The selection of qualifier and values should be such that combining them with NOT, OR or AND makes a grammatically correct sentence. (Expert System cannot tell, and does not care, if the sentence is grannatically correct, but users find it much easier to read correct grammar.)

The other type of conditions we will be using are mathematical conditions which are represented as algebraic expressions such as:

[X]+10 > SIN([X] * 5)

that can be tested for validity.

CHOICE: Choices are all the possible solutions to the problem among which the expert system will decide. The goal of Expert System is to select the most likely choice based on the data input, or to provide a list of possible choices arranged in order of likelihood. The choices can be of any form: item, actions, etc., depending on what type of expert system is being developed. Expert System display the choice followed by "- Probability=" and a number. The number indicates the confidence that the choice is correct and is 0, 1 or a ratio such as A/B. The indicates the maximum possible value (either 10 or 100). In the calculational system being used the numerator, A, is the probability value assigned to the choice. The person generating the knowledge base must select one of three options for how the program will use the probability data.

RULE: Rules are the way the knowledge that allows the program to arrive at its conclusions is represented. A rule is decided into four parts: an IF part, a THEN part, an optional NOTE and an optional REFERENCE.

IF

    CONDITION 1
and CONDITION 2
and CONDITION 3
    .
    .

THEN

    CONDITION n
and CONDITION n+1
and choice 1
and choice 2
    .
    .

NOTE: ---------------------
REFERENCE: ---------------

There are veriety of styles in expert systems especially recently developed. Much more facilities are available with them. However above remarkss are general and common among most expert systems.

3. Expert Systems in Power Engineering

A bibliographical survey of the research, development and application of expert systems in electric power systems based on over 80 articles published since 1982 is given in reference[6].

Currently most expert systems in power engineering are prototype for demonstration, research or field tests. However, some expert systems have been in practical use since 1980 in USA and in Japan. Although some progressive planed for demonstration have been reported, there is no clear demarcation between the practical-use stage and the development stage of expert systems in power system operation because of the following conditions:

(i) The process of building an expert system is an iterative cycle of development, improvment and expansion.

(ii) Proposed expert systems for power system operation are used only as dispatcher's aid or consultant.

(iii) A production prototype of expert system is different from a commercial prototype for power system operation.

Examples of expert systems in Energy management

Generic types of expert system applications in power industry are ~~are~~ given in Table III. The following points are made in a comparision with the aplications in other industries:

(a) The predominant role of expert systems in power industry is for diagnosis, accounting for 41% of the applications. This role is similar in other industries.

(b) The predominant subject of expert systems in power industry is not equipment but systems.

(c) Running in second place are applications dedicated to planning and scheduling in power industry.

(d) An equal important role of expert systems is control in power system operation.

Table

Generic types of ES application in power industry	
Type	**Percentage**
diagnosis	41%
Planning & Scheduling	19%
Control	18%
Design	11%
Prediction	8%
Instruction & Training	3%

The potential role of AI in Energy Management Systems (EMS) can be highlighted by comparing the function of an energy control center to the parts of an Expert System. First, and basically, an energy control center is a place of highly technical decision making. As such information is collected and used to define a situation which is compared with operational practices and experience. As a result, decisions are made and appropriate action is initiated.

Example (1):

In the contingency selection knowledge base described by J.N. Wrubel, there are ~~[illegible]~~ rules which if entered as typical expert system rules would look like:

```
IF
BKR4 SUB1 OPEN
THEN
INCLUDE GEN2_OUTAGE
INCLUDE TRANS_1_OUTAGE
```

From an AI perspective these rules are processed using foreward chaining and proceed to a depth of one. That is, these rules use data directly from the SCADA system (breaker statuses) and if a rule is satisfied it causes a contingency case to be included.

Example (2):

In the prototype alarm processing program described by S.L. Larsen a typical rule looks like the following:

```
(B-RULE SITU-ALARM-2-02
        (IF
           LAST_CRT-2_ALARM
           (NOT LOCKOUT_STATUS)
           (LESSP (DIFF EXEC_TIME
```

```
                LAST_CAT-2_ALARM_NEW_ALARM_TIME)
            *TIMEOUT*)
         (LESSP NUMBER_OF_CAT-2_ALARMS SURING_
            TRANSITION-TIME
            *TRANSITION-COUNT-LIMIT*))
      (THEN
         (SET-PARAM  'SITUATION_DECISION
                     '(SITUATION-PROCESSING
                       POINT_NAME)))
      NEEDS
        POINT_NAME))
```

Example (3):

Some rules used written in natural language are the following:

- IF a DC Motor runs too fast under load THEN:
  (cause : Weak field AND remedy: Check for resistance in shunt circuits)
  OR (cause:Line is too high AND remedy: Correct high voltage condition)
  OR (cause: Brushes are not on neutral AND remedy: set brushes on neutral)

- IF a DC Motor is sparking at brushes THEN:
  (cause: commutator in bad condition AND remedy: Clean and reset brushes)

OR (cause commutator eccentric or rough AND remedy: Grid and true commutator. Undercut mica)

OR (cause excessive vibration AND remedy: Balance armature. Make sure brushes ride freely in holders)

OR (cause: brushes too short AND remedy: replace brushes)

OR (cause:machine overloaded AND remedy: reduce load or install larger motor).

Example (4):

```
/* if the first circuit breaker on the device is
   closed , establish conclusion "C1" as a fact.
   The rule name is "Rule 1". The under score
   character denotes a blank. The word "first"
   is a position indicator. */
:Rule_1: If (first circuit_breaker = closed)
   then C1;
/* Establish conclusion "C2" if the second
   circuit breaker on the device is closed. */
:Rule_2: If (second circuit_breaker = closed)
   then C2;
/* The rule is fired if the first bus section
   voltage is low and conclusion "C1" is an
   establisshed fact */
```

:Rule_3: If (first bus_voltage = low) and (C1)
then C3;

....

:Rule_6: If (C4) and (C3) then C6

:Rule_4: If (third bus_voltage = low and (C5)
and (C2) then (C4);

:Rule_5: If (second bus_voltage =low) then c%;

:Rule_15: If (opposite bus_voltage = low) and
(adjacent bus_voltage = normal)
then R15;

4. AI in cement Industry

Modern cement plants operations is done by computers which performs the following:

(i) Alarms and Warning Signaling.
(ii) Interlocking of equipments.
(iii) Storage of information about abnormal conditions and readings.
(iv) Full automation of operation in steady conditions.
(v) Supervisors and operaters aid under starting condition and ubnormal circumstances.

These taskes contains a lot of information set up by experience gained during the last few decades in operation of different equipment used in cement industry.

However AI cannot be said to be used in cement industry in large scale. Fuzzy logic could be the main topic of AI which was used in cement industry and actully was one of the pioneer applications of this topic in any useful application.

Future definetly will wittness a greater scope of AI use in on line operation of cement plants.

One topic which still had recieved no attention is the use of expert system as an off line aid to the plant operator and in fault diagnosis.

Most cement plants operates for 20-30 years and the programs in control, informatics and modern operation strategies is difficult to incorporate in old plants. Gain of expecience by these operaters is a difficult and long task.

Hence it is very a aproperate to use well expercienced operators and engineers to feed their knowledege into expert systems which can be used later by less expereinced operators and joinior engeneers. Such expert systems should be specialised for a specific plant so that all parameters, machines specific characteristics, material local contents etc. are all part of knowledge to be fed to the expert system for specific plant. However a lot other informations such as chemical reactions heating characteristcs are common for all cement plants. It is suggested that use of expert system should be a normal practice in cement and other building material plants to aid the spread of technology transfer among developped countries.

5. Fuzzy logic

Usually facts are defined sharpely in computers. When a variable is given a value like big, young, short, .. etc. The exact meaning becomes relative to the scope under consideration and still is not exact.

Fuzzy logic is a new field of mathematics which deals with logical relationships and values of variables which are not defined in exact manners.

This topic necieved an attentian recentely and used in incorporating some intelligence in cement plant operation programs.

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Artificial Intelligence

In

Energy Censervation

By

Professor Mohammed Zeki Mohammed Khedher

Summary:

Artificial intelligence is a new field of knowledge which has recieved a lot of interest recently. Use of AI in industry lies in expert systems and robotics. Expert Systems in power engineering and energy management is only few years old and still gaining momentum, In cement industry some intelligent programs are being used for aid of proper automation of cement plants. The paper gives an overview of these topics and attracts attention specifically to these topics and gives special remark to the need of building up expert systems with information fed by experienced operators so that they are to be used by less experienced operators.

1. Introduction

Artifical intelligence (AI) is primarily concerned with the study of abstract problem solving. Most of the original AI work was concerned with modeling the human thought process. Knowledge Engineers analyze the responses (information used, rules implied, test results requested, etc.) of experts in the solution of a narrowly defined problem. The result of this analysis is a computer system (program(s)) which replicates the responses of the experts.

A Knowledge Engineer uses the general AI approaches to define the problem and to generate the solution space to be examined. There are three basic steps used by a Knowledge Engineer: (1) identify the facts and the explicit rules used by an expert to reach a conclusion, (2) deduce the inference rules (heuristics) necessary to reach the conclusion, and (3) build a computer system with the knowledge and rules which reproduce the expert's decisions. It should be noted that an Expert System may request additional facts and/or specific tests if the initial system information is incomplete before a specific recommendation can be made. A well designed Expert System should be able to identify the facts and/or rules and the potential solutions being considered during an analytic session. Most common languages used in AI are Lisp and prolog programing languages which are suitable to deal with objects rather than figures and values.

3. Expert System

An Expert System offers a number of advantages:

(a) Assist Human Experts.

An expert system can implement performance at the level exhibited by a person with recognized expertise in the problem domain. Therefore, it can reduce tedious and redundant manual tasks and provide a human expert with an environment that enhance his productivity, thus leading to efficient operation.

(b) Flexibility.

Each production rule represents a piece of knowledge relevant to the task. Hence it is very convenient to add, remove and modify a rule in the knowledge base as experience is gained.

(c) Understanding.

Production rules are close to natural language and, therfore easy to understand. The expert system can give the steps that led to the conclusion and explain the reasoning process. The user can confirm or correct the conclusion by examining the explanations given by the inference engine.

(d) Universality.

The knowledge base is problem domain dependent, but the inference engine is domain independent. So, different expert system can be developed by replacing the knowledge base.

(e) Rapidity.

The expert system can provide the right expertise whenever needed. Expert systems can provide more rapid reaction to emergency events than human operators. This is very useful in power system operation, cement plant operation and similar circumstances.

Following are some definitions related to expert system:

CONDITION: A condition is simply a statement of fact (or potential fact). Usually there are two types of conditions: text and mathmatical. A text condition is a sentence that may be true or false. For example "THE BACK COLOR IS BROWN" or "THE BILL IS OVERDUE". The condition is made up of two parts, a QUALIFIER and one or more VALUES. The qualifier is usually the part of the condition up to and including the verb (in the above examples THE BACK COLOR IS and THE BILL IS). The values are the possible completions of the sentence started by the qualifier. When a new qualifier is created it is given a list of possible values such that combining the qualifier with a value (or values) makes a sentence. In the above examples the value list associated with THE BACK COLOR IS might be BROWN, WHITE, BLACK, GREEN or BLUE. The value list associated with THE BILL IS might be OVERDUE, NOT YET DUE, or PAID. When we create a text condition in a rule we will select a qualifier and then select one or more values to form the sentence that will be the condition.

When more than one value is selected, the program will put "or" between the values and, if any one of the listed values is true the condition will be true. For example, we might form a condition THE BACK COLOR IS BLACK OR BLUE. If the back color is white, the condition is false. A condition can also be formed by using a qualifier, "NOT" and one or more values. For example, we could form the condition THE BACK COLOR IS NOT BLUE. In this case if the back color is actually green, any color other than blue, the condition will be true. (In the THEN part of a rule the "or" connecter is replaced by "and": since all of the values in THEN part are considered to be true if the rule is aplied).