THE IMPACT OF CULTURE ON EXPERT SYSTEMS

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Expert systems are computer programs that are designed and developed to include the expertise of a human expert. The knowledge and cognitive processes are simulated by the system. Expert systems promise to retain, transmit and utilize the expert's knowledge in dramatically different and revolutionary ways.

This paper presents a general approach to analyze the impact of different cultures on expert systems and their design, development and use. Culture manifests itself a number of ways, including, language and attitudes toward experts and expertise. Cultural differences affect the cognitive processes in a variety of ways, including causal explanation, assessing probabilities and even knowledge representations. As a result, cultural differences affect the design, development and use of expert systems at various stages, including expert/expertise identification, knowledge acquisition, knowledge representation, knowledge inferencing and user interface.

This paper proceeds as follows. In the next six sections, we examine what expert systems are, expert system structure, the computer languages used to build expert systems, the generic types of expert systems, uses of expert systems and the process of building the expert system. Then we examine some of the elements of culture that can impact the cognitive processes. Finally, we analyze the impact of those cultural elements on the development and implementation of expert systems.

The Impact of Culture on Expert Systems

ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

The term artificial intelligence (AI) is an umbrella term that includes a number of activities: expert systems (ES), pattern recognition by computers, learning and reasoning by computers, natural language use by computers, and other topics. Barr and Feigenbaum (1981), Rich (1983) and Winston (1984) provide comprehensive surveys.

Winston (1984, p. 1) defined AI as "...the study of ideas that enable computers to be intelligent." Barr and Feigenbaum (1981, p. 1) have defined AI as "... the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics associated with intelligence in human behavior...." These definitions indicate that AI is concerned with developing computer systems that perform cognitive tasks and do analysis that humans currently use knowledge and reasoning to carry-out.

Currently, the most frequently applied branch of AI in business is expert systems. ES's perform tasks normally done by knowledgeable human experts (Rich, 1983). Accordingly, ES's are developed by programming the computer to make decisions using the knowledge and a representation of the decision making processes of the expert.

ES STRUCTURE

Structurally, ES's usually have four major components: database, knowledge base, inference engine and user interface. The database contains the input data used by the expert system. The data may directly come from the user or may be part of the system or may be part of a computer database. This is normally the same data that a human expert would use to solve the problem. However, the system may use more or less data to solve the problem. For example, the human expert may use additional equivocal information for ill-defined problems that is not easily incorporated into the system. Whereas, the expert system may exploit the data processing capabilities of the computer and include unequivocal data that a human would not have time to process.

The knowledge base contains the set of knowledge that the system uses to process the database. Typically, this is the domain specific knowledge that the expert would use to solve the problem. Knowledge can be represented in a number of ways. One of the most frequently used methods is the rule-based approach. Rule-based knowledge representation takes the form of "if ... (condition) then ... (consequence/goal)." The rules may or may not include a numeric level of confidence or probability of occurrence. Alternatively, knowledge may be represented as a "frame" to capture the characteristics associated with a given entity. The characteristics define the knowledge about the entity that is of interest in the application. Typically, frames describe a class of objects. The frame generally consists of a collection of "slots" that describe characteristics of the objects. These slots may then be filled with other frames describing other objects (Rich, 1983).

The inference engine provides the reasoning basis to use the knowledge base to process the database. In a rule-based system, the inference engine normally uses either a forward or backward chaining approach (or some combination). Forward chaining reasons toward a goal. Backward chaining reasons backward from the goal to determine if or how the goal can be accomplished. In frame-based systems, the inference engine processes frames. The information within the frames then guides the choice of the next frame. Other approaches may be used depending on the knowledge representation and the problem solving approach used in the system.

The user interface provides the communication between the user and the system. Generally, the interface is user-friendly, particularly in those situations where data is generated by the user. The user interface may include an analysis of the reasoning of the system in developing its decisions.

AI LANGUAGES AND ES SHELLS

Developing expert systems requires a means to communicate with the computer. This is usually done in one of three ways: procedural languages, artificial intelligence languages and/or expert system shells.

Procedural languages, such as BASIC, allow the user to define a sequenced set of operations to solve a specific problem. Some expert systems and some expert system shells have been developed using procedural languages. Fortran, Pascal and most recently C are among the most frequently used procedural languages in the development of ES's and ES shells.

Two primary generic AI languages are in use: LISP (Winston and Horn, 1984) and Prolog (Clocksin and Mellish, 1984). The primary AI programming applications that have been developed in the United States have used LISP, whereas, the Japanese have chosen Prolog for their fifth generation project (Feigenbaum and McCorduck, 1983).

AI languages differ from procedural languages in two primary ways. First, the procedural languages are dependent on the order of the statements, whereas, AI languages do not have that constraint. This allows the development of a knowledge base independent from the rest of the system and facilitates changing that knowledge base in response to environmental changes. Second, in contrast to other computer languages that are designed to process numeric information, AI languages are designed to process symbolic information.

Expert system shells are software designed to simplify the development of an expert system by providing many user friendly features (e.g., Turbin, 1985). The inference engine can be specified and does not need to be developed. The knowledge base is easy to specify to the computer. The ES shells also may allow the user to access existing databases, such as dBase II, procedural languages and AI languages. Recently, many shells have been criticized for being computationally slow and for providing little beyond some versions of AI languages. In addition, the shells are still computer software and, accordingly, nonprogrammers still find it difficult to use the ES shells to develop an expert system.

GENERIC CATEGORIES OF EXPERT SYSTEMS

Expert systems can be divided into a number of categories, including, interpretation, prediction, diagnosis, planning, monitoring and control (Hayes-Roth, 1983). Interpretation infers situation descriptions using observed data, "What does the data mean?" Prediction infers possible outcomes from particular situations, "What will happen...?" Diagnosis infers reasons for system behavior, "What's wrong?" or "Why did it work?" Planning leads to prescriptions for future actions, "What should we do?" Monitoring observes and analyzes system behavior, "What is the system doing?" Control compares system behavior to a preestablished plan and then takes corrective action to ensure that the system behaves in a given manner.

USE OF THE SYSTEM

Expert systems can be used in a number of ways: an educational mode, an advisory mode and a replacement mode (e.g., O'Leary, 1986).

AI/ES are being used to model educational functions that previously would not have been placed in a computer model. STEAMER (Williams et al., 1981) is an example of a simulation program that uses concepts from AI to serve as a tutor; training students in the principles of propulsion engineering.

Most expert systems developed to-date are designed to function in an advisory manner. These systems make a recommendation and a human expert reviews the decision and the logic behind the decision, before the decision is implemented.

There are some systems designed to replace the decision maker. Glover et al. (1984) designed a system that they indicated should be called a "managerial robot" because it was designed to replace the manager. The system was designed to schedule employees in a decision making environment of weekly fluctuations. However, systems designed to replace the decision maker do not have to be implemented in that manner but instead can be used in an advisory manner.

PROCESS IN DEVELOPING EXPERT SYSTEMS

The process of developing an expert system has five basic steps: identifying and choosing the expert, acquiring knowledge from the expert, representing that knowledge, choosing an appropriate inference engine and developing an appropriate user interface. Cognitive processes are a critical element in all five stages of developing expert systems.

A key step in the development of the expert system is the identification and choice of the expert. The expert can be identified in a number of ways including, time on the job and level and position in the organization. From among the identified experts an expert is chosen based on other criteria, including cooperativeness, availability and interest in the project.

Knowledge is usually acquired by an interactive process between a "knowledge engineer" and the expert. The knowledge engineer (Feigenbaum, 1977) "...practices the art of bringing the principles and tools of AI research to bear on difficult applications problems requiring experts' knowledge for their solution."

As noted above, there are a variety of ways to represent knowledge, including rules and frames. The approach that is used would depend on the particular application and the structure that is encountered by the knowledge engineer.

The choice of inference engine depends on the problem that is being addressed. For example, if the consequence is known then the user is interested in chaining backward to determine the cause of the consequence.

The user interface includes the explanation facility and the input/output facilities. The type and extent of explanation can depend on the user and the problem type. The input/output facilities may include graphics and the native language of the user.

ELEMENTS OF CULTURE THAT IMPACT COGNITIVE PROCESSES

Some of the elements of culture that can affect cognitive processes include the following: language (Bloom, 1979), attitudes towards individualism and collectivism (Singh and Bhargava, 1985; Jaquish and Ripple, 1984), the way people think probabilistically (Wright and Phillips, 1979), attitudes of causation (Miller, 1984) and attitudes towards authority (expertise) (Jaquish and Ripple, 1984).

CULTURAL EFFECTS ON EXPERT SYSTEMS

Language has an impact on the development of expert systems in all phases of the process of expert systems development. Different languages have different capabilities. For example, there is no ability to have counterfactual statements in Chinese. To illustrate this consider the following example (Bloom, 1979):

If (1) all circles were large and
(2) this small triangle were a circle
Then the triangle would be large

When presented with this "If ... then ... " rule, most Chinese responded that "How can a triangle be a circle?" and "How can all circles be large?" "What do you mean?" Whereas Americans generally accepted without the question this counterfactual statement. This can impact the expression of expertise and the corresponding knowledge base.

In addition, programming languages developed for artificial intelligence applications, like LISP or PROLOG are based on English, French or other western languages. The symbolic capabilities of any artificial intelligence languages can be used to manipulate symbols in arbitrary languages. It is important to know whether such western language-based programming languages pose any restrictions or add any new dimensions for cognitive processes for either users, developers or experts (on whom the system is based) from other cultures.

Attitudes towards individualism and collectivism lead to a difference in causal explanation. This indicates that the explanation subsystem in an expert system should reflect the culture of the user for whom the system is designed and will reflect the culture in which it is designed.

The way people think probabilistically differs across cultures. Researchers have identified at least three aspects of probabilistic thinking: tendency to adopt a probabilistic set, discrimination of uncertainty, and realism or "calibration" of assessments of probabilities (Wright and Phillips, 1979). The cultural differences outweighed any influence of subculture, occupation, religion, arts/science orientation or sex. This indicates that the numerical probability weights on rules (1) may not be used or useful and (2) the probability estimates may be different--because of the impact of culture.

Attitudes towards causation in different cultures can impact the substance of the knowledge base and the choice of the inference engine. The knowledge base contains the expert's causal explanations in the problem domain. The inference engine summarizes the experts causal processing of the knowledge base. In some cultures, we are more likely to see the occurrence of events in causal relationships specified by a particular theory, whereas in others the occurrence of similar events can be attributed to correlational relationships in a positivistic manner.

Attitudes towards experts in different cultures or societies may can lead to the identification of experts based on different criteria. As an example, seniority may be the most important criterion in one culture, whereas another culture may use position in the organization. Thus, different expertise may be identified in different countries for the same problems. As a result, the approaches or systems used in the United States may not be appropriate for the Pacific Rim countries.

CONCLUSION

This paper presents an approach to the analysis of the impact of culture on expert systems. It also provides a new perspective for cross cultural cognitive studies and an application of that research.

The development of expert systems has been pursued by major industrialized nations at full speed. Expert systems promise to retain, transmit and utilize the expert's knowledge in dramatically different and revolutionary ways. While the Pacific Rim countries are vigorously pursuing further industrial developments, the need to accumulate the expertise in the areas that are targeted for national development is ever pressing. Expert systems provide a great opportunity to acquire and use needed knowledge and accelerate the targeted industrial development.

However, as noted in this paper, culture has an impact on expert systems development and implementation. As a result, the policies about the development of expert systems should consider the culture effect. These policies include strategies about expert systems technology, expert systems development and implementation, inter-cultural transfers of expert systems, and other strategies.

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