The Cognitive Engineering in Manufacturing Process through Reinforcement Learning

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Abstract: The reinforcement learning (RL), 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 to obtain 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.

Key-Words: - Competitiveness, Cognitive Engineering, Reinforcement Learning.

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1 Introduction

On a world wide plan, enterprises are confronted with a dynamic more and more and 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 to the global scale which assumes the request of a new settlement equilibrium between economy, technology and society. At this changes, the scientific community proposes to answer new paradigm: Knowledge-based Economy

Competitiveness characterizes synthetic and complete the viability of the enterprises. In economic literature, competitiveness is analyzed in particular from an economic and managerial viewpoint, entering or not at all in analyzing the role of the technology in the assurance and increase of competitiveness. The necessity to manage the manufacturing systems based on cognitive modeling.

The term cognitive engineering is connected directly to the area of the cognitive sciences and emphasizes the existence of a stock of techniques and technologists of processing knowledge. The principal idea of this area is considered the mental from perspective processing of the knowledge. The cognitive, the conception which unites the cognitive sciences, gives a capital importance for processing knowledge, in explication working the human mind. More, is done hypothesis that the faculty of human mind, such as intelligence, can be obtained of mechanisms, don't is can done a functional distinction (from viewpoint of the complete functions) between the human mind and the adequate machine.

The cognitive approach is based on continuing conscientiously of the situations and the decisions in real-time about activities.

The equivalence between the human mind and the computer preached of cognitive research, bears at two interpretations of cognitive engineering, accordingly the implications which build this equivalence. First acceptance is named knowledge engineering, the engineering area which pertains to artificial engineering and which proposes to build structures which purchases, manages, processes, expanding and exploits the human cognition. Here, are integrated the expert systems, the systems based on knowledge.

There is a second possible implication, from the cognitive sciences (informatics, artificial intelligence, psychology, just neurology and sociology) to man.

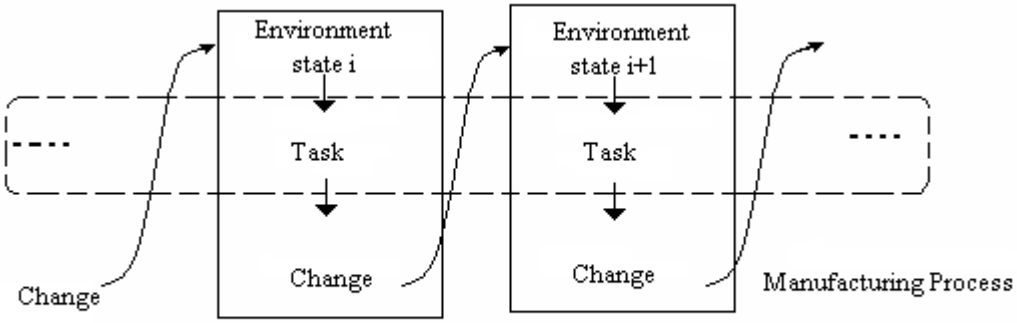

Figure 1 Manufacturing process in the cognitive approach

2 Application

The establishment of tight connections between the technical variables (the manufacturing parts) and economical variables (modeling as entities of costs) is realized through the estimation of the cost.

For most industrial companies, the estimation method of the cost determines in particular the performances of two strategic functions: product design and the offer (the price of product). In general, it is commonly admitted that product design can engage up to 70-80% of the total product cost. The recent progress achieved in Integrated Engineering such as concurrent engineering or integrated design opens a new field for cost estimating during the design stage.

In a competitive market, the incapacity of the company to quickly and adequately successfully request for quotation can severely affect its capacity to survive economically. Indeed, an underestimated cost will result in losses while an overestimated cost will prevent the company from remaining competitive. So, there is a strong need expressed by industry to have sound cost estimating solutions, both in terms of design and quotation that can improve the performance of these strategic functions.

To face this need, and to replace the analytical-based methods commonly used in manufacturing process planning, many companies apply parametric and analogous cost estimation methods. These methods are really fast because they are essentially synthetic, and provide the total cost of the product according to some of its characteristics.

After a detailed study of the cost estimating problem in mechanical engineering, it can be concluded that two support models are required: a knowledge model and a reasoning model.

In manufacturing, cost estimating is the art of predicting what it will cost to make a given product or batch of products. Various techniques exist for cost estimating. The manufacturing cost of a part can be estimated using one of four basic methods: intuitive, analogous, parametric and analytical.

Based on the theories "[1]", "[6]", "[7]", "[8]"about cognition and complexity, it is a design of a cognitive and adaptive mechanism that manages processes by responding flexibly to the demands of the economical environment (figure 1). This mechanism is characterized by an ability to perceive the economical process environment and make real-time decisions about interactions among the manufacturing system and the economical environment.

The cognitive approach is characterized by an ability to perceive the economical environment and make real-time decisions about tasks.

In general, anything that learns a problem through interaction can be reduced to three signals which are transmitted between the agent and the environment actions, the states and the rewards (figure 2).

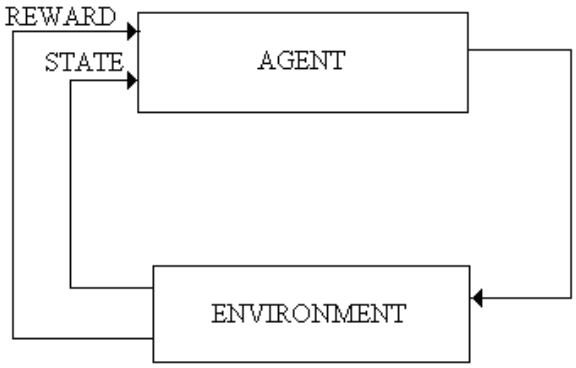

Figure 2 Reinforcement learning

In function of interaction between the agent and the environment distinguished the next types of learn:

1. supervised learning: the environment offers the problems on which the agent has solved and the correct answered at this problems;

2. reinforcement learning: the environment offers the dates about the correctness actions undertaker of agent, but don't says which are the correct action;
3. unsupervised learning: the environment doesn't offer the information about the correctness of the actions undertaken by the agent.

In reinforcement learning "[2]", "[3]", "[4]", "[5]", "[9]" the machine interacts with its environment by producing actions a_1, a_2,…..These actions affect the state of environment, which in turn results in the machine receiving some scalar rewards r_1, r_2,…. The goal of the machine is to learn to act in a way that maximizes the future rewards it receives (or minimizes the punishments) over its lifetime. Reinforcement learning is closely related to the fields of decision theory (in statistics and management science), and control theory (in engineering).

In general, the learning process, is an action, in abaft whom, a manufacturing system improves the capacity to react, so that, in temporally of a subsequent solicitations, this undertakes actions with efficient increase. Conception of a methodologies of modelling in the real-time, based on reinforcement learning, for relation of the manufacturing system with economical environment, it means, that the manufacturing system "learn" what to do in certain situations, on the based of given data of economical environment, so that the actions undertake to lead increase possibility of touches the suggested aim. The system must to "exploit" what it knows has already obtained the profit, but must at the same time to "explore" the possibility of finding other future actions. The manufacturing system must try a variety of actions and then to choose them on those which are even optimal.

Is done an evaluation of the evolution of the state economical environment, while, and gives an ensemble modeling based on the past events. Through reinforcement learning is understanding the capacity of the manufacturing system to learn permanently in interaction with the economical environment, to inform and update the info about auctions and anticipate the statement, the level profited, and how to act well. The relation modeling of the market – manufacturing system simulates, on the basis of environment states and one action of the manufacturing system, the behavior ensemble and can predict which will be the next state and the result obtained. The relation is used for planning, that is, for taking decisions about cognitive modeling of ensemble the manufacturing system – market, and considering possible future situations before these states are experienced. After each possible situation the manufacturing system will adapt the cognitive models, so that it can learn towards his next states values most probable. Through the process of learning, the manufacturing system will be left to execute a series of actions according to the instructions of the cognitive model of the ensemble and will select the act in which it will go in the state with maximum competitiveness.

3 Conception of a Methodologies of Modelling, in Real-time based on Reinforcement Learning, of the Relation of the Manufacturing System with Economic Environment

The research about learning in the word pointed out the crucial role it plays in the interaction with the environment. The practice of sensory connection with the environment produces a big quantity of info of type cause-effect about the consequences of the actions and keeping with decisions for touching the aims. These interactions are a major source of knowledge about the environment. In each moment, we are conscious of the manner in which the environment reacts to our actions and we search to influence this thing through our behavior. The interaction is the fundamental cause of theories about learning and intelligence.

In general, the learning process is a process in which the agent (it who learns) improves the capacity of act, so that, temporally of next solicitations, the agent carries on actions which are very efficient.

In reinforcement learning, the environment offers the dates about the correctness actions of the agent, but doesn't say which is the correct action.

We will develop at conceptual level a methodology of modelling based on reinforcement learning of relation manufacturing systems – economical environment for a real system of manufacturing of an enterprise which works on a real market with values of the parameters taken from the economical reality. The values economical parameters unite with values technical parameters, accordingly product achieved will be used to generate a relation which describes dependent the manufacturing system - market. It will analyze the details about the methodology of learning based on reinforcement learning that can be applied for the elaboration and modelling of the relation between the market and the manufacturing system. The activities investigatory afferent are:
a. Extract through the data mining of an information concerning the situation of the auctions,

from database derived from the marketing compartment of enterprises and the definiteness of an evaluation functions;
b. The elaboration of the cognitive model of the manufacturing system on the base of information from the data mining;
c. The elaboration of algorithm of reinforcement learning and this applied to the operation of the manufacturing system in relation with economic environment to obtain the maxim profit;
d. The integration of the model with the algorithm in the modelling of methodology, in real-time based on reinforcement learning of the relation of the manufacturing system with the economic environment.

4 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 to get 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 3, 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.

R*einforcement 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 what 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 state and the result obtained.

The relationship is used for planning, i.e. to take 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 likely to bring it to the maximum competitiveness state.

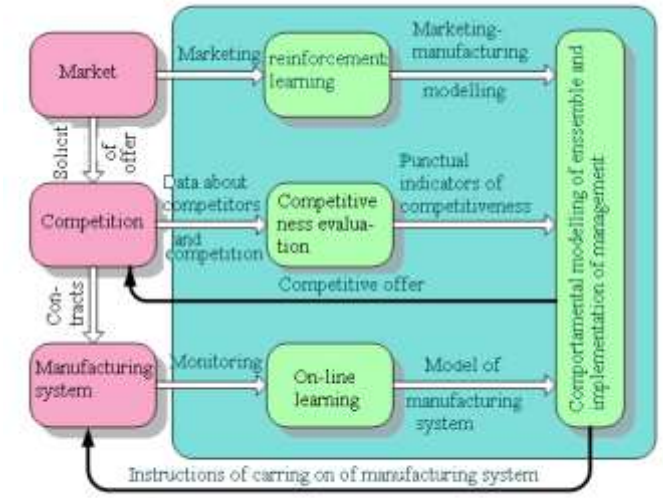

Figure 3 Competitive management of manufacturing system

5 Conclusion

At conceptual level a modeling methodology based on a 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 the 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 analyze 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) develop 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.

This approach opens new horizons in imagining how management systems can operate cognitively with technical appearances, economically, commercial, managerial.

The applications of cognitive engineering for a manufacturing system leads to the appearance of the new generations of enterprises which will achieve the products to the level of quality solicited of the market. In this paper is developed the new concept of management for the manufacturing system, the concept of competitive management.

The elaboration of a new concept of managing the manufacturing systems based on cognitive modeling of ensemble manufacturing systems – market and the implementation of management to the level of the manufacturing system which is generally applicable and proper to current requirements of the market.

In this paper is described the utilization of the method reinforcement learning in the assurance adaptability of the enterprise at the requirements market.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.