Conceptos
y fenómenos
fundamentales
de nuestro
tiempo

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EXPERT SYSTEMS APPLICATIONS IN MEXICO: PROBLEMS AND OPPORTUNITIES

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INTRODUCTION

The success of the participation of Mexico in the North American Free Trade Agreement (NAFTA) as well as in the global economy depends on the technological improvement of its production processes to reach high quality with smaller costs and a greater flexibility in product supply. This improvement is a function of the quality of Mexican engineering practice in the fields of natural resources exploitation as well as production and service technologies. This situation makes necessary to relate new technologies with the different branches of Engineering.

The computer is a major breakthrough in Engineering. It has changed the ways to make analysis and design of production processes. Artificial Intelligence is the most dynamic field in computer science and technology and Expert Systems also called Knowledge-based Systems are one of the most fruitful areas of Artificial Intelligence. Knowledge-based Systems technology has proven to have a high potential to solve real problems where human experience has an important role because algorithmic solutions do not exist or are not adequate.

In fact, Knowledge Engineering permits to capture the corresponding expertise from the human experts and convey it into a computer through a knowledge base. A knowledge base is a collection of logical propositions whose relationships model the knowledge about a certain topic. In this paper the principal issues to be taken into account to apply successfully the Knowledge-based Systems technology in Mexico are discussed, according to the experience at the Intelligent Systems Laboratory of the National Autonomous University of Mexico.

EXPERTISE AND ENGINEERING

During the last decade the development of production systems oriented to greater quality, productivity and flexibility has been a top issue in the production planning all over the

world. These systems are based on a better understanding of the production process and the characteristics and properties of materials as well as the availability of better equipment and instrumentation, that is, a high level of engineering and technology.

However, decision making in engineering is made taking into account a combination of:

A) Scientific theories and analytic techniques
B) Experimental methods
C) Last but not least, individual experience and judgment as well as common sense.

The fundamental role of individual expertise in engineering is due to several factors including:

a) Lack of specific information about the problematic systems
b) Uncertainty in the available information about those systems
c) The great diversity of phenomena and variables that affect the behavior of those systems
d) The occurrence of unexpected situations and conditions
e) The complexity of the problems
f) Theories applicable only to very specific cases and limited conditions.

Problems whose solution depends on empirical rules defined by an expert along his/her life experience are very common in engineering. In this sense, we find these empirical rules in the analysis, design and production phases of a certain product, as well as in the planning and management of the whole process. As a consequence, there is a need to ask the assistance of experts in the engineering and technology domains in order to have the proper solution, when a difficult problem is encountered.

In developing countries like Mexico there is however a lack of highly qualified experts in engineering and the existing ones are concentrated in the largest cities. This means that problems are not going to be solved unless the reservoir of technical knowledge and the

expertise of the existent experts are made available in the sites where problems originate. Moreover, the process of knowledge transfer from an expert to train a new expert is very time consuming.

A way to solve this technical problem and to improve the availability of qualified knowledge in the field, would be to capture the corresponding expertise from the experts into a computerized knowledge base. This knowledge base would be then the nucleus of a microcomputer consulting program that would be widely distributed among the users all over the country.

ADVANTAGES OF EXPERT SYSTEMS

The advantages of an Expert System are:

Autonomy: After a knowledge-based system has been designed and implemented, it becomes autonomous. This means that the system is physically independent of the system's developer and the domain expert.

Reproducibility: A knowledge-based system and the knowledge it contains can be reproduced easily, if necessary, to thousands of copies in a few minutes. On the other hand, a human expert takes years to become fully skilled.

Low Purchase and Operation Cost: Having experts available at all times is very expensive. On the other hand, the cost of a knowledge-based system lies only on its design and development. These costs can be later distributed among all users of the system, making each single copy very cheap.

Disposability: The knowledge-based system can be easily distributed to different locations and it can also be used in difficult working conditions.

Flexibility to expansion and modifications: The information contained in the knowledge base can be easily updated to incorporate new technological advances, simply by accessing text files because these files are not part of the knowledge bases.

A SAMPLE OF EXPERT SYSTEMS APPLICATIONS IN MEXICAN INDUSTRY.

Given the big number of small and medium sized enterprises, the Energy Academic Program of the National Autonomous University of Mexico found that it would be of great benefit to implement an energy conservation program in this kind of enterprise. This program should focus on design as well as simple maintenance and servicing measures, and should be based on the practical knowledge of energy experts, who would diagnose every case and prescribe the pertinent recommendations.

Taking this into account, the Intelligent Systems Laboratory of the National Autonomous University of Mexico developed a series of knowledge-based systems for energy conservation programs in small industrial and services enterprises.

The first Expert System to be developed was called SEILUM and was built for lighting systems analysis and design in small and medium sized industrial buildings, taking into account energy savings criteria.

The second Expert System in this area was called EXILCO and was aimed to optimize energy consumption by lighting in commercial buildings and hotels.

Both systems calculate the energy used by a given lighting system according to illumination levels in the different areas of the building and recommend energy saving policies and measures to improve the efficiency of the lighting system. These Expert Systems were developed for the non-expert final user who wants to analyze a particular building illumination system to reduce costs.

Both Expert Systems were validated by different lighting specialists. They compared the results obtained by the systems against the reports of several studies performed by the

government energy agency FIDE in Mexico City along 1993 and 1994. The effectiveness shown by the Expert System was of 85% in average with a cost reduction of up to 60% compared to the cost of traditional studies.

A third Expert System called ESCAF was built to design compressed air facilities for small and middle size plants in the cement, chemical, pharmaceutical, painting, glass, mining and textile industry and to review existing ones in order to optimize the energy used in such facilities. In this way, for a new compressed air facility ESCAF provides in an adequate way the type and capacity of the compressors and drying system if necessary, as well as dimensions of pipelines and recommended accessories including cooling systems. All this information is given considering criteria of efficient usage of energy. For an existing installation, ESCAF provides an analysis of actual equipment and the necessary recommendations for an adequate supply of compressed air, according to energy efficiency. Moreover, for both cases ESCAF recommends appropriate preventive maintenance programs and allows detection and correction of operative failures.

ESCAF was validated by experts engineers from a very prestigious international corporation dedicated to designing and manufacturing compressed air equipment. The experts made very positive evaluations of the performance of ESCAF and recommended it for internal use at their corporation. A license for unlimited use of ESCAF was given to that company.

A fourth developed Expert System, TUTORES, is a tutorial Expert System, built for training of technicians and engineers in the field of design and evaluation of cogeneration plants.

Within the field of efficient use of energy, industrial cogeneration of energy is a very important way to reduce waste and to increase the supply of this important resource. However the bottleneck for the full implementation of this solution at the level of the industrial sector in Mexico lies on the lack of trained human resources for the design and

operation of cogeneration plants. In fact, there are very few human experts in such field compared with the number required by industry.

In this sense, it was decided to develop a tutorial Expert System to provide technical training in the design, selection and evaluation of cogeneration plants, considering the new technologies available in the market. The users of this system would be engineering students, technicians and professionals interested in this theme as well as training departments of industrial corporations interested on this kind of energy saving measures.

TUTORES was carefully validated by cogeneration specialists and instructors as well. Its evaluation took place at the National Commission for Energy Conservation in Mexico, in special courses designed to train people from industry and the public sector. The results have been excellent.

Finally, a fifth Expert System built for the energy sector was ESDOW, an Expert System for the design of oil well drilling in State Tabasco. ESDOW was developed for PEMEX, the Mexican oil corporation. The users of ESDOW are engineers of the technical staff of PEMEX at Villahermosa. The inputs of this Expert System are the characteristics of the corresponding oil field and its already producing oil wells, specially those that are the nearest ones to the location where the oil well will be drilled. Based on this information, ESDOW prescribes the best procedures and materials to be used in the drilling. ESDOW produces in a couple of minutes a report with results, for obtaining which, a team of engineering experts used to work a couple of weeks.

ESDOW was fully validated by the technical staff of PEMEX and was such a success, that an enlargered version is now under development.

ISSUES IN THE DEVELOPMENT OF EXPERT SYSTEMS APPLICATIONS IN MEXICO.

Expert Systems constitute a new concept for most corporations and governmental agencies in Mexico. This means that in most cases when the development of an Expert System was

advised as the proper solution to a certain problem, we faced the problems related with the introduction of technological innovations in organizations. In other words, the application of Expert Systems to industrial problems in Mexico cannot be reduced to a mere technical implementation. In fact, it is a cultural assimilation process, resulting from the interaction between the development of the Expert System and the cultural and technological environment of the organization. Taking into account this environment and the people that could be affected by the system, reduced the possibilities of failure.

Some factors that were taken into account to promote the success of the Expert System assimilation were the following:

a) The Mexican organization already had a core technology similar to the new one. For instance, a computerized data base system, a computer network and/or a management information system. This technology was already an integral component of the technological culture of the organization.

b) The Mexican organization had at least a middle or top executive, convinced of the new technology, and willing to play the role of "champion of the technology". He pushed the project, defended it within the organization and convinced people to accept the project.

c) To get real support from the final users, the development team involved them actively in the project from the very beginning, thus becoming facilitators instead of obstacles of the implementation. This involvement assured that the user requirements were taken into account in the design. Moreover, it resulted in the best way to train the users to operate the system and to gain their support for the implementation. This was also the ideal measure to avoid the "Not-Invented-Here" syndrome, consisting in the blocking out of every innovation coming from outside the organization, with a hard opposition.

d) The development team made itself familiar with the problems of the organization, the problems of the final users within the organization and the characteristics of the environment before to arrive to a proposal on how the Expert Systems technology could

help to solve the problems. We considered the requirements of the organization in order to explain the benefits of Expert Systems. Moreover, it was taken care, not to oversell the technology, promising outstanding results beyond reality.

e) The development team tried to relate the Expert System with the available systems at the organization, as a useful "add-on" to the existing systems. This permitted to get the support from the management and the users, because they got new, useful capabilities of their systems, that were difficult to obtain by another technology.

f) The University team looked for solving real problems, not invented ones. The aim was not to develop a system that never would be used.

g) The Expert Systems team tried to build and consolidate a credibility environment in users and executives of the Mexican organization about the real possibilities of Expert Systems in general and the proposed project in particular. To that purpose, the Expert System was gradually implemented in order to validate it with the user since the very beginning. The best way to do that was to build a "rapid prototype" that contained only a few rules and very basic knowledge, but that could deliver "correct" results in a particular domain of the problem. We installed this first prototype in the user machines and encouraged all kind of tests and feedback. Then we abandoned it and built successively larger versions, getting user feedback everytime to improve the design. Finally we ended with a viable and operational final version. The development of the successive prototypes helped to train the own development team in the characteristics of the problem and at the same time to involve final users in the project, building a common language with them.

CONCLUSIONS

In this paper some principal issues that were taken into account to apply successfully the Knowledge-based Systems technology in Mexico were discussed, according to the experience at the Intelligent Systems Laboratory of the National Autonomous University of Mexico.

An important conclusion is that Expert Systems constitute a new concept for most corporations and governmental agencies in Mexico. This means that in most cases the Expert Systems developer faces the problems related with the introduction of technological innovations in organizations. In other words, the application of Expert Systems cannot be reduced to a mere technical implementation. In fact, it is a cultural assimilation process, resulting from the interaction between the new Expert System technology and the cultural and technological environment of the organization. Therefore, the development team should take into account this environment and the people that could be affected by the system, reducing the possibilities of failure and paving the way to the technological innovation.