EXPERIMENT 10

**RULES**

Any rule consists of two parts: the IF part, called the antecedent (premise or condition) and the THEN part called the consequent (conclusion or action). The basic syntax of a rule is:

| IF <antecedent> THEN <consequent> |
| --- |

In general, a rule can have multiple antecedents joined by the keywords AND (conjunction), OR (disjunction) or a combination of both. However, it is a good habit to avoid mixing conjunctions and disjunctions in the same rule. The antecedent of a rule incorporates two parts: an object (linguistic object) and its value. In our road crossing example, the linguistic object ‘traffic light’ can take either the value green or the value red. The object and its value are linked by an operator. The operator identifies the object and assigns the value. Operators such as is, are, is not, are not are used to assign a symbolic value to a linguistic object. But expert systems can also use mathematical operators to define an object as numerical and assign it to the numerical value.

Rules can represent relations, recommendations, Rules can represent relations, recommendations, directives, strategies and heuristics: directives, strategies and heuristics.

**Relation**

IF the ‘fuel tank’ is empty

THEN the car is dead

**Recommendation**

IF the season is autumn AND the sky is cloudy AND the forecast is drizzle

THEN the advice is ‘take an umbrella’

**Directive**

F the car is dead AND the ‘fuel tank’ is empty

THEN the action is ‘refuel the car’

**Strategy**

IF the car is dead

THEN the action is ‘check the fuel tank’; the action is ‘check the fuel tank’;

**Heuristic**

IF the spill is liquid AND the ‘spill pH’ < 6 AND the ‘spill smell’ is vinegar the ‘spill smell’ is vinegar

THEN the ‘spill material’ is ‘acetic acid’ the ‘spill material’ is ‘acetic acid’

**EXPERT SYSTEM**

In artificial intelligence, an expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming. The first expert systems were created in the 1970s and then proliferated in the 1980s. Expert systems were among the first truly successful forms of AI software.

As soon as knowledge is provided by a human expert, we can input it into a computer. We expect the computer to

1. Act as an intelligent assistant in some specific domain of expertise or to solve a problem that would otherwise have to be solved by an expert.
2. Be able to integrate new knowledge and to show its knowledge in a form that is easy to read and understand, and to deal with simple sentences in a natural language rather than an artificial programming language.
3. Explain how it reaches a particular conclusion.

In other words, we have to build an expert system, a computer program capable of performing at the level of a human expert in a narrow problem area.

The most popular expert systems are rule-based systems. A great number have been built and successfully applied in such areas as business and engineering, medicine and geology, power systems and mining.

**THE APPLICATIONS OF EXPERT SYSTEMS**

The spectrum of applications of expert systems technology to industrial and commercial problems is so wide as to defy easy characterization. The applications find their way into most areas of knowledge work. They are as varied as helping salespersons sell modular factory-built homes to helping NASA plan the maintenance of a space shuttle in preparation for its next flight.

Applications tend to cluster into seven major classes.

1- **Diagnosis and Troubleshooting of Devices and Systems of All Kinds**: This class comprises systems that deduce faults and suggest corrective actions for a malfunctioning device or process. Medical diagnosis was one of the first knowledge areas to which ES technology was applied, but diagnosis of engineered systems quickly surpassed medical diagnosis. There are probably more diagnostic applications of ES than any other type. The diagnostic problem can be stated in the abstract as: given the evidence presenting itself, what is the underlying problem/reason/cause?

2- **Planning and Scheduling**: Systems that fall into this class analyze a set of one or more potentially complex and interacting goals in order to determine a set of actions to achieve those goals, and/or provide a detailed temporal ordering of those actions, taking into account personnel, materiel, and other constraints. This class has great commercial potential, which has been recognized. Examples involve airline scheduling of flights, personnel, and gates; manufacturing job-shop scheduling; and manufacturing process planning.

3- **Configuration of Manufactured Objects from Subassemblies**: Configuration, whereby a solution to a problem is synthesized from a given set of elements related by a set of constraints, is historically one of the most important of expert system applications. Configuration applications were pioneered by computer companies as a means of facilitating the manufacture of semi-custom minicomputers. The technique has found its way into use in many different industries, for example, modular home building, manufacturing, and other problems involving complex engineering design and manufacturing.

4- **Financial Decision Making**: The financial services industry has been a vigorous user of expert system techniques. Advisory programs have been created to assist bankers in determining whether to make loans to businesses and individuals. Insurance companies have used expert systems to assess the risk presented by the customer and to determine a price for the insurance. A typical application in the financial markets is in foreign exchange trading.

5- **Knowledge Publishing** This is a relatively new, but also potentially explosive area. The primary function of the expert system is to deliver knowledge that is relevant to the user's problem, in the context of the user's problem. The two most widely distributed expert systems in the world are in this category. The first is an advisor which counsels a user on appropriate grammatical usage in a text. The second is a tax advisor that accompanies a tax preparation program and advises the user on tax strategy, tactics, and individual tax policy.

6- **Process Monitoring and Control**: Systems falling in this class analyze real time data from physical devices with the goal of noticing anomalies, predicting trends, and controlling for both optimality and failure correction. Examples of real-time systems that actively monitor processes can be found in the steelmaking and oil refining industries.

7- **Design and Manufacturing**: These systems assist in the design of physical devices and processes, ranging from high-level conceptual design of abstract entities all the way to factory floor configuration of manufacturing processes.

**Roles in Expert System Development**

Three fundamental roles in building expert systems are:

1. ***Expert*** - Successful ES systems depend on the experience and application of knowledge that the people can bring to it during its development. Large systems generally require multiple experts.

2. ***Knowledge engineer -*** The knowledge engineer has a dual task. This person should be able to elicit knowledge from the expert, gradually gaining an understanding of an area of expertise. Intelligence, tact, empathy, and proficiency in specific techniques of knowledge acquisition are all required of a knowledge engineer. Knowledge-acquisition techniques include conducting interviews with varying degrees of structure, protocol analysis, observation of experts at work, and analysis of cases.

On the other hand, the knowledge engineer must also select a tool appropriate for the project and use it to represent the knowledge with the application of the ***knowledge acquisition facility***.

3. ***User*** - A system developed by an end user with a simple shell, is built rather quickly an inexpensively. Larger systems are built in an organized development effort. A prototype-oriented iterative development strategy is commonly used. ESs lends themselves particularly well to prototyping.

**ADVANTAGES**

* Natural knowledge representation. An expert usually explains the problem-solving procedure with expressions like “In such-and-such situation, in such a situation, I do so-and-so”. These expressions can be so”. These expressions can be represented quite naturally as IF-THEN production THEN production rules.
* Uniform structure. Production rules have the Production rules have the uniform IF-THEN structure. Each rule is a THEN structure. Each rule is an independent piece of knowledge. The very syntax of production rules enables them to be self of production rules enables them to be self documented. documented.
* Separation of knowledge from its processing Separation of knowledge from its processing. The structure of a rule-based expert system based expert system provides an effective separation of the knowledge and provides an effective separation of the knowledge base from the inference engine. This makes it base from the inference engine. This makes it possible to develop different applications using the possible to develop different applications using the same expert system shell. same expert system shell.
* Dealing with incomplete and uncertain Dealing with incomplete and uncertain knowledge. Most rule-based expert systems are based expert systems capable of representing and reasoning with capable of representing and reasoning with incomplete and uncertain knowledge.

**DISADVANTAGES**:

* Opaque relations between rules. Although the individual production rules are relatively simple and individual production rules are relatively simple and self-documented, their logical interactions within the documented, their logical interactions within the large set of rules may be opaque. Rule-based systems make it difficult to observe how individual systems make it difficult to observe how individual rules serve the overall strategy. rules serve the overall strategy.
* Ineffective search strategy. The inference engine applies an exhaustive search through all the applications and an exhaustive search through all the production rules during each production rules during each cycle. Expert systems cycle. Expert systems with a large set of rules (over 100 rules) can be slow, with a large set of rules (over 100 rules) can be slow, and thus large rule-based systems can be unsuitable based systems can be unsuitable for real for real-time applications. time applications. Disadvantages of rule-based expert systems based expert systems
* Inability to learn. In general, rule-based expert based expert systems do not have an ability to learn from the systems do not have an ability to learn from the experience. Unlike a human expert, who knows experience. Unlike a human expert, who knows when to “break the rules”, an expert system cannot when to “break the rules”, an expert system cannot automatically modify its knowledge base, or adjust automatically modify its knowledge base, or adjust existing rules or add new ones. The knowledge of existing rules or add new ones. The knowledge engineer is still responsible for revising and engineer is still responsible for revising and maintaining the system. maintaining the system.

**IMPLEMENTATION EXAMPLE**:

**Topic: Rule Based Expert System for a weapons collection**

Modern warfare possesses some typical characteristics such as dynamic and uncertainty with the emergence of many multiplatform weapon systems. However, it is impossible to rely on real combat entirely to verify the feasibility of battlefield operational plans. Consequently, a virtual battlefield environment is highly recommended to be built for military training in order to improve the decision-making capacity of military commanders.

As the weapon systems have become increasingly important in modern warfare, higher requirements are brought forward for military commanders of joint operations to enhance their skills of using weapon systems.

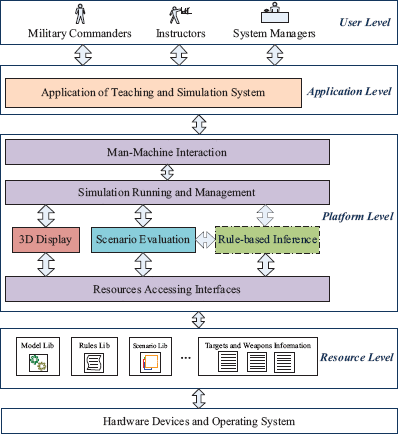
It is noted that the virtual battlefield environment could improve the users' sense of immersion and interactivity greatly, enabling military commanders to master the rules of weapon systems better.

The proposed teaching and simulation system for application of weapon systems world adopt a distributed C/S framework with integrated use of database, network, 3D-GIS and so forth. In addition to general functions such as resource browsing, fuzzy queries and decision support, it would possess the capacity to connect with other systems through the local area *network(LAN)* with the purpose of sharing resources.

## **Distributed Architecture of Expert System**

The essential information about targets and weapons were stored in the server computer as well as the knowledge base and models library which were downloaded to the client computer while they were being requested

Military commanders learn how to make good use of weapon systems under instructions from these instructors while system administrators try to manage and maintain the system on the user level. Instructors may set different military backgrounds and arrange distinct courses for those military commanders on the application layer. The platform layer, as the core of the whole system, consists of simulation management module, rule-based reasoning module, 3D-display module and other components. The underlying data including basic information on targets and equipment are provided to support the expert system from the resource layer.



## **Implementation of Rule-Based Expert System for Weapon Systems**

The adoption of a rule-based inference engine allows the separation of expert domain knowledge and its control strategy. As a consequence, system administrators have the ability to add, delete and edit expert rules, thereby enhancing the system's scalability and flexibility. Rule-based expert systems(RBES) usually contain three components: rule base, working memory and inference engine. The working memory provides the facts as input parameters for the inference engine, and the other input parameter is the domain knowledge stored in the form of rule components.

The inference engine is made up of three components similarly, namely, pattern matcher, execution engine and the agenda. Pattern matcher decides which rules could meet the demands of input facts, then grants different priorities to these rules and inserts them on the agenda. Execution engine is responsible for the implementation of specific operations according to the rule that has the top priority.

### **Representation and Format of Production Rules**

The rules about the application of weapon systems can be extracted into the five following categories.

1. **Target-matching rules**. Military commanders should select the appropriate combat weapons in accordance with the unique characteristics of the enemy targets;
2. **Environment-matching rules**. The conditions of natural environment such as appropriate time, favourable weather, transitable terrain and other restrictions must not be neglectable;
3. **Performance-constraint rules**. The inherent capacity and performances of weapon systems are supposed to be taken into account. For instance, the accuracy of satellite reconnaissance should be considered when the satellite is going to be chosen;
4. **Equipment-combination rules**. Such rules describe static attachment relationships between equipments and their ammunition along with other affiliations;
5. **Evaluation-analysis** **rules**. The assessment of military commanders' scenarios will be undertaken on the basis of these principles, like the dynamic sequence constraints of the joint use of equipment, for example.

It can be found that these expert rules are mostly the standardizable description of such content like the state of targets, equipment and the environment. The general form of the production rules can be described as follows.

| IF x1 AND x2 AND...AND xn THEN Y1 OR Y2 |
| --- |

**Conclusion:** We learnt about rule based expert systems and implemented it in a example where we developed a weapons expert system for modern warfare weapons.