness of the process of economic forecasting [Tal, Nazareth, 1995]. They are successfully used in various economic studies including investment, economic and financial forecast [Hsieh, 1993; Swales and Yoon, 1992; Hutchinson, Lo, and Poggio, 1994; Shaaf, 2000].

The enterprise strategy development requires not only predictions but also have to be optimized and adapted according to the environment changes. A suitable control design algorithm is needed. During the last years a number of methods for automatic control synthesis are applied for managing business processes. Many authors suggest the Model-Based Predictive Control (MBPC) algorithm to be used as a decision-making tool for handling complex integrated production planning problems [Tzafestas, Kapsiotis, Kyriannakis, 1997] and supply chain management [Braun et al., 2003]. MBPC is a very popular controller design method in the system engineering. It is a suitable technique for prediction of future behaviour of a plant.

Both, ANN and MBPC, are tools for solving complex problems under uncertainty by providing the ability to learn from the past experience and use information from various sources to control the enterprise performance. Generalized Strategy Development approach combines the advantages of artificial neural networks and Model-Based Predictive Control algorithm to increase the effectiveness of the enterprise management in the entire decision making process and development of all functional strategies (incl. production-, marketing-, financial-, sales-, innovation strategy etc.).

Business Trends and Management Theory

The contemporary business is accomplished in highly dynamic environment. The continuous changes in the internal and external environment of the enterprise force it to apply a number of adaptation mechanisms, which contribute to its surviving and competitive power. These adaptation mechanisms are based on the degree of information availability. This makes providing the information a necessary condition for adaptation process and the adaptation itself – the most important characteristic of each system. In this regard the developing and the implementing of tools, which enables the corporate adaptation according to the environment changes becomes a strategic need.

Globalization [Кирев, 2001; Голдщейн 2002, 2003; Ганчев, 2004; Стоилова, 2004; Стоянов, 2003; Краева, 2003], *virtualization* [Мейтус, 2004; Баксанский, 2000; Манюшис, Смольянинов, Тарасов, 2003; Вютрих, Филипп, 1999], *Internet* and the developing of the *Information Technologies* [Христова, 1997; Върбанов, 2000; Илиев, 2003; Седлак, 2001] have a deep impact on the economic and social life of the society. These global trends determine the transition from the traditional industrial society to the information age society. A *new economic based on knowledge* [Applegate et al., 1996] appears and as a result the traditional managerial hierarchy seize to exist and a horizontal relationships are formed. Enterprises of a new type appear, which accomplish their activity on the global market from their founding. They overcome the spatial and time boundaries. The common name for such structures is *"globally born"* [Андерссон, Виктор, 2004]. These enterprises have their own mechanisms for developing, which substantially differ from those of the traditional industrial enterprises. Thus, the small national companies become multinational very fast.

The adaptation to environment changes requires new knowledge for its elements, the relationships between them, and characteristics of their functioning. Thus the concept of *"Learning enterprise"* [Senge, 1990] comes into being. It is based on the continuous acquiring new knowledge regarding the environment, using it for innovation strategies and this process applies to the enterprise as a whole.

The global trends in business development mentioned above cannot be considered partially. There are mutual relationships and dependencies between them. The existing of certain trend is a prerequisite for appearing and developing of another one and vice versa. Therefore, they influence the contemporary enterprise activities by forming an integrated set of strategies.

Now let us consider the modern business trends in a management theory point of view. Many authors [Каменов, 1984; Камионский, 1998; Рубцов, 2001] state that an unified management theory does not exist. There are different managerial concepts. Some of them claim to be universal, other are a tool for solving particular problems, some are not developed enough, other are just catchwords, some contribute and expand each other, and other contradict each other [Айвазян, Балкинд, Баснина, 1998]. This causes difficulties for the development the enterprise strategy, which strongly depends on the environment changes.

The experience shows that there is time delay between the problems, which arise in the practice and the developing of methods for their solving, which constitute the theory. In this regard, the new structures mentioned above – "globally born" and "learning enterprise" are not considered in the general management theory. Therefore, there is a lack of methodologically developed and scientifically based management approaches. These enterprises do not respond to the traditional rules and concepts as they arise and perform in strongly uncertain and highly dynamic environment. They need new management, approaches, which have to correspond to their characteristics and meet their requirements. These enterprises can be presented as complex nonlinear cybernetic systems. Thus, the laws of system and control theory can be applied to their management.

Model-Based Predictive Control

Model-Based Predictive Control has established itself in industry as an important form of advanced control [Townsend, Irwin, 2001]. An overview of industrial applications of advanced control methods in general can be found in Takatsu et al. [Takatsu et al, 1998] and in Qin and Badgwell [1998].

The main advantage of MBPC algorithm is the simplicity of the basic scheme, forming a feedback, which combines with adaptation capabilities. This determines its successful applying in the practice of designing control systems.

MBPC is an efficient methodology to solve complex constrained multivariable control problems in the absence, as well as in the presence of uncertainties [Mayne et al., 2000]. It makes possible the uncertainty of the plant and disturbances to be taken into account and enables the on-line optimization and control synthesis.

In general, it is used to predict the future plant behaviour. According to this prediction in the chosen period (prediction horizon), the MBPC optimizes the manipulated variables to obtain an optimal future plant response. The input of chosen length (also known as control horizon) is sent into the plant and then the entire sequence is repeated again in the next period. An important advantage of MBPC is that it allows the inclusion of constraints on the inputs and outputs.

The prediction plant model is realized with neural network. It provides predictions of the future plant response over a specified time horizon. The predictions are passed to an optimization routine to determine the control signal that minimizes the following performance criterion over the specified time horizon:

$$J = \sum_{j=N_1}^{N_2} \left(y_r(t+j) - y_m(t+j) \right)^2 + \rho \sum_{j=N_1}^{N_u} \left(u'(t+j-1) - u'(t+j-2) \right)^2$$

subject to the constraints, which are imposed on the state and control variables. The constants N_1, N_2, N_u define the horizons over which the tracking error and control increments are evaluated. The u' variable is the tentative control signal, y_r is the desired response and y_m is the network model response. The ρ value is weight coefficient.

Generalized Strategy Development approach will be introduced in Model-Based Predictive Control framework.

Generalized Strategy Development Approach

The purpose of the Generalized Strategy Development Approach is to transform the incomplete information about the environment and the processes inside the enterprise into complete strategy for its adaptation and evolution. From cybernetic point of view, this can be considered as a control system. The functional structure is given in Fig.1

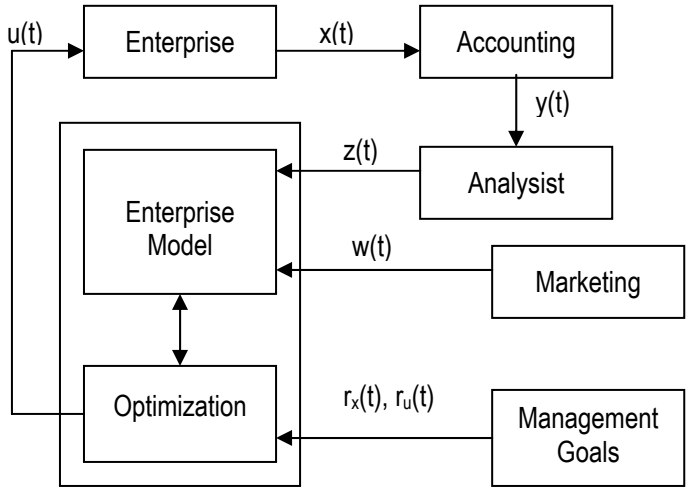

Fig.1 Global Strategy Development functional structure

Enterprise

The enterprise is a dynamic system with a high complexity. In order, the management and control [*u(t)*] to be effective we need to know its physical structure, the relationships between the constituting elements, their dynamic behaviour and the characteristics of the environment. We have to compare the current state of the enterprise to the desired state. In case they coincide entirely the management goals are achieved. In order to register the difference we need to measure the state of the enterprise. This could be realized by performance measurement system.

Performance management is the prerequisite to performance improvement. For the enterprises to improve their performance, they must be able to measure how they are performing at present, and how they are performing after any changes. So, the companies will have the possibility to monitor if a chosen strategic direction is appropriate.

Traditional performance management systems are frequently based on cost and management accounting. There are five main difficulties with traditional management accounting techniques for performance measurement [Maskell, 1991]:

1. Management accounting reports are not relevant to strategy development;
2. Some of the data which are used for decision-making process can be distorted by cost accounting;
3. Traditional accounting reports are inflexible and are usually received too late to be of value;
4. The information about the pay-back on capital projects comes late;
5. To be of value, management accounting systems must be based on different methods and assumptions than on the financial accounts.

As traditional performance measurement systems are based on management accounting, they are primarily concerned with cost. But in today's manufacturing environment, cost based measures are no longer the only basis for decision making in enterprises. The new performance measurement systems should have some additional characteristics [Maskell, 1991].

Accounting

In Fig.1 the Accounting is the traditional performance measurement system. Therefore, the current state of the enterprise [*y(t)*] is represented by the measured one from the accounting and measurement error. The reports, which are formed by the accounting, need to be interpreted in order to be useful for the management. This task is performed by analyst.

Analyst

The accounting information is now manipulated for giving proper estimate for the current enterprise state [*z(t)*]. The manipulations include: recapitulation, generalization, estimation, recalculation etc. in order to analyze the entire enterprise activity. The results are used by managers to make decisions about the future behaviour of the enterprise.

The analysis is performed on the basis of incomplete information about the environment changes. Another error is formed. The obtained information is passed to the prediction model of the enterprise in order to minimize the tracking error.

Enterprise model

The model is used to determine the direction in which changes in the manipulated variables will improve performance. The plant operating conditions are then changed by a small amount in this direction, and a new, updated model is evaluated. The enterprise is a complex, dynamic and non-linear plant. Also different disturbances affect the its performance. Because of that, there is a lack of knowledge on the function or construction of the system.

The process output can be predicted by using a model of the process to be controlled. Any model that describes the relationship between the input and the output of the process can be used and a disturbance or noise model can be added to the process model [Duwaish, Naeem, 2001]. We can build a model using the observations of the enterprise activities.

Therefore the enterprise can be viewed as a black-box [Sjoberg et al., 1995] which aims to describe the relationships between input/output data. The non-linearities and the disturbances are taken into consideration.

During the past few years, several authors [Narendra and Parthasarathy, 1990; Nerrand et al. 1994] have suggested neural networks for nonlinear dynamical black-box modeling. To date, most of the work in neural black-box modeling has been performed making the assumption that the process to be modeled can be described accurately by neural models, and using the corresponding input-output neural predictors [Rivals, Personnaz, 1996]. Therefore, artificial neural networks are used as effective black-box function approximators with learning and adaptation capabilities.

Marketing

We could receive information [*w(t)*] about the environment changes from the Marketing Information System (MIS) which is used in the enterprise. It is passed to the enterprise model by taking into account the forming of a new error. This error is due to impossibility of MIS to register all trends in global economy and social life of the society.

Optimization and Management Goals

Using the enterprise model, we predict the future plant response and taking into consideration the management goals [rx(t), ru(t)] we optimize it and develop a new management strategy. This is an iterative process, which provides the continuous enterprise adaptation to the environment changes.

Conclusion

Strategy development is a complex task in the continuously changing environment. The enterprise management must combine internal and external information in order to survive and evaluate. Therefore, the company needs an efficient control and strategy development and evaluation system to work in rapidly changing business conditions.

The Generalized Strategy Development approach suggested here is very suitable for this problem, namely for optimization and adaptation of the strategy development process. Thus, the effectiveness of management is increased.

Bibliography

[Айвазян, Балкинд, Баснина, 1998] Айвазян, С. А., Балкинд, О. Я., Баснина, Т. Д., и др., Стратегии бизнеса: Аналитический справочник. / Под ред. Г. Б. Клейнера. – М.: КОНСЭКО,1998

[Андерссон, Виктор, 2004] Андерссон, С., Виктор, И., Инновационная интернационализация в новых фирмах, Международный журнал "Проблемы теории и практики управления", 1/2004

[Баксанский, 2000] Баксанский, О.Е., Виртуальная реальность и виртуализация реальности,//Концепция виртуальных миров и научное познание, СПб.: РХГИ, 2000 (http://sociology.extrim.ru)

[Върбанов, 2000] Върбанов, Р., Електронният бизнес като отражение на Интернет революцията в деловата сфера, Бизнес управление 3/2000, стр.83-95, СА "Д.А.Ценов", Свищов

[Вютрих, Филипп, 1999] Вютрих, Х., Филипп, А., Виртуализация как возможный путь развития управления, Международный журнал "Проблемы теории и практики управления", 5/1999

[Ганчев, 2004] Ганчев, П., Глобализацията и българските национални интереси, Диалог, СА "Д.А.Ценов" – Свищов, 2/2004, стр.32-47

[Гольдштейн, 2003] Гольдштейн, Г. Я., Основы менеджмента, ТРТУ, Таганрог, 2003

[Гольдштейн, 2002] Гольдштейн, Г. Я., Стратегический иновационный менеджмент: тенденции, технологии, практика, ТРТУ, Таганрог, 2002

[Илиев, 2003] Илиев, П., Виртуална организация на електронния бизнес, Сборник доклади от научна конференция "Иновации и трансформации на организираните пазари в България", ИУ-Варна, 2003, стр.147-153

[Каменов, 1984] Каменов, С., Ефективност на управлението, Издателство "Г.Бакалов", Варна, 1984

[Камионский, 1998] Камионский, С. А., Менеджмент в российском банке: опыт системного анализа и управления/ Общая ред. и предисловие Д. М. Гвишиани. М.: Деловая библиотека "Омскпромстройбанка", 1998

[Кирев, 2001] Кирев, Л., Относно факторите за глобализация на научноизследователската дейност от транснационалните корпорации, Бизнес управление, 4/2001, стр.49-64, СА "Д.А.Ценов" – Свищов

[Краева, 2003] Краева, В., Глобални аспекти на електронната търговия, Сборник доклади от научна конференция "Иновации и трансформации на организираните пазари в България", ИУ-Варна, 2003, стр.192-197

[Манюшис, Смольянинов, Тарасов, 2003] Манюшис, А., Смольянинов, В., Тарасов, В., Виртуальное предприятие как эффективная форма организации внешнеэкономической деятельности компании, Международный журнал "Проблемы теории и практики управления", 4/2003

[Мейтус, 2004] Мейтус, В., Виртуализация производства, Международный журнал "Проблемы теории и практики управления", 1/2004

[Рубцов, 2001] Рубцов, С., Целевое управление корпорациями, Москва, 2001

[Седлак, 2001] Седлак, Я., Мировая экономика: возможность неожиданных потрясений, Международный журнал "Проблемы теории и практики управления", 5/2001

[Стоилова, 2004] Стоилова, М., Глобализацията – познати плюсове и минуси, Диалог, СА "Д.А.Ценов" – Свищов, 1/2004, стр.63-68

[Стоянов, 2003] Стоянов, В., Пазар, трансформация, глобализация, нов световен ред, Галик, София, 2003
[Христова, 1997] Христова, С., Материали от дискусия, Предизвикателствата на информационните технологии на прага на 21-и век, Национална научна конференция АИ'97, Автоматика и информатика 5/6 – 1997, САИ, София, стр.10-11
[Abdallah, Al-Thamier, 2004] Abdallah, J., Al-Thamier, A., The Economic-environmental Neural Network Model for Electical Power Dispatching, Journal of Applied Sciences 4 (3): 340-343, 2004
[Applegate et al, 1996] Applegate, L. M., McFarlan, F. W., McKenney, J. L., Corporate information systems management: text and cases, 4th ed., IRWIN, USA, 1996
[Braun et al., 2003] Braun, M., Rivera, D., Carlyle, W., Kempf, K., A Model Predictive Control Framework For Robust Management Of Multi-Product, Multi-Echelon Demand Networks, Annual Reviews in Control, 2003, vol.27, no. 2, pp.229-245(17)
[Duwaish, Naeem, 2001] Duwaish, H., Naeem, W., Nonlinear model predictive control of Hammerstein and Wiener Models using genetic algorithms, In Proceedings of the 2001 IEEE International Conference on Control Applications (CCA'01), 5-7 September, Mexico City, Mexico, pp.465-469, IEEE
[Hsieh, 1993] Hsieh, C., Some potential applications of artificial neural system in financial management. Journal of System Management, April, 1993, 12-15
[Hutchinson, Lo, and Poggio, 1994] Hutchinson, J., Lo, A., and Poggio, T., A nonparametric approach to the pricing and hedging of derivative securities via learning networks. Journal of Finance, 49, 851-99, 1994
[Maskell, 1991] Maskell, B. H., Performance Measurement for World Class Manufacturing, Productivity Press, Cambridge, Massachusetts, 1991
[Mayne et al., 2000] Mayne, D. Q., J. B. Rawlings, C. V. Rao and P. O. M. Scokaert, Constrained model predictive control: Stability and optimality, Automatica, 36, 2000, 789-814
[Narendra and Parthasarathy, 1990] Narendra, K. S., Parthasarathy, K., Identification and control of dynamical sysems using neural networks, IEEE Trans. on Neural Networks 1 (1990), pp. 4-27
[Nerrand et al. 1994] Nerrand, O., Roussel-Ragot, P., Urbani, D., Personnaz, L., Dreyfus, G., Training recurrent neural networks: why and how? An Illustration in Process Modeling, IEEE Trans. on Neural Networks 5 (1994), pp. 178-184
[Qin, Badgwell, 1998] Qin, S. Joe and Badgwell, T.A., An Overview of Non-linear Model Predictive Control Applications, Proc. Workshop on NMPC, Ascona, Switzerland, 1998
[Rivals, Personnaz, 1996] Rivals, I., Personnaz, L., Black-box modeling with state-space neural networks. In: "Neural Adaptive Control Technology", R. Zbikowski and K. J. Hunt eds., World Scientific (1996), pp. 237-264
[Senge, 1990] Senge, P. M., The Fifth Discipline. The Art & Practice of The Learning Organization. – Currency Doubleday, 1990
[Sjoberg et al., 1995] Sjoberg, J., Zhang, Q., Ljung, L., Benveniste, A., Delyon, B., Glorennec, P.Y., Hjalmarsson, H., Juditsky, A., Nonlinear black-box modeling in system identification: an unified overview. Automatica, 12. 1691-1724, 1995
[Shaaf, 2000] Shaaf, M., Predicting recession using the yield curve: an artificial intelligence and econometric comparison. Eastern Economic Journal, 26(2), Spring, 2000
[Swales, Yoon, 1992] Swales, G. S., Yoon, Y., Applying artificial neural networks to investment analysis. Financial Analyst Journal, September-October, 70-80, 1992
[Takatsu et al., 1998] Takatsu, Haruo, Itoh, Toshiaki and Araki, Mituhiko; Future needs for the control theory in industries – report and topics of the control technology survey in Japanese industry, J.Proc.Cont., Vol.8, no 5-6, 369-374, 1998
[Tal, Nazareth, 1995] Tal, B., Nazareth, L., Artificial Intelligence and Economic Forecasting, Canadian Business Economics, Volume 3, Number 3, Spring 1995
[Townsend, Irwin, 2001] Townsend , S., Irwin, G., Non-linear model based predictive control using multiple local models. In: B. Kouvaritakis, & M. Cannon (Eds.), Non-linear predictive control: Theory and practice, IEE Control Engineering Series, IEE, London, 61(11), 47-56
[Tzafestas, Kapsiotis, Kyriannakis, 1997] Tzafestas, S., G. Kapsiotis and E. Kyriannakis (1997). Model-based predictive control for generalized production planning problems. Computers in Industry 34(2), 201-210

Authors' Information

Todorka Kovacheva – Economical University of Varna, Kniaz Boris Str, e-mail: todorka_kovacheva@yahoo.com

Daniela Toshkova – Technical University of Varna, 1, Studentska Str., Varna, 9010, e-mail: daniela_toshkova@abv.bg