Expert System: Empirical Add-ons to Artificial Intelligence

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Abstract: ***A computer-based system composed of a user-dialog system, an inference engine, one or several intelligent modules, a knowledge base and a work memory, which emulates the problem-solving capabilities of a human expert in a specific domain of knowledge. The focus area of this work is on exchanging information relating to expert and intelligent systems applied in industry, government, and universities.***

Keywords: ***Inference Engine, Knowledge Base, User-Dialog System.***

1. Introduction

"An expert system is a system that employs human knowledge captured in a computer to solve problems that ordinarily require human expertise." Well-designed systems emulate the reasoning processes used by experts to solve problems, and are popularly used in medicine, business management, design, and searching for natural resources.
"Even though expert systems aim to mimic human experts, they lack an extremely important capability of human intelligence: the ability to learn from experience."
First of all, it takes a significant amount of time to build an expert system with many hours of testing and debugging. If a human expert comes to an incorrect conclusion, he may be able to learn from the mistake and avoid making the same or similar mistakes in the future. Once an expert system is found to have an error, the only way to correct that error is to reprogram the expert system. In other words, most current expert systems are lacking an adaptive capability.
Computer based adaptive capabilities are essential in situations where environments change, in situations where standards of expertise are changing, and in situations where there are no historical data and learning occurs as a task that has been performed.

2. Rule-Based Programming and Object-Oriented Design

Rule-based programming is commonly utilized to develop expert systems. Rules are used to represent heuristics, which specify a set of actions to be performed for a given situation.
Rule-based expert systems are popular for a number of reasons:
Modular nature. This makes it easy to encapsulate knowledge and expand the expert system by incremental development.
Explanation facilities. By keeping track of which rules have fired, an explanation facility can present the chain of reasoning that led to a certain conclusion.
Similarity to the human cognitive process. Rules appear to be a natural way of modelling how humans solve problems. Object-Oriented design is "a technique for developing a program in which thesolution is expressed in terms of objects – self-contained entities composed of data and operations on that data" proposes that object-oriented design is an ideal approach for building adaptive systems because "objects are naturally adaptive elements. If allowed to interact freely, managing their own actions, they can be excellent components for building up adaptive systems "

3. A Learning Environment

The word 'learning' is mainly reserved for human beings. Researchers have long wondered whether computers could also learn. In order to answer this question, a definition of learning is necessary. According to Lacey (1998), learning is "Any relatively permanent change in behaviour brought about through experience – that is, through interaction with the environment". It could be assumed that learning may involve four factors: the learner; the environment; their interaction; and, state. A learner could be defined as a relatively independent system, exhibiting a learning capability and adapting to its environment. In other words, a learner is a system with the capability to change itself as a result of interactions with its environment. The constantly changing environment provides a basic force that drives a leaner to learn.
A state is a collection of characteristics that can be used to define the status of a learner and its environment at a certain time. An environment is partially comprised of the external circumstances of a learner, and influences the way in which a learner behaves. In other words, a learner exists in an environment, which changes over time. The internal impact of this external environment impels the learner, which results in adaptive action on the part of the learner. An approach to learning, therefore, is through the interaction between the learner and its environment. The interaction operates in terms of three basic elements: precepts; actions and goals. "An action is a physical change that occurs inside the learner, such as a muscle contraction inside a human body or an electrical signal sent to some

switch in a robot. A percept is a representation inside the learner about the state information of the environment. A goal is defined as a set of precepts that the learner wishes to receive from the environment."

Learning process can be defined as: "With actions and precepts as building blocks, the learner is to construct a model of the environment so that it can predict the consequences of its actions and direct its actions towards the goal."

Accordingly, a learning process is a process in which a learner builds models of its environment. In addition to the physical world that is external to the learner, it is suggested that there also exists an internal model world within the learner. The learner builds models and stores them in this model world. These models represent the learner's understanding and knowledge of the external physical world. When knowledge is available, and a learner possesses and uses a capability to obtain and store this knowledge from its external environment, this capability could be defined as memorization. An example is a child studying arithmetic from a textbook. When an old model has been evaluated as inappropriate to any given circumstance, and no existing, applicable knowledge is available, creation becomes an important approach to the production of new knowledge. Creation may be considered a higher level of learning. Memorization and creation represent an initial phase of a learning process. The construction of a model, "essentially a loop process of generate-and-test: one starts with a model, tests the model by observing its performance, and generates a new model if the current one is not good enough ". This might suggest another significant factor in a learning system: evaluation. Evaluation generates feedback after an action has been taken. This feedback then goes back to the percept process, causing the updating of the model. If we regard a system that cannot learn as a dead system, then this evaluation process is an essential difference between a learning system and a dead system. In this generate-and-test loop, the evaluation adjusts the actions as well as the goals of a learner, and sends stimuli back to the loop for model revision. From the point of view of human beings, a process that discerns between right and wrong, or appropriate and inappropriate, must contain a set of criteria. When a change in the physical world causes a change in the criteria system, a corresponding change in the learning system results. This process would not occur in a dead system, because it is not represented by a loop, but rather by a unidirectional flow, with no provision for feedback. Memorization and creation do not exist in a dead system because the process of evaluating and handling feedback, which affects actions, does not exist.

4. Knowledge Representation

4.1 From Data, Meaning, Information to Knowledge

Computer systems have displayed significant increases in sophistication and capability while maintaining basic data storage and manipulation principles. Data in a computer system, based on a particular computer language, are letters, numbers, strings or special characters. A single piece of data consists of a combination of electrical pulses. It has no meaning to the computer by itself.

The meaning of a single piece of data derives from its association with other data. For example, A Chinese character may have little meaning to English speakers if they do not know anythingabout the Chinese language. For them to gain understanding, an explanation of this Chinese character in the English language is necessary. During this process, the English speakers establish associations between this character and what they already know, and then meaning appears. Approaches to building associations between data in a rule-based, object-oriented expert system include writing rules and object methods that manipulate the behaviours of data. Information is

data with behavioural characteristics and relationships. Data are basic building blocks of information, and relationships among data window meaning. Functionally, a piece of information must describe a state, such as, 'mail is sent' and 'it is raining'. Information may be defined as data linked by relationships, which can describe the state of an event, a condition, an item, or an object.

"When human beings or computer-based agents draw conclusions (i.e., inferences) from information then these conclusions are knowledge" (Pohl, pers.com.). Knowledge exists when humans attempt to solve problems or make decisions based on the state of a condition, and information provides a description of the state. In a rule-based computer system, the process of taking certain actions based on certain conditions can be represented as rules.

Heuristic rules provide shortcuts when describing relationships and behaviours.Heuristic rules mostly come from experience. Intermediate steps are skipped because those steps might be functionally unnecessary or unlikely to lead to a quick solution of the problem. This is why an expert usually has been perceived as a person who is capable of "solving problems without thinking".

4.2 Objects and Agents

Everything an object 'knows' is captured in its variables (data), everything it can do is expressed in its methods. This notion not only keeps simple things simple, but also makes complex things simple as well. No matter how many objects or what types of objects exist inside a system, relationships among those objects are clearly described by their methods. The more objects the system contains, the more complex it can become. When a change occurs in an object, other objects will react correspondingly to adapt to the change; thus the system can reorganize itself automatically. Objects are ideal building blocks to build adaptive systems. Since methods are encapsulated with data into objects in an object-oriented computer system, when a change is necessary, even if it is possible to change only a single or a few objects then the whole system will adapt to this change automatically through the reactions of other objects. However, in a conventional system (i.e. non-object-based), a change will require significant

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restructuring, anything less will result in a broken system. Information in an object-based computer system is not separated into data and procedure, but rather stored as objects. Objects can be exchanged with, or shared by, other systems, enabling adaptive behaviour to occur not only inside a system but also among different systems.
During the related processes of problem-solving and decision-making, human beings may be capable of drawing conclusions, finding solutions and taking actions based on available information. A computer-based system that behaves in such a fashion may be referred to as an agent. Agents act at the knowledge level. Data within an object describe 'what' the object is, and object methods indicate 'how' it will react to changes. A rule, which acts as an agent, will provide some control of 'when' and 'whether' the object carries out its methods.

5. Human-Computer Collaboration

While engaged in the process of problem-solving and decision-making, human beings typically draw upon a broad range of personal experience and often rely upon intuition. Computers, on the other hand, have a narrow area of expertise, greater computational power, and lack a good mechanism for knowledge acquisition through experience.
Human-computer collaboration proposes an approach in which computers and humans cooperate to solve problems, especially to solve those problems that neither can effectively solve alone. For example, an expert system helps non-expert humans to solve problems and make decisions based on internal expertise. The system might not work appropriately if the problem changes, unless human users provide more knowledge. The system may thus be said to learn through its interactions with humans.

6. Building an Adaptive Expert System

An expert system could be viewed as one heuristic rule, or if-then statement, since all rules in the system work together to define a specific condition, which is achieved by asking user relevant questions. Thereafter, the system reacts with one or more actions. It is postulated that an expert system becomes adaptive during an interaction with a human user if this system proves to be capable of the formulation of new relevant questions and the adjustment of action(s).

6.1 Knowledge-Node-Network

The concept of a knowledge-node-network is proposed as an approach to knowledge representation in building an adaptive rule-based, object-oriented expert system. In a knowledge node- network, all nodes are represented as objects, and adaptively of the system is achieved through node modification and creation. Two types of nodes exist in a knowledge-node-network: question nodes (i.e., representation of relevant questions); and, action nodes (i.e., representation of corresponding actions).

A question node may contain one or more input-connections, each weighted, whose values change based on a successful search or a failed search. Each input-connection corresponds to two output-connections, each of which connects to another question node or action node. A question node carries a relevant question and a corresponding answer-key. During a reasoning process, if a question node is activated by a message, the question will be evaluated, and the return value will lead to the next activation.
An action node may contain one or more input-connections, each weighted, whose values change based on whether user feedback is positive or negative. An action node carries one or more actions, and may be activated by messages sent from question nodes.
Also, such a knowledge-node-network contains an initial body of knowledge (i.e., a group of question nodes and action nodes with appropriate connections). Upon interaction with human users, this initial body of knowledge may prove inadequate within the context of a changing problem. The system adapts to these changes through the modification of existing knowledge nodes and the creation of new knowledge nodes.
In a knowledge-node-network, each node is associated with a value represented by either a relevant question or an action. Each node also contains connections to other nodes. The creation of new nodes and the modification of either the value or the connections of the node are defined as constituting a form of system adaptation in response to a change evaluation system and goals. A future study of an evaluation system in an adaptive system may significantly benefit the research study presented in this paper.

7. References

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