# FACTFILE:
# GCE DIGITAL TECHNOLOGY

## A21 INFORMATION SYSTEMS

Rewarding Learning

## Expert systems

### Learning Outcomes

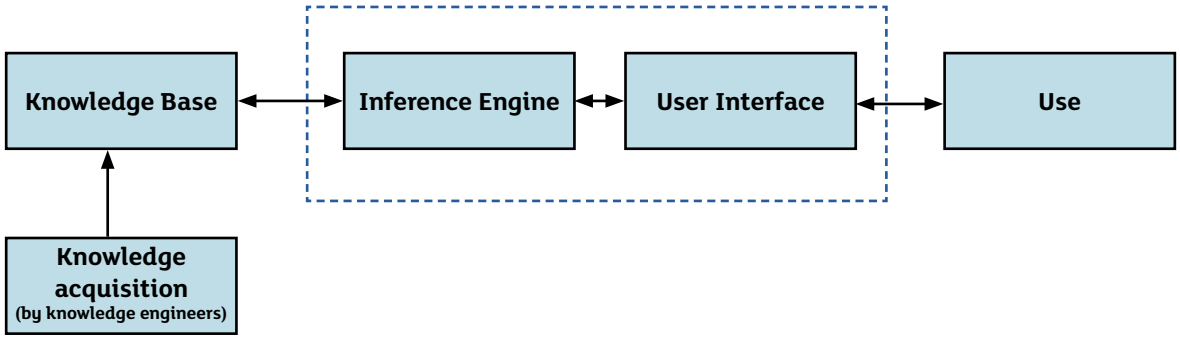
**Students should be able to:**

- describe the structure of an expert system;
- describe the purpose of the knowledge base and inference engine in an expert system;
- explain the following terms in relation to expert systems:
  - shell;
  - heuristics;
  - fuzzy logic; and
  - knowledge engineer; and
- evaluate the use of expert systems in medicine, car engine fault diagnosis and life insurance;

### Content in Expert systems

- The structure of an expert system.
- Key components of an expert system.
- Evaluating the use of expert systems.

### The structure of an expert system




An Expert System Structure – Source BCS Glossary of Computing

Expert systems are also known as knowledge based-systems. An expert system is an application of artificial intelligence. In this case, the knowledge of a human expert is made available through a computer package. An expert system is almost always used in a narrow field of knowledge. The field of knowledge is called the knowledge domain of the system.

## Key components of an expert system

In order to create an expert system a subject expert and a team of programmers and technical experts (knowledge engineers) are required. An expert is an experienced practitioner in a particular field for example a medical specialist, a repair technician or a financial analyst. The initial stage of building the expert system is known as knowledge acquisition. The knowledge of the human expert is programmed into the expert system and is represented using rules and facts. The result is the creation of a **knowledge base**. The knowledge base holds knowledge about the domain. This can be stored as a series of IF-THEN-ELSE rules.

The knowledge base stores both, factual and heuristic knowledge.

- **Factual Knowledge** – is the factual information acquired by the Knowledge Engineers from the human experts, relating to the subject domain. This type of information would be widely agreed.

- **Heuristic Knowledge** - captures information about accurate judgement and the ability to estimate and evaluate. Such rules are not derived from logic alone but are derived from a person's experience. They could be described as 'rules of thumb'. A heuristic system is designed to work with uncertainty and to simulate producing decisions based on experience.

Facts that may be in an expert system:
- Water boils at 100 degrees Celsius.
- The personal allowance before tax is £11,500.
- Any person over the age of 17 can apply for a driver's licence.

Rules may include
- If water reaches its boiling point, steam will be produced.(Chemical system)
- A person is not taxed if they earn less than £11,500 (financial expert system).
- Insurance policies for young people tend to be more expensive. (insurance company expert system).

Extra rules and facts may be added to the knowledge base as time passes and users provide feedback about the quality of the answers.

Once the knowledge base has been created, a system for consulting it must be put in place. This is known as the **inference engine**. This software interrogates the knowledge base and draws inferences and conclusions based on the rules stored about the subject domain. The inference engines poses questions to the user and uses the answers provided by the user to determine a suitable response.

Examples of questions that a medical diagnosis tool may ask would be:

*Do you have a cough? Yes/No*

*Do you have sore ears?Yes/No*

Examples of rules that allow the inference engine to determine and answer would be:

IF the patient has a cough AND sore ears, THEN the diagnosis is a severe head cold.

The **user interface** allows a user to communicate with the system. Requests for information or advice are passed from the user interface to the inference engine. The request is processed by the inference engine which applies rules to the knowledge base and then returns a response to the user.

*The shell* is a piece of software which contains the structure for creating an expert system. It is described as an empty expert system without a knowledge base. The creator can enter appropriate rules and facts to generate an expert system.

## Fuzzy logic

Propositional (binary) logic applies only to concepts that are either true (1) or false (0).

| | |
|---|---|
| Example | If it is raining I will take my umbrella |

Standard logic applies to concepts that can possess a degree of truth anywhere between 0.0 and 1.0.

| | |
|---|---|
| Example | The chance of getting an odd number when I throw a dice is 0.5 |

Fuzzy logic is a generalization of standard logic. It is used for reasoning about inherently vague concepts, such as 'tallness.'

Example — We might say that X is tall,' with a degree of truth of 0.9.

Many terms, such as 'tall,' 'rich,' 'famous' or 'dark,' are valid only to a certain degree when applied to a particular individual or situation. Fuzzy logic tries to measure that degree and to allow computers to manipulate such information.

Current applications include modeling, evaluation, optimization, decision making, control, diagnosis and information. Fuzzy logic is best suited for control-systems and has been applied in areas such as breakdown prediction of nuclear reactors in Europe, earthquake forecasting in China, and subway control in Japan.

Many of the useful applications of fuzzy logic are not in high-level artificial intelligence but rather in lower-level machine control, especially in consumer products. Fuzzy logic has been integrated into home appliances such as vacuum cleaners, microwave ovens and video cameras. Such appliances could adapt automatically to different conditions; for instance, a vacuum cleaner would apply more suction to an especially dirty area. Another application of fuzzy logic is in the anti-lock braking system found in modern cars. The control rules that describe an anti-lock braking system consists of parameters such as the car's speed, the brake pressure, the brake temperature, the interval between applications of the brakes and the angle of the car's lateral motion to its forward motion. The range of values of these parameters are all continuous, open to interpretation by a design engineer. For example, the temperature might have a range of states such as cold, cool, warm and hot. One such rule in an anti-lock braking system could be:

IF brake temperature is 'warm' AND speed is 'not very fast,' then brake pressure is 'slightly decreased.'

## Evaluating the use of expert systems

Expert systems are used in a wide range of areas such as medicine, car engine fault diagnosis and life insurance.

## Medicine

Expert systems have been used for diagnosis and treatment in a range of medical contexts. For example, doctors, nurses, GP's, consultants and patients themselves make use of them for diagnosis, prognosis and treatment. Medical professionals have difficult decisions to make. Good information ensures that timely and effective decision making takes place. Expert systems can enable this to happen in situations such where:

- they have to decide who gets treated first;
- their knowledge may be out of date or they may not be aware of modern drugs and their contra-indications;
- they may have not have seen a particular rare condition and therefore not recognise it or not know how to deal with it;
- the specialists may be in different part of the world; and
- they may be unsure about their diagnosis and want to check it with someone more experienced.

Where expert systems are used in medical diagnosis, the knowledge base would contain medical information; the patient's symptoms would be used as the query and the advice would be a diagnosis of the patient's illness.

## Car Engine Fault diagnosis

Engines and vehicle technology is becoming more complex. When something goes wrong it can be difficult for the mechanic to determine where the problem is. Car manufacturers now create their own expert systems about their cars. This is stored on a computer which can be 'plugged' into the car to determine the nature of the fault. The system will recommend how to fix the problem.

## Life insurance

Life insurance involves an insurance company in taking a risk by covering an individual's life for a set monthly fee. The fee is known as an insurance premium. The cost of life insurance for people depends on a number of factors and premiums vary between each person. Life insurance companies consider many factors when calculating premiums including:

- **Age** – Generally speaking the older you are, the higher your premium may be.

- **Gender** – With all other things being the same, senior men pay more for life insurance than women because they have a lower life expectancy.

- **Smoking Status** – Smokers can pay as much as two to three times more for life insurance than non-smokers. Most insurers will not consider you a non-smoker until you've been a non-smoker for at least 12 months.

- **Health** – Depending on the insurer, if you are in

good health or if you have minor health issues such as high blood pressure or high cholesterol, then you will more than likely qualify for a standard term life insurance policy.

*(Source: https://www.comparingexpert.com.au/life-insurance seniors-premiums-calculated/)*

This type of rule based calculation is an ideal scenario for an expert system in the first instance. The expert system will present questions to the user and based on their responses will, through the use of the inference engine, interrogate the knowledge base to produce a cost for the premium based on the individual response of the user.

When designing an expert system to provide insurance quotations, human experts in the form of insurance consultants are required. The consultants will be questioned by the knowledge engineers. They will explain how they make decisions about life insurance applications the information/data they use and the rules they use including intuition or 'rules of thumb'.

## Benefits of using an expert system

√ Expert advice is always available.

√ Knowledge of experts can be recorded and used before they move on.

√ Can be used as a training aid to increase the expertise of staff.

√ Makes rational decisions without any emotional overhead.

√ Does not get tired or overworked.

√ Can perform some tasks much faster than a human expert for example, calculating a benefit claim.

√ Can quickly identify faults in equipment. For example systems to diagnose faults in cars can be directly connected to the cars for immediate diagnosis.

√ Successful expert systems are very accurate – possibly more so than a human being.

√ More than likely cheaper than using the time of a highly paid professional human being.

√ Recommendations will be consistent and always impartial. The expert system can produce very accurate diagnoses and up to date diagnoses consistently and provide reasoning/probabilities.

An expert system can be used to harness the combined knowledge of lots of experts. The knowledge of one expert can be shared globally

## Limitations of using an expert system

x Expert systems can 'make mistakes' and they do not learn from them. Humans can learn from their mistakes.

x There is a risk of over reliance on technology. Experts may become deskilled and follow the expert system recommendations instead of applying their own tuition to situations.

x Expert systems work best when the problem is specific and well defined. They are less suited to less predictable decisions where a lot of interpretation is required.

x A human advisor may take into account special circumstances which an expert system may overlook.

x Although the expert system should give its reasons for coming to a particular decision, it cannot be questioned any further.

x Every scenario cannot be programmed – therefore errors may be possible.