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Reengineering Based on Using Artificial Neural Networks in Manufacturing and Production Industries

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Abstract: Processes are designed in response to new facilities, technologies, products, markets and customers. Processes should be reviewed continuously in order to improve operations. When attempts to improve processes continuously fails but customers' expectations are not met re-designing or reengineering the process is required. Neural network is a current technique in artificial intelligence that has proved to be highly popular because of its diverse applications so that it can be utilized as a solution to facilitate full consistency of processes. Nevertheless, the concept of neural network has been rarely connected to the reengineering and manufacturing design process directly. This paper tries to introduce neural networks in a general mode and explain the five main characteristics of the reengineering (optimization, prediction, modeling, simulation, planning and decision support and generalization) where using neural networks may be employed. We also explain the reengineering process and analyze how neural networks can be used in the reengineering process. Ultimately, we offer a model for the application of this technique in the industry.

Key words: Reengineering · Neural networks · Artificial intelligence · Decision support · Expert systems

.INTRODUCTION

Processes constitute the foundation of management and covert inputs to outputs. The ability to perform tasks in correct processes creates more competitive advantages for a firm as compared to using higher technologies to produce high quality products. The strategy of process outlines the working method to produce goods physically and provide services. Decisions relating to the process must show how the firm engages in a competitive market? How are decisions enhanced? How do the processes facilitate achieving the firm's goals? A firm unable to improve its view of technology cannot reengineer its business. This conclusion is also true with the companies that interpret information technology synonymous with automation or those who try to find a problem first and then find a technology to cope with it. The reengineering concept is a product of the rapid change in information technology because rapid changes in information technology render existing processes futile. Taking advantage of information technology as a facilitating tool is a basic requirement of reengineering [1].

Neural networks are widely used by the people needing some type of automated intelligence in various fields. Indeed, the acceptable performance of this technique in terms of speed and precision in predicting trends in financial markets, recognizing handwriting characteristics, or tracking routes in automatic instruments such as robots or cranes introduces it as a unique A.I. technique. It is not surprising that false interpretations of the capacity of neural networks have inevitably appeared along with the use of this approach. Nevertheless, this technique can be effectively used in process control, manufacturing design, service compensation and service and maintenance [2, 6]. This paper introduces neural networks in a general and then tries to describe reengineering and survey some applications of neural networks in reengineering and manufacturing design process. Furthermore, this paper recommends neural networks as complementary to other techniques such as expert systems, mathematical planning, simulation etc. Ultimately, we discuss the obstacles that have prevented neural networks not to be used as expected.

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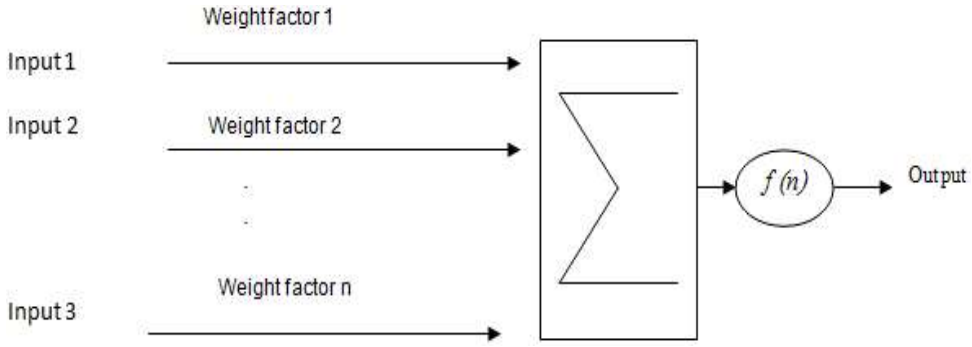

Fig. 1: McCulloch and Pitts Neuron

The Nature of Neural Networks: Neural artificial networks imitate the human brain's capability in processing data through thousands of nervous routes. In human brain, the motive instantly transfers from one nerve to another. The greater the motive functions the more powerful will be the communication among nerves. An artificial network operates in the same way. These networks are suitable for searching in large databases with definite methods and patterns. These networks are successfully used in discovering movements, collation of DNA, identifying sounds and handwritings, assessment of financial risk, creation of sound, manifesting condensation and making forecasts of the stock market [2].

In designing a neural network we actually try to invent a computer system that imitates biological neural systems and provides us with the ability of reasoning. The main element of a neural network is a mathematically designed artificial neuron that was first introduced by McCulloch and Pitts in 1943 [3]. Figure 1 illustrates the function of an artificial neuron. A neuron has several inputs and one output. An input is multiplied by a predefined weight factor. Then, the output is determined with respect to a mathematical function [*f(n)*], which is the product of inputs and weight factors. Likewise, a brain neuron is simulated in terms of calculations. It is interesting to know if an artificial neuron is invented with some variation in weight factors and the f(n) for an identical set of inputs the output may be different to some degree. This may seem unimportant at the first glance but when these neurons are connected to selected weight factors in suitable topologies a basis for a powerful computational paradigm is achieved. Indeed, research on artificial networks and their applications are focused on network topologies and weight factors. It has been established that in solving problems concerning classification and regression, neural networks, by taking into account the non-linear relation between input and output variables, can efficiently estimate functions under definite conditions. Neural networks are simple computational tools to test data and create a model of data structure. The data used in modeling are known as educational data. Figure 2 depicts one of the most popular network topologies known as the used up in advance network which includes three layers: input layer, output neural layer and at least a hidden neural layer positioned between input and output neurons. The data flow is directed from left to right. The process begins with inputting X and the passage of data through the hidden layer through related weights and arrives in the output layer. Each signal in the input layer is thoroughly to one neuron in the hidden layer.

These connections are also established among neurons in the hidden and output layers.

Reengineering is aimed at analyzing organizational processes with the purpose of finding the most efficient methods of performing certain jobs. To found a useful and effective a planning system for production resources production methods must be modified and new methods must be developed. Therefore, reengineering is in close ties with the implementation of resources planning systems. The process reengineering considers various methods of performing a certain process and chooses the best.

A neural network is developed in two stages: education and operation. Educating a general network is carried out as follows:

- Random values for weight factors are determined.
- Input and output samples are introduced to input and output layers, respectively.
- Weight factors are adjusted in a way that input-output pairs are correlated properly.
- This procedure is repeated for other input-output pairs in the sample.

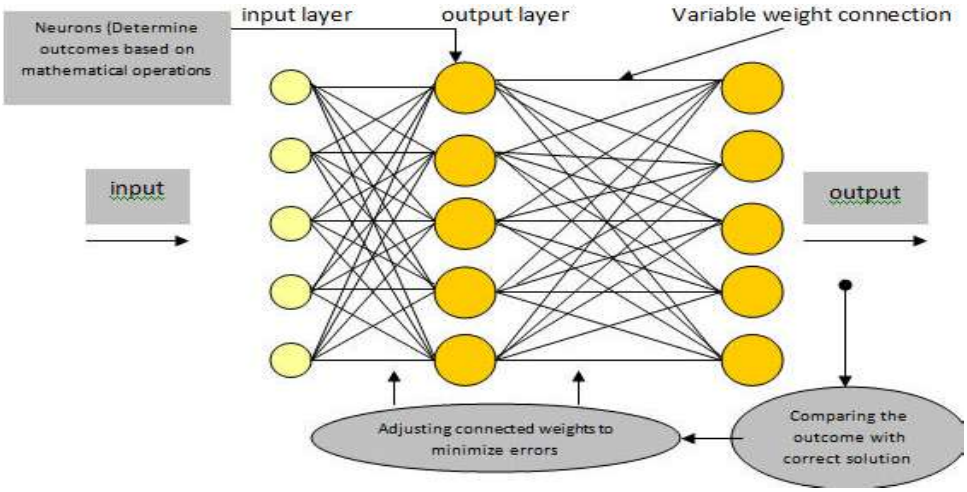

Fig. 2: Teaching a three-layer neural network

- As the adjustment of weight factors for each input-output affects others steps 3 and 4 must be repeated in way that each pair in the sample is correlated with respect to the predefined error rate. In other words, this is the stage of converging weight factors and the network stability. When a network is property taught operations may be launched and the network may be set in motion. A new input is introduced and the proper output is attained. The advantage of neural networks, in addition to their capacity to replicate examples, is to extend relations to include the inputs that have not been taught in the course of education. For instance, in identifying handwriting the neural networks are designed to recognize features of handwritings that are extremely difficult to be deciphered. Therefore, neural networks can process many algorithms used in identifying patterns especially when inputs contain few variances.

Regarding these abilities, neural networks are used in solving similar problems in other fields, such as predicting time series and it has been found out these networks can make good predictions. An instance of applying neural networks is in operations management that allows cutting expenditures remarkably [4-6]. We will further discuss applying neural networks in reengineering processes later.

Reengineering Process and Neural Networks: Reengineering is an innovative activity and intends to achieve new goals by using latest findings of technology. One of the most difficult tasks of reengineering is to cognize new and unparalleled capacities of technologies, rather than focusing on its unknown potentials. Buying present technologies is not so outstanding but the important task is to discover latent features and creative aspects of existing technologies. The process design decides how a product is produced or a service is presented. In process design, the components that must be made within the organization and the ones that must be provided from outside are determined. Reengineering means a restart and a fresh opportunity to reconstruct processes and reproduce production methods and operations Reengineering projects are often devised to remove obstacles and improve process efficiency and performance. The average rate of performance improvement in 12 months may increase from 50% to 100%. Since, reengineering is a relatively new initiative in production improvement its methods and applications are still being developed. Because applying reengineering concepts may be very diverse it leads to different methodologies because. These methodologies will be different from this project to another because of emphasis on certain factors in each project [1, 7].

The steps of reengineering process may be illustrated in terms of Condore methodology as follows (Figure 3 depicts steps of reengineering): Goals and specifications: In the first step, goals and specifications are defined. Analyzing the difference between the current performance and desired performance will show whether the process needs reengineering or not. Where reengineering is needed the reengineering team is formed and a preliminary analysis will determine goals of the process.

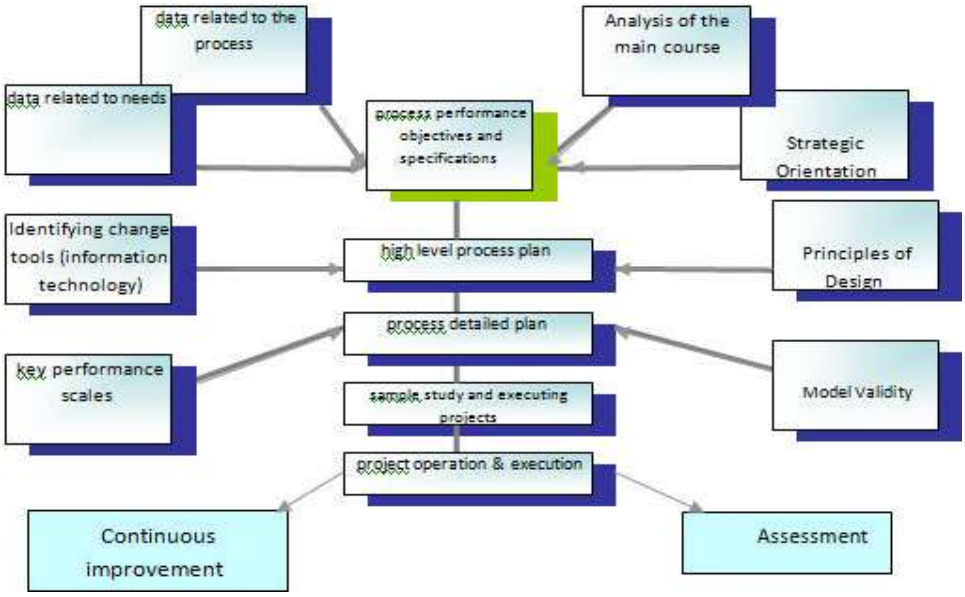

Fig. 3: Reengineering Process

High-level Process Plan: This is a useful tool in reengineering design. This plan is drawn by focusing on goals and reverse movement from outputs to partial processes and elementary requirements.

Process Detailed Plan: After a consensus on general concepts of redesign is obtained the process detailed design (product design plan) for each partial processes or blocks are prepared. Blocks are added to the process when they actually contribute to the realization of the output. Preparing the detailed plan of the process helps the decisions on the allocation of resources and working methods.

Trial Study: Reengineering is not similar to other projects and a perfect and precise planning for it is almost impossible. Reengineering is an attempt to define new and untried subjects. It also tries to estimate expenses and resources optimally. Therefore, firms shall allocate a portion of their resources to reengineering and should not evade it.

Operation and Execution of Plans: Following a successful trial study the complete execution of the process begins. Since reengineering requires crucial changes. This includes converting old processes into new ones in the course of day-by-day operations which is a rigorous and time-consuming activity.

Several features of this model have been identified and neural networks, as the main or subsidiary methodology in problem-solving, may be used in solving such problems[16]. Features of this methodology may be summarized as follows:

Optimization: Some activities may be categorized as optimized actions. Just-in-time production management, product optimization and the allocation and scheduling of resources are instances of this group of activities.

Forecasting: The absence of precision in a process that easily propagates to other activities is a serious problem encountered in organization. Therefore, forecasting is an important matter in process design and reengineering.

Modeling and Simulation: This topic covers the analysis of the dynamics of reengineering process using techniques such as Discrete Even Simulation and the Dynamic Systems Theory.

Planning and Decision Support: Neural networks are used to simplify decision-making process in reengineering.

Globalization: Globalization in reengineering refers to increasing coordination among events in progress in various fields.

Optimization: Optimization is a technique to overcome restraints. Assume a set of restraints. The aim is to find an arrangement to meet all restraints and minimize the expense function. Perhaps, the most known example is the traveler salesman problem. The plot of the story is as follows: there are a number of towns and the salesman has to find the shortest route for visiting the towns. Counting all possible routes, measuring distances and finding the shortest course is the process that intuition suggests. This method focuses on finding an approximately good solution. Experience shows approximate solutions are often acceptable and close to the best solution. Neural networks are currently known as one of the most common approaches in finding sub-optimal or close-to-optimal solutions. Specifically, the related literature contains instances of using neural networks in TSP, workshop production timing, group production timing, navigation of vehicles and warehousing. Sometimes, comparing the performance of various algorithms in optimization is difficult though it has been found that neural networks have a large capacity in calculating new restraints while they are increasing in a very dynamic environment [2, 8].

Forecasting: One of the major objectives of reengineering is to improve the precision of forecasting demand for products. Techniques that are generally used to forecast demand is used in design planning. These techniques include simple forecasting, casual forecasting, forecasting based on time series, exponential function, movable mean, mean, multiple linear regression, neural networks [1].

As is explained below, for two reasons advanced methods are expected to work more efficiently as compared to traditional ones: first, advanced methods combine non-linear models and can consequently make better estimates than linear models. Second, because of the complex behavior a high degree of non-linearity in demand. For instance, when demand is to be assigned to a certain production period and one or more production substitutes are to be defined in terms of non-linear expenses the whole expense of production plan will be non-linear and it will be impossible to use traditional methods. In these cases, the linear decision rule or an innovative method such as neural networks may be devised because only methods based on the linear decision rule can produce an optimal solution.

Because of the frequent successes of the neural networks in forecasting the performance of financial markets, production timing or manufacturing design, users may arrive at this conclusion that the ability to forecast processes is the main advantage of neural networks in the said fields [1, 10, 11].

Using neural networks in forecasting can be explained in this way: assume a certain data that can be used to analyze the behavior of a system. Then, the data are employed to educate a neural network to assess the correlation of the response of the system to time or other system parameters. Furthermore, assume a definite pattern of input data. A neural network is able to recall similar patterns in the past and then forecast one or two steps that my happen in the future. Experience shows the neural network technique forecasts more accurately than expert system or other statistical counterparts [12].

Modeling and Simulation: A careful analysis can determine the form of decision rules and a regression analysis or simulation may produce a good estimate of unknown parameters. Applying neural networks in modeling and dynamic system analysis shows certain features make the neural networks much more attractive as compared to the system dynamic theories.

Using neural networks as a meta model to simulate separate events that has produced good results. Surely, some problems due to the non-linear behavior of systems and diversity of input and output parameters involved in the process may appear in the modeling. Simulation-based software programs not only allow graphic depiction of the process but also help logical test of the system, determining bottlenecks, unused displays, performance assessment and the process improvement analysis [1, 9].

Decision Support System: Decision support systems (DSS) are information systems that help managers make decision in a replicate process. In most cases, a quantitative method is amalgamated in a DSS. This decision support system is used in estimating oil and gas reserves, labor timing, choosing trial markets and establishing distribution networks.

Types of Information Systems Are: Decision support system, management information system, expert system, artificial intelligence and planning system.

In fact, an expert system is a form of artificial intelligence. Neural networks, genetic algorithms and fuzzy logic are other types of expert systems.

Now this question is set forth whether neural networks are able to provide required solutions. Most studies on the decision support system depend on the data management and analysis for supporting a decision. Exclusive characteristics of neural networks in cognizing patters, classifying data and self-organization have proved it as an ideal choice to complete query techniques in searching within traditional databases. It is assumed

that required parameters can be estimated using neural networks. The advantage of metaheurisitc views stems from their close relations to the behavior of managers in true decision-making [1].

Another important feature of decision support systems is the extraction of relations from data in the absence of prior knowledge of proper models for data [15]. Sometimes this feature is classified as a non-conservative issue. Classic applications in this field can be illustrated more clearly by the application of neural networks in imitating decision-making processes.

Generalizations: To guarantee the success of a reengineering process the consistency among activities is very important. Before this, the importance of using information technologies such as the VAN (Value added network) and EDI (Electronic Data Interchange) in shortening the time of transferring data had been proved [6]. As various sections in a firm grew independent the concept of a virtual firm developed in the same form that a separate process is carried out in an entity [13].

This paper actually is aimed at focusing on the DAI (Distributed Artificial Intelligence) to facilitate general optimization. DAI uses the problem solving strategy that accompanies with categorization and achievement. In this connection, Falk et. [14] showed that a workshop timing problem can be solved by using a intelligent technique. An intelligent factor can be treated as a computational process that is matched to a machine tool in the workshop. Then, the timing is fulfilled as a negotiation process among intelligent factors. Technology decisions can remarkably affect the cost, quality, speed and flexibility. The more important, this method makes clear future decisions to be made and arrange the firm for competitive objectives.

Iv. Discussion and Suggested Model [17-19]: Applying neural networks facilitates optimizing complicated problems. Neural systems are part of general problem-solving methods that provide a general structure and strategic directives to develop special innovative solutions fitted to special problems. From the standpoint Regarding the features described in quality of applied development, neural networks are the best the choice in terms of software retrieval because they may be embedded in every desirable part of the software whose function is needed. Technologically, the ability of neural networks in unification with current technologies is highly important because this ability allows the implementation of developed tools that is a common strategy in introducing new technologies. It can be foreseen that neural networks will function as an integrated system in the field of industry. Specifically, neural networks are often integrated with other techniques where a single technique cannot produce the desired solution.

Previous sections, the intelligent integral model to be used in industries is introduced as depicted in Figure 4:

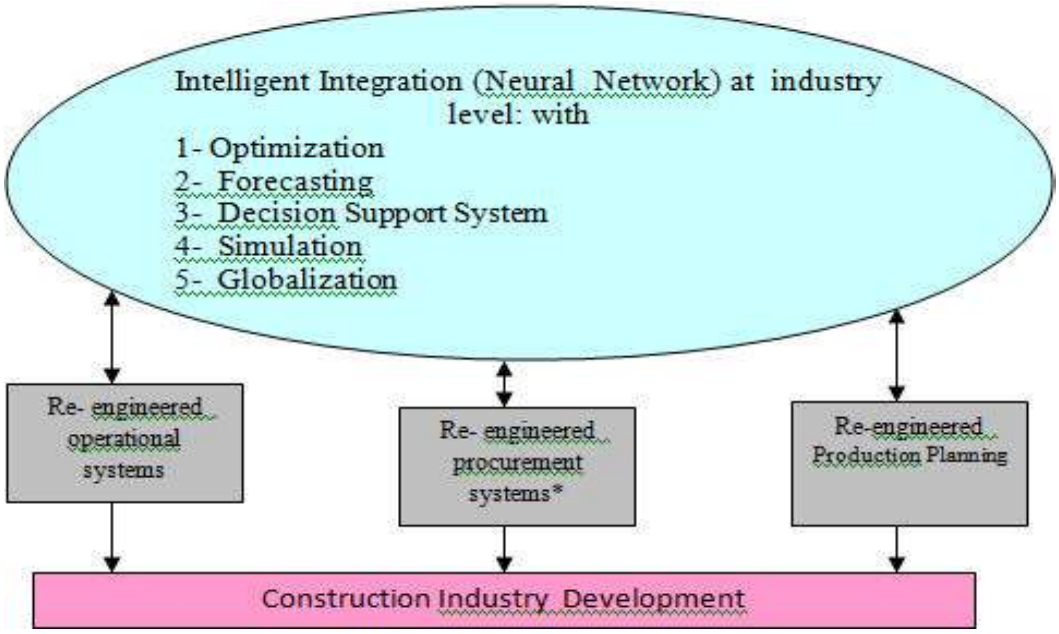

Fig. 4: The Intergrated neural model and reengineering

This integral technique may be used for optimizing processes, managing delivery services, assessing the performance of equipment, modeling, planning preventive repairs, controlling the quality of materials bought from various suppliers, forecasting expenses stemming material shortage, supervising terminal operations, minimizing production time, organizing the procurement and order delivery chain with respect to the nature of processes, determining optimal capacities, cost management and investment.

Applying neural networks and using this technique in finding solutions have been discussed in numerous papers although sometimes it is perceived employing neural networks may be problematic sometimes. Therefore, it is important to know general defects of neural networks, when they are installed in operational systems, in order to guarantee their successful performance. Marco [20] states the problems are of two types. The first, neural networks produce solutions that are not useful for the user. Indeed, this is the most important defect that is highlighted when neural networks are compared to expert systems. Neural network researchers are trying to rectify this fault. The second defect stems from the fact that finding high data to provide education suitable for neural network is somewhat difficult. In many cases, the data are not available and sometimes the management obstruct accessing the data.

* *Operational systems such as : planning and control, information management, quality management, safety management*

CONCLUSION

Neural networks, both from the standpoint of analysis and in terms of hardware implementation, are expanding qualitatively and quantitatively and various techniques of neural computation are numerically increasing and offer solutions for practical means and major improvements in engineering operations. From the standpoint of reengineering, the paper discusses several aspects where neural networks can considerably contribute to them. One of these aspects is forecasting, analysis and planning to facilitate successful and consistent reengineering operations in order to make possible lower costs and higher speed and quality accompanied with continuous improvement because neural networks can help administrating the risk analysis system, quality forecast, machinery maintenance analysis, management and planning, inventory cost analysis systems, product forecast, risk forecast, process control modeling, production line arrangement, non-linear modeling, manufacturing process control, financial analysis, production process forecast, production optimization, product analysis and design, machine and process recognition, system control forecast. Furthermore, it was explained that the literature shows neural networks can produce more satisfactory solutions as compared to traditional techniques. It was also discussed that regarding restraints and various capabilities of different techniques, integrating artificial neural networks with other techniques may lead to more desirable results. Investments to develop new equipments, especially untried technologies, are always prone to risks. To estimate the performance of equipments and shelf-life and operational cost may be a difficult uncertain task and, for the same reason, the management's ignorance of new technologies will intensify such difficulty. Additionally, there are other negative factors that may cause the failure of reengineering if they are escaped from our attention; mending a process instead of revolutionizing it, the failure to pay attention to processes and employing the leadership styles unfamiliar to reengineering are among these negative factors.

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