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Expert systems: human intelligence using computational means in industries

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ABSTRACT
Expert systems, which are the most commercially successful result of research in artificial intelligence, are software entities that follow the cognitive abilities of human experts in complex decision making situation. As one of the primary activities in computer science and dependent heavily on the rapid development in computer technology, Expert systems have been eagerly adopted by industries and applied to a wide range of applications. Expert systems belongs to a field of intelligence knowledge based systems the constitute one of the principle field of activity of computational intelligence, a field which been referred to as the science that attempts to reproduced human intelligence using computational means.

Introduction

Conventional control techniques based on industrial three term controllers almost universally used in industry and manufacturing today, despite the obvious limitations. Modern control techniques have not proved possible to apply because of the difficulties in establishing faithful microscopic models of the processes under control. In the early 1970's intelligent control techniques, which emulate the processing of human knowledge about controlling a process by machine, appeared and a new era of control was born. Intelligent control has come a long way since then, breaking down the barriers of industrial conservatism with impressive result.

The principle medium of intelligent control is computational intelligence the branch of soft computing which includes expert systems. The fields of expert systems use linguistic rules to specify domain knowledge and are used extensively today in industry in such diverse applications. Computer intelligence has many branches, one of the earliest and most important of which belongs to expert systems.

Elements of an Expert System

Expert systems are the outcome of a major effort in computer science to emulate the cognitive faculty of humans. Conventional computer software can be viewed as the synergy of:

Software = Data + Algorithm

Here the algorithm process data in a top down manner until the result is arrived at. In contrast computer software used in expert systems can be described as the synergy of:

System=Knowledge + Interface

In this case the system structure differs radically and the principle elements are knowledge base, which is a depositary of all the available domain specific knowledge and the inference engine, the software whose function is to infer decisions.

An expert system can be categorized as an intelligent knowledge based system provided it reproduced knowledge in the form of rules. The most significant characteristic of this class of system is that it draws on human knowledge and emulates human experts in the manner with which they arrive at decisions.

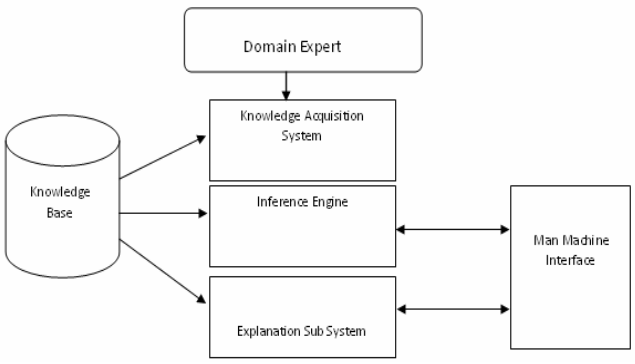

Figure 1. Basic elements of an Expert System

The basic elements of an Expert System are shown in Figure 1. An expert system includes the following elements:

1. The knowledge base, which comprise facts and rules with which to control a plant.
2. The inference engine, which processes the data in the knowledge base in order to arrive at logical conclusions.
3. The explanation sub system, which is capable of a giving a rational explanation on how the decision was arrived at.
4. The knowledge acquisition system, which is used by the knowledge engineers to help them analyze and test the knowledge elicited from human domain expert and
5. The man machine interface through which the human operator interact with the system.

Intelligent Control

Intelligent control takes radically different approaches to the control of industrial processes and plants from conventional control. Intelligent control seeks solution to the problem of controlling plants from the viewpoint of the human operator. Computational intelligence provides the tools with which to

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make intelligent control a reality. Figure 1 show how computational intelligence can be classified according to the form of the knowledge and the manner in which this knowledge is processed. For control application, knowledge can be structured or not, but processing is invariably numerical. Fuzzy and neural control from the core of intelligent control and are the principal component of computational intelligence.

Techniques of Intelligent Control

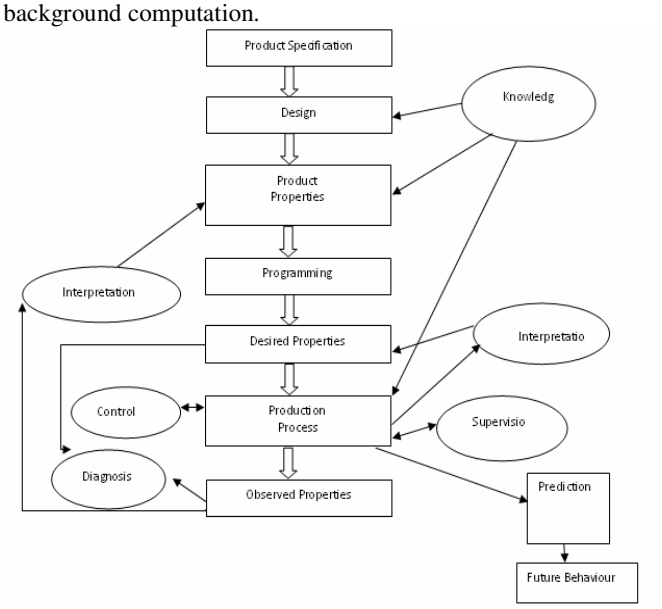
One or more of the following techniques of computational Intelligent may be used to this end:

- Expert systems
- Fuzzy logic
- Artificial Neural Networks
- Neuro fuzzy Systems
- Evolutionary Computation

Expert System Paradigm

a. Expert system for product design

Modern flexible manufacturing system produce specialized product of high quality, limited production runs and short life cycles. These product undergo changes often and their design must be completed in very short times, imposing considerable stress on product designer. Expert computer aided design systems are now available to assist the designer permitting him to exploit his creative abilities to the utmost while advising him on design and materials constraint following extensive background computation.



While conventional computer aided software can process geometric shapes rapidly, the designer needs to know rapidly certain characteristics of product being designed. Expert CAD systems provide all this information while in addition advising the designer of alternative shapes from a priori experience with similar design.

Expert System for Plant simulation and operator training

The role of the instructor can be taken by expert systems, which can untiringly repeat plant malfunctioning and like their human counterparts, examine and instruct the trainee operators, the knowledge with which to operator is embedded in a set of if.....then.....else rules that are used to operate the plant. Multimedia and virtual reality is used in man machine interface in training plant operators even before the plant has been commissioned.

Expert supervisory control systems

The primary objective of any supervisory control and data acquisition system, which constitute the kernel of any CIM system, is data acquisition the overall supervision of the health of the plant, prompt alarming of out of range variables and control of the principle variables of the plant under control. Expert system is used in industrial controls, which is an integral part of SCADA system in the following field:

- The design of industrial controller
- The supervision and control of manufacturing plants

The use of the expert system in the design of the industrial controller has two aspects. The first involves the rules on the most appropriate design technique to use in order to achieve the desire result .the second aspect involves rules that specify the best control strategy to follow in any situation, given as advice to the operator.

Expert system for fault prediction and diagnosis

A very new field of application of expert system has been in equipment fault prediction and diagnosis, sometimes termed equipment health condition. The use of expert systems for fault prediction results leads to a drastic reduction in the mean time to repair equipment and a corresponding increase in the availability of the equipment and most importantly, an increase in plant productivity. Expert system in fault diagnosis can be either off line or online. In the former case maintenance personnel enter into a dialog with the expert system, supplying answers to questions posed by the expert system on the health of the equipment. The expert system then give the instruction on what further measurement and what actions should be followed that will focus on the source of the problem and then give advice on how to repair it.

Expert systems for energy management

With the ever increasing cost of energy the management of energy in large industrial plants is of major concern and means to contain these costs are actively sought. Real time expert energy management systems have been developed and have been very successful in containing energy costs, replacing the human operator in this tough task. Indeed avoiding just one or two overload penalty often pay for the cost of expert system.

Expert systems for the prediction of emergency plant condition

Effective control of large complex industrial systems, such as nuclear reactors, power distribution networks and aircraft and aircraft, is critically important since breakdowns can lead to unforeseen and potentially disastrous results. A human operator has great difficulty in making decision when facing conflicting or excessive information, particularly under stress. Expert systems using data from the plant and the rules derived from logical reasoning and prior experience, advise the plant operator on the best course of action to take in order to advert a catastrophe and return the plant to its nominal operating state as quickly as possible, with minimal disruption of production and damage to the equipment.

Conclusion

The field of expert system is one of the most exciting and promising new directions of automatic control that is opening up new frontier for research and development in radical solution to the control of industrial system in the new millennium.

In this paper, we have just scratched the surface of the wide area of expert systems which have turned out to be the most commercial aspect of Artificial Intelligence. A large number of expert systems are in real use and quite a few even being sold for individual use. In the future one is likely to see more expert

systems packaged with domain knowledge being sold. Further, these systems are also likely to carry out specialized tasks as parts of much larger software systems.

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