Reiforcement learning in Cognitive Engineering of Manufacturing processes

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Abstract: - The researches about learning in the word pointed out the fact that a crucial role it own the interaction with environment. The practice of sensory connections with the environment produces a big quantity of information of type cause-effect about the consequences of actions and adequate decisions for the touch of the aims. These information are a major source of knowledge about environment. In each moment, we are conscious of manner in which the environment reacts at our actions and we search to influence this thing through our behavior. The interaction is the fundamentally cause of the theories about learn and intelligence. Learning process, in general, is a process, in abaft whom, the agent (he who learn) improves the capacity of act, so that, in temporally of next solicitations, the agent undertakes actions with big efficient.
The cognitive approaching is based on acknowledge continue of the situations and the decisions in real-time about activities. Thus can offer solutions for develop and competitiveness of the manufacturing systems based on theories about knowledge and complexity. Cognitive management in manufacturing systems is characterized through the ability to perceive the environment, take the decision on time, in behind of interactions, haven't specific procedures.

Key-Words: - competitiveness, cognitive engineering, reinforcement learning

1 Introduction

On world wide plan, enterprises are confronted with a dynamics more and more an accelerated and the unpredictable changes. This is influenced by the technical and scientific progress, dynamic requirements of the customers, science of management and mathematical economy [19]. These changes enforce an aggressive competition at the global scale what 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 what determined in the way decisively competitiveness of manufacturers of components and mechanics buildings on market. The current dynamism of industrial and business environment represents a big global provocation and we must manage it.

This paper presents a new approach of technical-economical competitiveness for manufacturing systems, and a new type of competitive management of them, so that their technical-economical performance to be maximized.

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

The manufacturing system is composed when the product is started into manufacturing and stay in this structure just up to the completion execution

produced respectively. After when another product is started, the problem of manufacturing system structure is rerun from begin.

In literature, a manufacturing system is competitive on a certain the market when it obtains certain economic indicator: encipher of business, profits, segments of the comparable its superior market with one have another competitors. The approaches of the competitiveness problem [5], [15], [4], [16], [10], [2], [12], [14] show that, in this time, the competitiveness is defined though economical factors and indicators obtained and it is a suggested notion than numerical evaluation. In world exist the prestigious research centres of competitiveness, such us: Centre for International Development - Harvard University USA, European Institute of Technology with its centres from Cambridge, Geneva, Oxford and Organizational Competitiveness Research Unit of Sheffield Hallam University- Great Britain, which approach the competitiveness at global, regional level up to enterprise level. But, approaches, are economical and managerial nature, unless noticed the link with technical aspects of competitiveness.

Thence, it follows at the current level the competitiveness is definited by the economical factors and indicators obtained.

We can say as through competitiveness of the enterprises we understand the capacity (the potential) of enterprise operated comparative performant with other enterprises in the punctual mod context macro economical concrete to a given moment.

The performance is measure in which the enterprise meet aim for which is creased.

In this moment the algorithm for technical-economical competitiveness evaluation is not defined and, more the technical factors are not taken into account, also 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 isn't reported in the special literature a approach of the ensemble manufacturing system-market. It isn't known an algorithm of management of ensemble manufacturing system - market, but just algorithm of technical management of the manufacturing system and economical of the relation with the market [12], [14].

Today the manufacturing systems are managed through the programs of the machines tools with numerical program [10], [1].

Management is exclusive technique because don't exist an economical variable which in fact is an ultimate consequence.

Dynamics changes and the general progress of society translated to the level of the enterprise through many commands as the little volume, very varied, obtained through frequent auctions with answers in short terms, carry it doesn't offer the times for analysis pertinence statements.

Consequence, it doesn't managed for a long time. It is enforced a method of the fluctuant on-line, prompt reaction, speeder management [8]. The dynamism from the market is transmitted into the management.

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 determine in especially the performances of two strategic functions: product design and the offer (the price of product). In general, 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 successful request for quotation can echo severely on 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, the 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, is can

concluded that two support models are required: a knowledge model and 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.

Base on the theories [8] about cognition and complexity, is an design a cognitive and adaptive mechanism that manages processes by responding flexibly to the demands of the economical environment (figure 1).

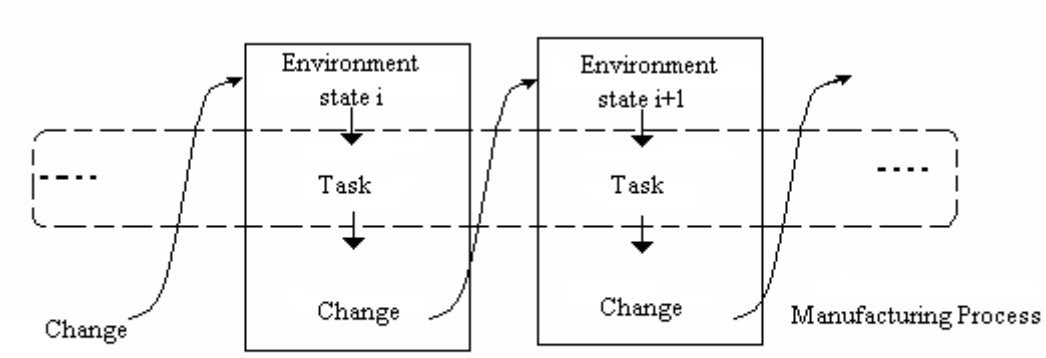

Fig. 1 Manufacturing process in the cognitive approach

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 learn problem through interaction is can reduced at three signals which transmitted between the agent and the environment (figure 2): actions, the states and the rewards.

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 don't offers the informations about the correctness actions undertaker of agent.

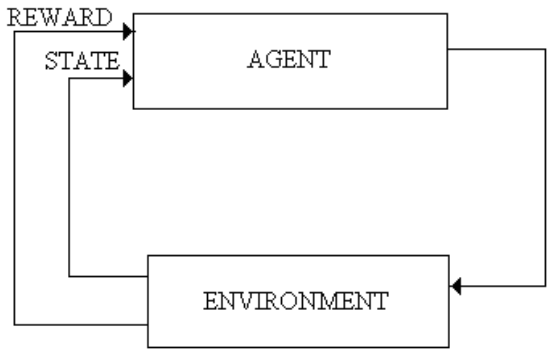

Figure 2 Reinforcement learning

In reinforcement learning [11] 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 of reacted, 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 knows already obtained the profit, but must in the same time to "explore" the possibility of finding other future actions. The manufacturing system must try a variety of actions and then to chooses them on those which even optimal.

Is done an evaluation of the evolution of state economical environment, while, and give a ensemble modeling based of the past events. Through reinforcement learning is understand the capacity of the manufacturing system to learn permanently in interaction with economical environment, to inform and updated the info about to auctions and anticipated took the statement, the level profited, and how to acted well.

The relation modeling of the market – manufacturing system simulates, on the based 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 a decisions about cognitive modeling of ensemble the manufacturing system – market, and considering of a possible future situations before these states to be experienced. After each possible situation the manufacturing system will adapted the cognitive models, so that, it to learn towards of his next states values most probable.

Through the process of learn, the manufacturing system will be leaved to execute a series of actions according to the instructions of the cognitive model of ensemble and will selected the act which it will goes in the state with maxim competitiveness.

3 Conception of a Methodologies of Modelling, in Real-Time Based on Reinforcement Learning, of the Relation of the Manufacturing System with Economical Environment

The competitive management includes and bases on comportamental modelling and on-line learning, and it is necessary to know in every moment the manufacturing system state, namely the relation between its capacity to function at the performance optimum parameters and economical environment, suddenly, in a given situation.

The answer at this necessity is generated by the mathematic evaluation methodology of the technical-economical competitiveness of a manufacturing systems in a given frame.

In the concrete case of the manufacturing system, the performance can evaluate through profit rate P, given by the relation:

$$P=(p-c)q[Euro/hour] \quad (1)$$

where p is the price, c is the cost and q is the productivity. This relation will be analysed in connection with other aspects, such as, investment amount and business efficiency,

For identification of system state relation, is necessary to establish and multiply of some manufacturing system attributes – productivity, quality, flexibility, saving, predictability both its with external environment attributes- owned market section, the evolution of client requirements dynamic, market price, concurrent systems.

These attributes are state variables of systems with which is operated through their logical connection, the state relation is determined which define in a concrete mode the system competitiveness, which mean that a X product, at the moment T, on Y market in a concrete conditions.

Comportamental modelling offers the possibility that attributes which could be modified and became in this way control and drive variables, to be used for functional system setting, for optimal values of competitiveness achievement.

Mainly, the methodology of mathematical evaluation and on-line identification of competitiveness will generate solutions for competitiveness measures knowledge, in a concrete mode above explained, and based on-line learning and give to the management disposal dates and solutions to elaborate the politics which follow to get, to keep and to increase the technical-economical competitiveness level.

The researches about learning in the word pointed out the fact that crucial role it own the interaction with 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 to touch the aims. These interactions are a major source of knowledge about environment.

In each moment, we are conscious of manner in which the environment reacts at our actions and we search to influence this thing through our behavior. The interaction is the fundamentally cause of theories about learn and intelligence.

In general, learning process is a process in abaft whom, the agent (it who learn) improves the capacity of act, so that, in temporally of next solicitations, the agent carry on actions which big efficient.

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

We will develop at conceptual level a methodology of modelling based on reinforcement

learning of relation manufacturing system – economical environment for a real system of manufacturing of a enterprises which works on a real market with values of the parameters take from the economical reality.

The values economical parameters unite with values technical parameters, accordingly product achieved will be used for to generate a relation which describes dependent the manufacturing system - market.

Is will analyzed the details about the methodology of learn based on reinforcement learning 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 a information concerning the situation of the auctions, from database derived from the marketing compartment of enterprises and the definiteness of a evaluation functions;
b. The elaboration of the cognitive model of the manufacturing system on the base of information from the data minig;
c. The elaboration of algorithm of reinforcement learning and this applied to the operation of the manufacturing system in relation with economical environment to obtain the maxim profit;
d. The integration of the model with the algorithm in frame of modelling of methodology, in real-time based on reinforcement learning of relation of the manufacturing system with economical environment.

The authors of the paper propose a block scheme and on its basis it can be elaborated a competitive management algorithm, figure 3.

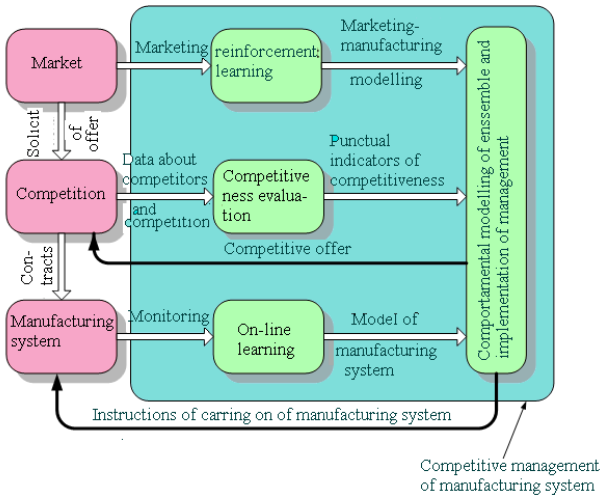

Fig. 3 Block scheme for competitive management

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 3), 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 exogen 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.

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 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 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.

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 behaviour 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.

5. 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 analysed 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.

6 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.

This approach opens the news horizons in imaginary of a management systems can operate cognitive with technical appearances, economically, commercial, managerial.

The applications of cognitive engineering for a manufacturing system leads to appearance of the new generations of enterprises which will achieve the products to the level quality solicited of the market.

In this paper is developed the new concept of manage for the manufacturing system, the concept of competitive management.

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