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THE ROLE OF REINFORCEMENT LEARNING IN BUSINESS INTEGRATED MANUFACTURING

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ABSTRACT

Reinforcement learning (RL) has received some attention in recent years from researchers, because it deals with the problem of how an autonomous manufacturing system can learn to select proper actions for achieving its goals through interacting with its environment. Although there have been several successful examples demonstrating the usefulness of RL, its application to business integrated manufacturing has not been fully explored yet. The interaction between the economic environment and the manufacturing system is a major source of knowledge about the economic environment and the manufacturing system themselves.

KEYWORDS: manufacturing system, competitiveness, online learning, technical-economical characteristics of manufacturing system

1. INTRODUCTION

All over the world, companies are faced with increasingly accelerated and unpredictably dynamic changes. This is influenced by the scientific, technical progress and the dynamics of customers' demands. Changes lead to aggressive competition on a global scale, which calls for the establishment of new balances between economy, technology and society.

The reinforcement learning, through its role, in business integrated manufacturing, means the manufacturing system capacity to 'learn' in permanent interaction with the economic environment, to inform and update the information about the auctions and to anticipate, before deciding to conclude a contract, the level of costs, profit and what is the best way to act. In other words this means that the manufacturing system 'learns' what actions to take in certain situations, based on the data supplied by the economic environment, so that such actions increase the possibilities of achieving the aim proposed.

The business integrated manufacturing should 'exploit' what it already knows it obtains profit, but at the same time it must 'explore' the possibility of finding other suitable actions for the future. The manufacturing system should try a variety of actions and then choose those that seem best. This study shows the potential of RL for application to the business integrated manufacturing.

On world wide plan, enterprises are confronted with a dynamics and the unpredictable changes. This is influenced by the technical and scientific progress, dynamic requirements of the customers, science of management and mathematical economy [1]. These changes enforce an aggressive competition at the global scale that assumes the request of a new settlement equilibrium between economy, technology and society.

The characteristic aspects of the actual market, in the particular case of the mechanical parts market, are the following: the current dimension of requests is decreasing continually, what drives to composition of the manufacturing small series; accentuated tendency of personification of products drives to a marked diversity of the forms, of the sizes and another characteristics of the mechanical components requested by the market; the flexibility, efficient management of the manufacturing systems tending to become the characteristics that determined decisively competitiveness of manufacturers of mechanics components on market. The current dynamism of industrial and business environment represents a big global challenge and we must manage it.

Through the manufacturing system we understand the wholey technological systems, which are used for obtaining of particular product. Each of these technological systems is composed of machine tools, tools, appliance, parts, operator and manufactures of technological process operation for realization of the product. The manufacturing system

is composed when the product starts being manufactured and it stays in this structure just up to the completion execution produced respectively. After another product is started, the problem of manufacturing system structure is rerun from the beginning.

According to the literature, a company is competitive on a certain market when it succeeds to reach, up to an acceptable level, some economic indicators: turnover, profit, market share comparable or superior to that of other competing companies acting on the same market. Many approaches to the problem of competitiveness [2], [3], [4], show that, today, competitiveness is defined by the economic factors and indicators obtained and is more a suggested notion than a numerically evaluated one. In the world there are prestigious competitiveness research centers , such as: Center for International Development-USA Harward University, European Institute of Technology with its research center in Cambridge, Geneva, Oxford and Organizational Competitiveness Research Unit of Sheffield University Halle-UK which deals with competitiveness at the global, regional down to enterprise/company level. But, approaches are economical and managerial natures, unless it is noticed the link with technical aspects of competitiveness.

We can say that through business integrated manufacturing competitiveness of the enterprises we understand the capacity (the potential) of enterprise operated performant comparative with other enterprises in the context macro economical concrete. The performance is measured in which the enterprise meets the aim for which it is created.

Business integrated manufacturing is based on the modeling of the manufacturing operation taking into account its corresponding business operation. At a practical level, the aim is to create the business integrated manufacturing model of the machining system, available for any part operation and its use for either on-line or off-line control.

In this moment the algorithm for technical-economical business integrated manufacturing competitiveness evaluation is not defined and, more the technical factors are not taken into account, consumptions and expenses caused by the technological processes are generated by the technical actions. In this context, competitiveness notion has new valences, because it assembles the factors and politics which determine the enterprise capacity to occupy a favourable place on market, to keep that place and to improve the position. Unless the competitiveness characterizes synthetically and completely the viability of enterprise.

It is not reported in the special literature an approach of the ensemble manufacturing system-market. The approaches are of economic and managerial nature , while the relationship with the technical aspects of competitiveness is less noticeable. At this point there is no defined algorithm to evaluate the technical and economic competitiveness, moreover, the technical factors are not considered at a practical level, when defining competitiveness, although consumption and costs incurred by the technological processes are generated by technical actions . In this context, the notion of competitiveness gains new valences, including factors and policies that determine the ability of the enterprise to get a favorable place on the market , to hold that place and to continuously improve its position. Only in this way can competitiveness fully and synthetically characterize the enterprise viability.

Today the manufacturing systems are managed through the programs of the machines tools with numerical programs.

The control is exclusively technical because there is no economic variable, although this is actually the ultimate goal of any processing process. The dynamic changes and the overall progress of society are reflected at company level by many orders in number, small in volume, very diverse, obtained through frequent auctions with short- term response, which leaves no time for a relevant analysis of said orders. As a result, a long-term management is no longer possible.

Consequence, it doesn't managed for a long time. It is enforced a method of the fluctuant on-line, prompt reaction, speeder managemen. The dynamism from the market is transmitted into the management.

2. THE ROLE OF REINFORCEMENT LEARNING IN BUSINESS INTEGRATED MANUFACTURING WITH APPLICATION IN MECHANICS BUILDINGS

Through reinforcement learning in business integrated manufacturing of the competitiveness management at manufacturing system of the mechanics buildings, we can release a control for these systems. The authors of the paper propose a block scheme and on its basis it

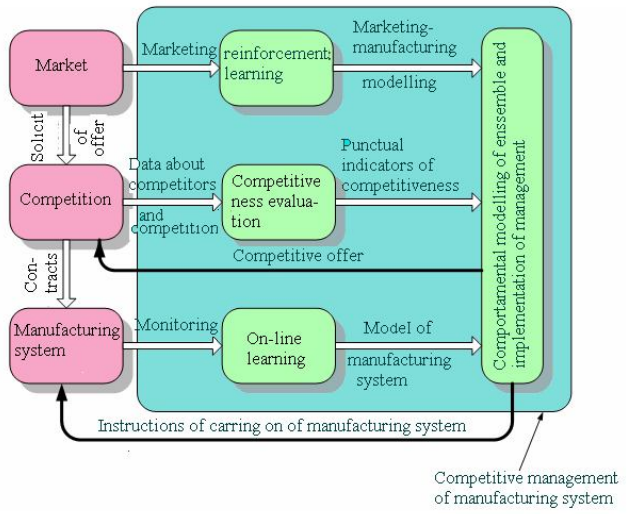

Figure 1 Competitive management algorithm

can be elaborated a competitive management algorithm, figure 1.

The manufacturing system receives contracts after the tenders (competitions) generated by the market offer quatations. The competitive management system means competitiveness assessment, and based on it, an intervention on the manufacturing system through instructions regarding the progress of the manufacturing process in order to obtain maximum competitiveness.

On the other hand, the management system must give the elaborate possibility of the competitive offers which will enter in auctions.

The competitive management system uses the reinforcement learning method to know the market and the on-line unsupervised learning method to know the manufacture system.

The next step is the behaviour modelling of the system for elaboration of the necessary adjustment instructions of the technological process and management politics. Watching each line from block scheme (figure 1), we can see the following: the modelling algorithm of the market-manufacturing system relation includes using the data base from economical environment (auctions), extraction of the knowledge through data mining and realisation of the model through reinforcement learning; for obtaining the punctual competitiveness indicators will be constituted the data bases from competition environment and it will be extracted knowledge to evaluate the competitiveness; the offers from market enter to competition environment to generate contracts for manufacturing system; the modelling algorithm of the manufacturing system is realised leaving from the contract specifications and identifying the system.

Using data mining will be obtained a data set about functional and economic parameters, the data which will be used for development of the model through unsupervised learning methods.

The manufacturing system will receive instructions about the way of development of manufacturing processes to achieve the maximum level of the efficiency (maximum profit).

The algorithm will be able to materialize through relations system between numerical values of the hexogen and endogen factors of the manufacturing system taken over from the reality, through the modelling of the manufacturing system- economical environment relation, on the one hand, and functional modelling of the manufacturing system, on the other hand. The algorithm is based on the reinforcement learning method and on-line learning. The testing of the elaborated algorithm will be done through the simulations on the virtual enterprise.

The algorithm follows conceptually and it will be materialized through the system of relations between the value measures of exogenous and endogenous factors of the manufacturing system got from reality through the relation modeling manufacturing system – economical environment and functional modeling of the manufacturing system. The modeling is based on reinforcement learning and on-line learning.

3. DEVISING A REAL-TIME MODELING METHODOLOGY BASED ON REINFORCEMENT LEARNING, OF THE MANUFACTURING SYSTEM RELATIONSHIP WITH THE ECONOMIC ENVIRONMENT

The learning process, in general, is an action in which the manufacturing system can improve its ability to react so that, during subsequent requests, it should take actions more efficiently.

Devising a real-time modeling methodology, based on reinforcement learning (which is a specific non supervised learning technique) of the manufacturing system relationship with the economic environment means that the manufacturing system 'learns' what actions to perform in certain situations, based on the data supplied by the economic environment, so that such actions increase the possibilities of achieving the aim pursued. The system should 'exploit' what it already knows it gets profit, but at the same time it must 'explore' the possibility of finding other suitable actions for the future. The manufacturing system should try a variety of actions and then choose those that seem best.

According to the competitive management algorithm presented in Figure 1, regarding the market-manufacturing system relationship by reinforcement learning, from the data supplied by the marketing section of the enterprise (auctions situation) , an evolution of the economic environment for a period of time is carried out and an overall modeling is provided on the basis of past events.

Reinforcement learning is to be understood as the manufacturing system capacity to 'learn' in permanent interaction with the economic environment, to inform and update the information about the auctions and to anticipate, before deciding to conclude a contract, the level of costs, profit and which is the best way to act. Modeling the market - manufacturing system relationship simulates, based on a state of the environment and an action of the manufacturing system, the behavior of the assembly and can predict what will be the next step and the result obtained.

The relationship is used for planning, to make decisions regarding the behavioral modeling of the manufacturing system – market assembly while considering possible future cases before such situations are experimented.

After each possible situation, the manufacturing system will adapt its behavior, so that it tends towards its next most favorable state. By the learning process, the manufacturing system will be allowed to execute a number of actions in accordance with the instructions from the behavioral model operation of the assembly

and that action will be selected so as to bring it to the maximum competitiveness state.

4. DEVISING A METHODOLOGY FOR MODELING IN REAL-TIME, BASED ON REINFORCEMENT LEARNING, THE RELATIONSHIP BETWEEN THE MANUFACTURING SYSTEM AND THE ECONOMIC ENVIRONMENT

At the conceptual level a modeling methodology based on the reinforcement learning of the manufacturing system - economic environment relationship will be developed. The methodology will be tested on an actual manufacturing system from an enterprise working on a real market and on parameter values taken from economic reality. The values of the economic parameters, together with the values of the technical parameters corresponding to the product developed, will be used to generate a relationship that describes the dependence of the manufacturing system on the market. It will be analyzed the details of how the reinforcement learning based methodology can be applied to develop and shape the relationship between market and manufacturing system. The research activities include: a) extraction by data mining of information on the status of the auctions database from the marketing department of the company and defining an evaluation function; b) developing the behavioral model of the manufacturing system based on the data mining information; c) developing a reinforcement learning algorithm and its application to the manufacturing system operation in relation to the economic environment in order to obtain maximum profit; d) integration of the model algorithm into the methodology for modeling in real-time, based on reinforcement learning, the relationship of the manufacturing system with the economic environment.

5. CONCLUSION

This paper proposes a modern approach of manufacturing system competitiveness because:
manufacturing system competitiveness is approached in a new original manner, by using investigation modern methods, which take into account all the factors which influence the realisation, keeping and increasing industrial enterprise competitiveness; it is proposed a mathematical evaluation methodology of technical and economical competitiveness of manufacturing system; it is proposed a new management concept of manufacturing systems, based on behavioural modelling of the ensemble of manufacturing systems-market and management setting at the manufacturing system level, which is all levels applicable and proper to the actual market requirements.

In this context, competitive management can offer solutions for development and competitive enterprises. Through this type of management the technical phenomenon is associated with the economical phenomenon.

Increasing competitiveness is not a process of exploiting short-time advantages but it appears as a complex process and constitutes the support of economic structures based on capital investments, on scientific research, development and innovation. It is necessary to make obvious the correlations between the economical average (the market, competition) and the manufacturing system and to study the role which they have in the acquirement and the increase of enterprise competitiveness. This becomes even more pressing due to the fact that the special literature consigns studies on competitiveness at least to the level of the enterprise and the studies on the process and technology of manufacturing system do not make the connection between the two entities in the context of the technical economical competitiveness.

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