Chapter 8: Expert system

Expert Systems

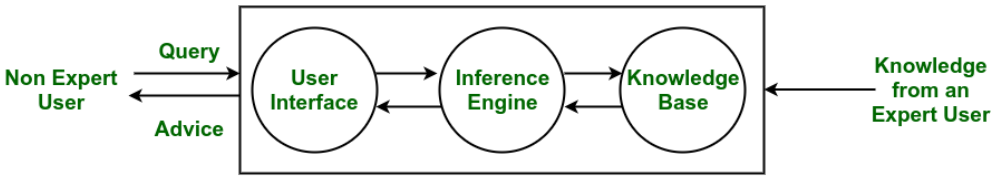
- Artificial Intelligence is a piece of software that simulates the behavior and judgment of a human or an organization that has experts in a particular domain is known as an expert system. It does this by acquiring relevant knowledge from its knowledge base and interpreting it according to the user's problem. The data in the knowledge base is added by humans that are experts in a particular domain and this software is used by a non-expert user to acquire some information. It is widely used in many areas such as medical diagnosis, accounting, coding, games etc.

- An expert system is AI software that uses knowledge stored in a knowledge base to solve problems that would usually require a human expert thus preserving a human expert's knowledge in its knowledge base. They can advise users as well as provide explanations to them about how they reached a particular conclusion or advice. Knowledge Engineering is the term used to define the process of building an Expert System and its practitioners are called Knowledge Engineers. The primary role of a knowledge engineer is to make sure that the computer possesses all the knowledge required to solve a problem. The knowledge engineer must choose one or more forms in which to represent the required knowledge as a symbolic pattern in the memory of the computer.

Example : There are many examples of an expert system. Some of them are given below –

- **MYCIN –**
  One of the earliest expert systems based on backward chaining. It can identify various bacteria that can cause severe infections and can also recommend drugs based on the person's weight.
- **DENDRAL –**
  It was an artificial intelligence-based expert system used for chemical analysis. It used a substance's spectrographic data to predict its molecular structure.
- **R1/XCON –**
  It could select specific software to generate a computer system wished by the user.
- **PXDES –**
  It could easily determine the type and the degree of lung cancer in a patient based on the data.
- **CaDet –**
  It is a clinical support system that could identify cancer in its early stages in patients.
- **DXplain –**
  It was also a clinical support system that could suggest a variety of diseases based on the findings of the doctor.

Components of an Expert System :



Architecture of an Expert System

- **Knowledge Base –**

  The knowledge base represents facts and rules. It consists of knowledge in a particular domain as well as rules to solve a problem, procedures and intrinsic data relevant to the domain.
- **Inference Engine –**

  The function of the inference engine is to fetch the relevant knowledge from the knowledge base, interpret it and to find a solution relevant to the user's problem. The inference engine acquires the rules from its knowledge base and applies them to the known facts to infer new facts. Inference engines can also include an explanation and debugging abilities.
- **Knowledge Acquisition and Learning Module –**

  The function of this component is to allow the expert system to acquire more and more knowledge from various sources and store it in the knowledge base.
- **User Interface –**

  This module makes it possible for a non-expert user to interact with the expert system and find a solution to the problem.
- **Explanation Module –**

  This module helps the expert system to give the user an explanation about how the expert system reached a particular conclusion.

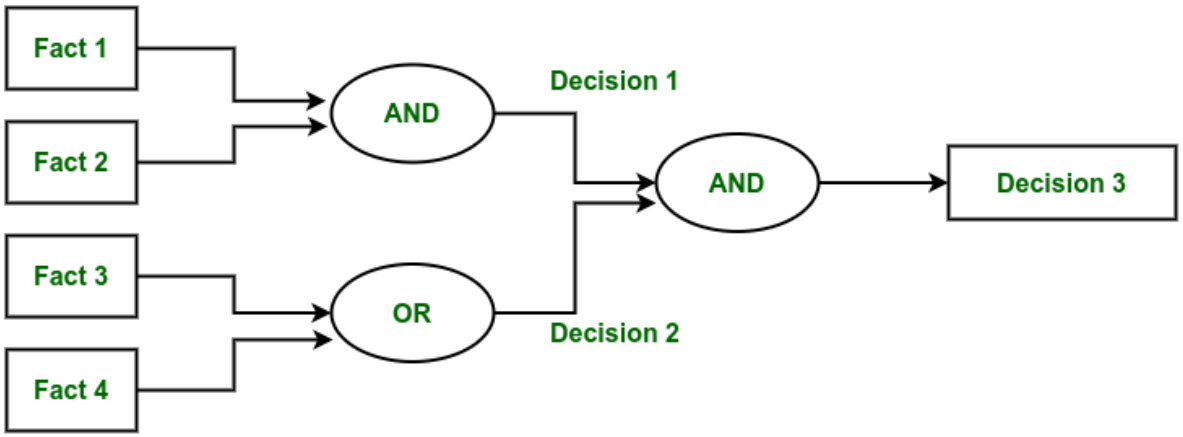
The Inference Engine generally uses two strategies for acquiring knowledge from the Knowledge Base, namely –

- **Forward Chaining**
- **Backward Chaining**

Forward Chaining –

Forward Chaining is a strategic process used by the Expert System to answer the questions – What will happen next. This strategy is mostly used for managing tasks

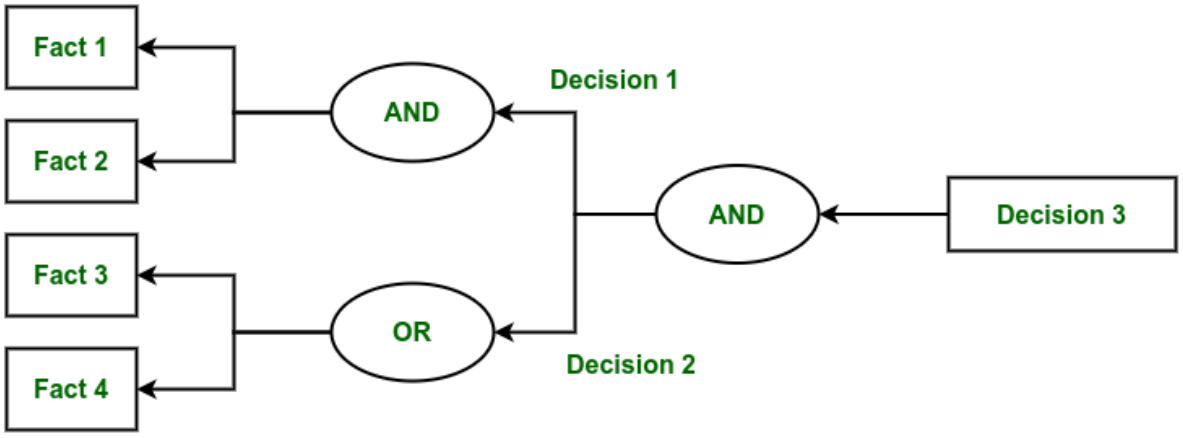
like creating a conclusion, result or effect. Example – prediction or share market movement status.



Forward Chaining

Backward Chaining –

Backward Chaining is a strategy used by the Expert System to answer the questions – Why this has happened. This strategy is mostly used to find out the root cause or reason behind it, considering what has already happened. Example – diagnosis of stomach pain, blood cancer or dengue, etc.



Backward Chaining

Characteristics of an Expert System :

- Human experts are perishable, but an expert system is permanent.
- It helps to distribute the expertise of a human.
- One expert system may contain knowledge from more than one human expert thus making the solutions more efficient.
- It decreases the cost of consulting an expert for various domains such as medical diagnosis.
- They use a knowledge base and inference engine.
- Expert systems can solve complex problems by deducing new facts through existing facts of knowledge, represented mostly as if-then rules rather than through conventional procedural code.
- Expert systems were among the first truly successful forms of artificial intelligence (AI) software.

Limitations :

- Do not have human-like decision-making power.
- Cannot possess human capabilities.
- Cannot produce correct results from less knowledge.
- Requires excessive training.

Advantages :

- Low accessibility cost.
- Fast response.
- Not affected by emotions, unlike humans.
- Low error rate.
- Capable of explaining how they reached a solution.

Disadvantages :

- The expert system has no emotions.
- Common sense is the main issue of the expert system.
- It is developed for a specific domain.
- It needs to be updated manually. It does not learn itself.
- Not capable of explaining the logic behind the decision.

Applications :

The application of an expert system can be found in almost all areas of business or government. They include areas such as –

- Different types of medical diagnosis like internal medicine, blood diseases and show on.
- Diagnosis of the complex electronic and electromechanical system.
- Diagnosis of a software development project.
- Planning experiment in biology, chemistry and molecular genetics.
- Forecasting crop damage.
- Diagnosis of the diesel-electric locomotive system.
- Identification of chemical compound structure.
- Scheduling of customer order, computer resources and various manufacturing tasks.
- Assessment of geologic structure from dip meter logs.
- Assessment of space structure through satellite and robot.
- The design of the VLSI system.
- Teaching students specialize tasks.
- Assessment of log including civil case evaluation, product liability etc.

Development of Expert System

Here, we will explain the working of an expert system by taking an example of MYCIN ES. Below are some steps to build an MYCIN:

- Firstly, ES should be fed with expert knowledge. In the case of MYCIN, human experts specialized in the medical field of bacterial infection, provide information about the causes, symptoms, and other knowledge in that domain.
- The KB of the MYCIN is updated successfully. In order to test it, the doctor provides a new problem to it. The problem is to identify the presence of the bacteria by inputting the details of a patient, including the symptoms, current condition, and medical history.
- The ES will need a questionnaire to be filled by the patient to know the general information about the patient, such as gender, age, etc.
- Now the system has collected all the information, so it will find the solution for the problem by applying if-then rules using the inference engine and using the facts stored within the KB.
- In the end, it will provide a response to the patient by using the user interface.

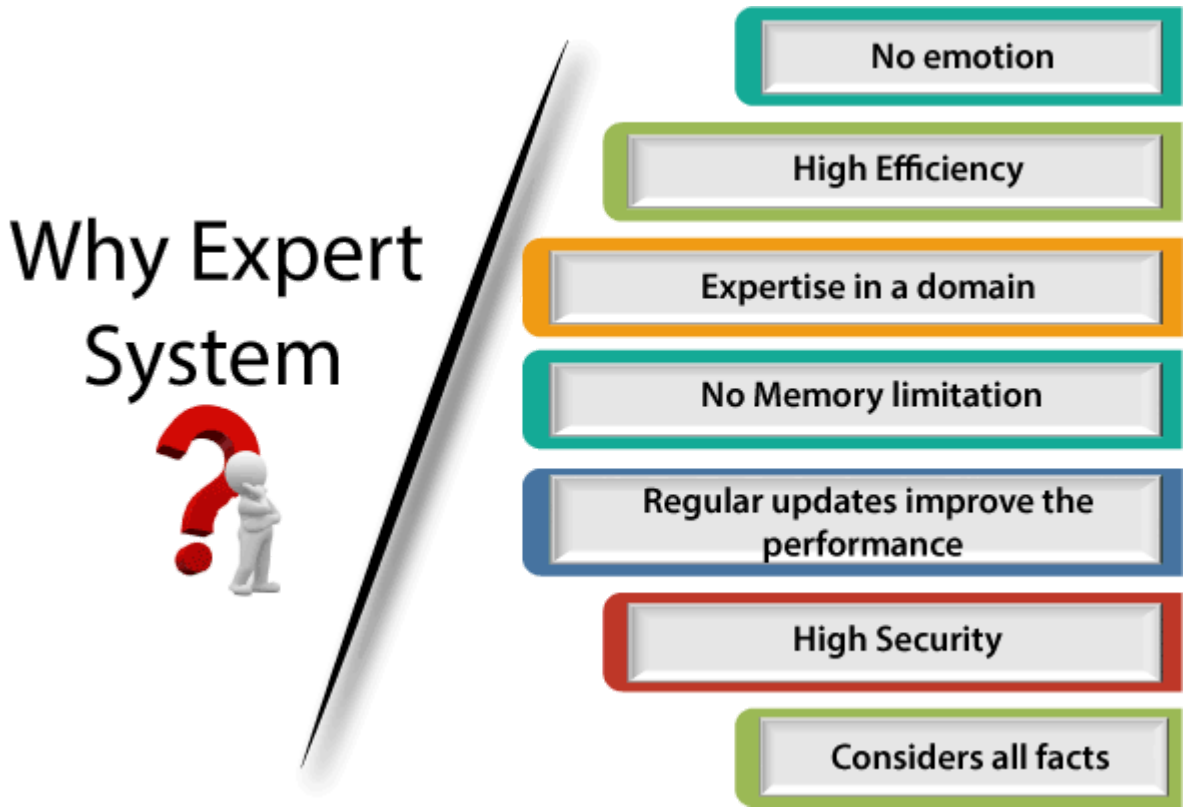
Participants in the development of Expert System

There are three primary participants in the building of Expert System:

1. **Expert:** The success of an ES much depends on the knowledge provided by human experts. These experts are those persons who are specialized in that specific domain.
2. **Knowledge Engineer:** Knowledge engineer is the person who gathers the knowledge from the domain experts and then codifies that knowledge to the system according to the formalism.

3. **End-User:** This is a particular person or a group of people who may not be experts, and working on the expert system needs the solution or advice for his queries, which are complex.

Why an Expert System?



Before using any technology, we must have an idea about why to use that technology and hence the same for the ES. Although we have human experts in every field, then what is the need to develop a computer-based system? So below are the points that are describing the need of the ES:

1. **No memory Limitations:** It can store as much data as required and can memorize it at the time of its application. But for human experts, there are some limitations to memorizing all things at all times.
2. **High Efficiency:** If the knowledge base is updated with the correct knowledge, then it provides a highly efficient output, which may not be possible for a human.

3. **Expertise in a domain:** There are lots of human experts in each domain, and they all have different skills, different experiences, and different skills, so it is not easy to get a final output for the query. But if we put the knowledge gained from human experts into the expert system, then it provides an efficient output by mixing all the facts and knowledge
4. **Not affected by emotions:** These systems are not affected by human emotions such as fatigue, anger, depression, anxiety, etc.. Hence the performance remains constant.
5. **High security:** These systems provide high security to resolve any query.
6. **Considers all the facts:** To respond to any query, it checks and considers all the available facts and provides the result accordingly. But it is possible that a human expert may not consider some facts due to any reason.
7. **Regular updates improve the performance:** If there is an issue in the result provided by the expert systems, we can improve the performance of the system by updating the knowledge base.

Capabilities of the Expert System

Below are some capabilities of an Expert System:

- **Advising:** It is capable of advising the human being for the query of any domain from the particular ES.
- **Provide decision-making capabilities:** It provides the capability of decision making in any domain, such as for making any financial decision, decisions in medical science, etc.
- **Demonstrate a device:** It is capable of demonstrating any new products such as its features, specifications, how to use that product, etc.
- **Problem-solving:** It has problem-solving capabilities.
- **Explaining a problem:** It is also capable of providing a detailed description of an input problem.

- **Interpreting the input:** It is capable of interpreting the input given by the user.
- **Predicting results:** It can be used for the prediction of a result.
- **Diagnosis:** An ES designed for the medical field is capable of diagnosing a disease without using multiple components as it already contains various inbuilt medical tools.

Difference between Human expert and Expert system

1. **Expert System:** The other name of expert systems is **knowledge based systems**.

   They are used for real world problems like expert quality advice, diagnosis and recommendations. Basically, it is a type of computer program that is used to simulate the judgment and behavior of humans or an organization that has an expert knowledge and experience about the particular field. Building an expert system requires a human expert that extracts the required knowledge.

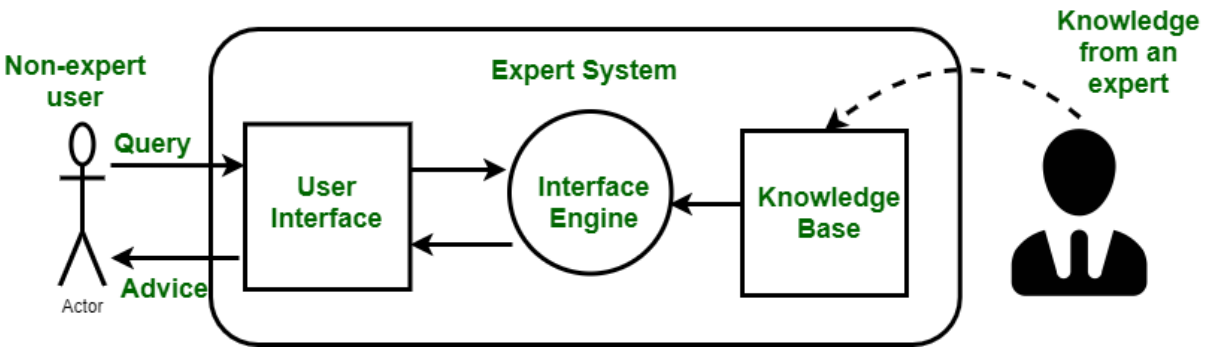


Figure – Expert System

2. Human Experts : Human expert is an individual who has the capability of recognizing things in a superior way. For example: a doctor etc.

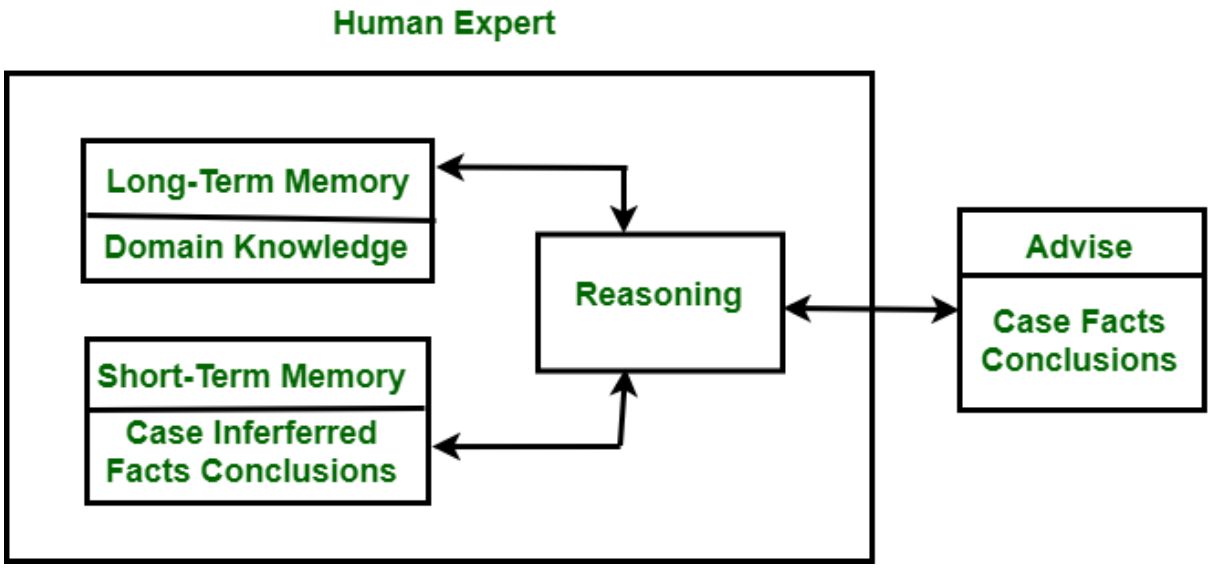


Figure – Human Experts

Difference between Human expert and Expert system :

S.No.	Human experts	Expert System
1.	Use knowledge in the form of rules of thumbs or heuristics to solve problems in a narrow domain.	It processes knowledge expressed in the form of rules and uses symbolic reasoning in a narrow domain.

2.	In a human expert we deal with the human brain in which knowledge exists in a compiled form.	It provides a clear separation of knowledge from its processing.
3.	It is capable of explaining line of reasoning and providing the details.	Expert system helps in tracing the rules that are produced during solving a problem and also explain how that particular conclusion was reached and why specific data was needed.
4.	It uses inexact reasoning and is also able to deal with incomplete, uncertain and fuzzy information.	It permits inexact reasoning but is able to deal with incomplete, uncertain and fuzzy data.
5.	It enhances the quality of problem solving because of years of learning and practical training.	It enhances the quality of problem solving by the addition of new rules or by adjusting the old ones in the knowledge base and when new knowledge is acquired, changes are easy to observe.

6.	Human experts can be available at a specific working day.	Expert system can be available wherever and at any time.
7.	To solve any problem, human experts can take variable time.	To solve any problem, an expert system takes a very short interval of time.
8.	It is not replaceable.	It can be replaceable.

Comparison of Human Experts and ES

Features	Human Experts	Expert Systems
Mortality	Yes	No
Knowledge transfer	Difficult	Easy
Knowledge documentation	Difficult	Easy
Decision consistency	Low	High
Unit usage cost	High	Low
Creativity	High	Low

Designing of an Expert System

Designing an expert system involves several key steps to ensure its effectiveness in solving specific problems or providing expert-level advice in a particular domain. Here's a general outline of the design process:

Identify the Problem Domain:

- Define the specific problem or domain in which the expert system will operate. This could be medical diagnosis, financial analysis, troubleshooting technical issues, etc.

Knowledge Acquisition:

- Gather knowledge from human experts in the domain. This can be done through interviews, documentation review, observation, or existing data sources.

Knowledge Representation:

- Formalize the acquired knowledge into a format that the expert system can understand and manipulate. Common knowledge representation techniques include rules, frames, semantic networks, and ontologies.

Inference Engine Design:

- Develop the inference engine, which is the core component responsible for reasoning and making decisions based on the provided knowledge. The inference engine applies logical rules or algorithms to draw conclusions from the available information.

User Interface Design:

- Design the user interface through which users interact with the expert system. The interface should be intuitive and provide a means for users to input queries or receive recommendations.

Knowledge Base Management:

- Implement mechanisms for managing and updating the knowledge base over time. This may involve adding new rules or facts, modifying existing ones, or removing outdated information.

Testing and Validation:

- Test the expert system extensively to ensure its accuracy, reliability, and performance. This involves both functional testing to verify that

the system behaves as expected and validation against real-world cases or expert judgment.

Deployment and Maintenance:

- Deploy the expert system in its intended environment and provide ongoing support and maintenance. This includes monitoring its performance, addressing user feedback, and updating the system as needed to adapt to changes in the domain or technology.

Integration:

- Integrate the expert system with other systems or applications as necessary. This may involve connecting to databases, external APIs, or incorporating machine learning components for tasks like data analysis or pattern recognition.

Training and Documentation:

- Provide training materials and documentation to users and administrators to help them understand how to use and maintain the expert system effectively.

Throughout the design process, it's important to involve domain experts, end-users, and stakeholders to ensure that the expert system meets their needs and addresses relevant challenges in the problem domain. Additionally, iterative development and feedback loops can help refine the system and improve its performance over time.