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PBCA (604) VI Sem
Artificial Intelligence and Expert system
Unit IV

Topic covered

- **Concept of Learning**
- **Knowledge Acquisition**
- **Rote Learning**
- **Discovery**
- **Analogy**
- **Concept of Expert system**
- **Components of Expert system**
- **Stages in Developmentof an Expert system**
- **Advantages and disadvantages of Expert system**
- **Applications of Expert system**

Learning:

- "Learning denotes changes in a system that enables system to do the same task more efficiently next time."
- Learning is the improvement of performance with experience over time.
- Learning element is the portion of a learning AI system that decides how to modify the performance element and implements those modifications.
- We all learn new knowledge through different methods, depending on the type of material to be learned, the amount of relevant knowledge we already possess, and the environment in which the learning takes place.

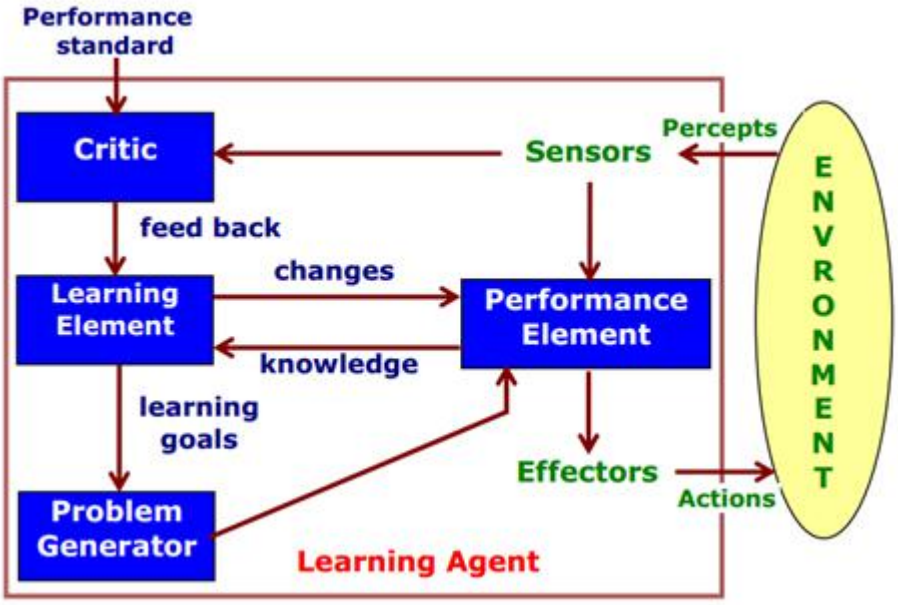


Figure 1: Concept of Learning

Machine Learning :-Definition

A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P,if its performance at tasks in T,as measured by P,improves with experience E.

Components of Learning System

Performance Element:

The performance element is the agent that acts in the world .It percepts and decides on external actions.

Learning Element:

It responsible for making improvements, takes knowledge about performance element and some feedback ,determines how to modify performance element.

Critic:

It tells the learning element how agent is doing by comparing with the fixed standard of performance.

Problem Generator:

This component suggests problems or actions that will generate new examples or experience that helps the system to train further.

Let us see the role of each component with an example.

Example: Automated Taxi on city roads

Performance Element: consists of knowledge and procedures for driving actions.

eg:turning ,accelerating,breaking are the performance elements on roads.

Learning Element: It formulates goals.

Eg:learn rules for breaking,accelerating,learn geography of the city.

Critic: Observes world and passes information to learning element.

Eg:quick right turn across three lanes of traffic ,observe reaction of other drivers.

Problem Generator: Try south city road

Types of learning:

1. **Supervised learning** generates a function that maps inputs to desired outputs (also called labels, because they are often provided by human experts labeling the training examples). For example, in a classification problem, the learner approximates a function mapping a vector into classes by looking at input-output examples of the function.
2. **Unsupervised learning** models a set of inputs, like clustering. See also data mining and knowledge discovery.
3. **Semi-supervised learning** combines both labeled and unlabeled examples to generate an appropriate function or classifier.
4. **Reinforcement learning** learns how to act given an observation of the world. Every action has some impact in the environment, and the environment provides feedback in the form of rewards that guides the learning algorithm.

5. **Transduction**, or transductive inference, tries to predict new outputs on specific and fixed (test) cases from observed, specific (training) cases. Learning to learn learns its own inductive bias based on previous experience.

KNOWLEDGE ACQUISITION

- Knowledge acquisition is the gathering or collecting knowledge from various sources. It is the process of adding new knowledge to a knowledge base and refining or improving knowledge that was previously acquired.
- Acquisition is the process of expanding the capabilities of a system or improving its performance at some specified task. So it is the goal oriented creation and refinement of knowledge.
- Acquired knowledge may consist of facts, rules, concepts, procedures, heuristics, formulas, relationships, statistics or any other useful information.
- Source of these knowledges may be experts in the domain of interest, text books, technical papers, database reports, journals and the environments.
- The knowledge acquisition is a continuous process and is spread over entire lifetime. Example of knowledge acquisition is machine learning. It may be process of autonomous knowledge creation or refinements through the use of computer programs. The newly acquired knowledge should be integrated with existing knowledge in some meaningful way.
- The knowledge should be accurate, non-redundant, consistent and fairly complete. Knowledge acquisition supports the activities like entering the knowledge and maintaining knowledge base. The knowledge acquisition process also sets dynamic data structures for

existing knowledge to refine the knowledge. The role of knowledge engineer is also very important with respect to develop the refinements of knowledge.

- Knowledge engineers may be the professionals who elicit knowledge from experts. They integrate knowledge from various sources like creates and edits code, operates the various interactive tools, build the knowledge base etc.

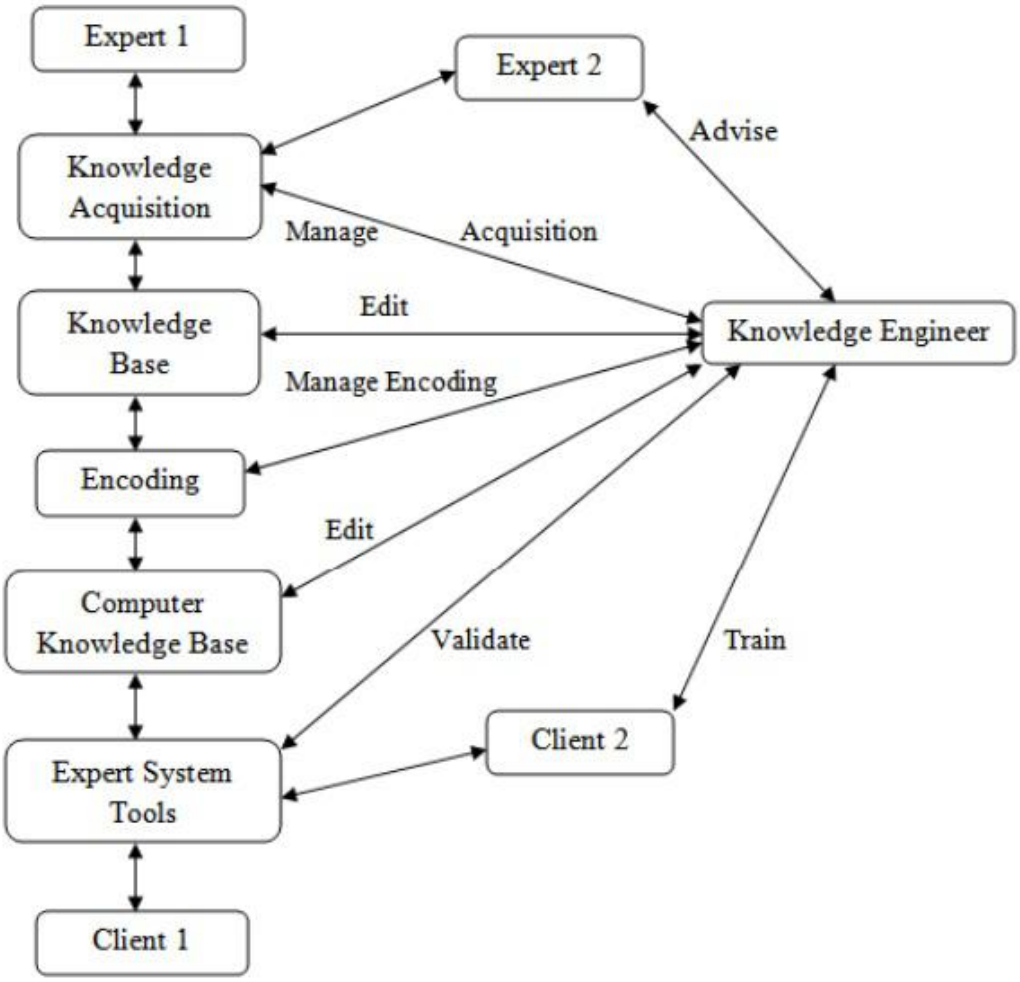


Figure 2: Knowledge Engineer's Roles in Interactive Knowledge Acquisition

Knowledge Acquisition Techniques:

Many techniques have been developed to deduce knowledge from an expert. They are termed as knowledge acquisition techniques. They are:

a) Diagram Based Techniques
b) Matrix Based Techniques
c) Hierarchy-Generation Techniques
d) Protocol Analysis Techniques
e) Protocol Generation Techniques
f) Sorting Techniques

Rote Learning

- Rote learning is the basic learning activity.
- Rote learning is a memorization technique based on repetition.
- It is also called memorization because the knowledge, without any modification is, simply copied into the knowledge base. As computed values are stored, this technique can save a significant amount of time.
- Rote learning technique can also be used in complex learning systems provided sophisticated techniques are employed to use the stored values faster and there is a generalization to keep the number of stored information down to a manageable level. Checkers-playing program, for example.
- This strategy does not require the learning system to transform or infer knowledge. It is the simplest form of learning.
- It includes learning my imitation, simple memorization and learning by being performed. For example we may use this type of learning when we memorize multiplication tables.
- In this method we store the previous computed values, for which we do not have for recomputed them later.

- Also we can say rote learning is one type of existing or base learning. For example, in our childhood, we have the knowledge that "sun rises in the east". So in our later stage of learning we can easily memorize the thing. Hence in this context, a system may simply memorize previous solutions and recall them when confronted with the same problem. Generally access of stored value must be faster than it would be to recompute.
- Methods like hashing, indexing and sorting can be employed to enable this.
- One drawback of rote learning is it is not very effective in a rapidly changing environment. If the environment does change then we must detect and record exactly what has changed.
- Also this technique must not decrease the efficiency of the system. We must be able to decide whether it is worth storing the value in the first place.

Learning by Analogy

- It is a process of learning a new concept or solution through the use of similar known concepts or solutions.
- We make frequent use of analogical learning.
- The first step is inductive inference, required to find a common substructure between the problem domain and one of the analogous domains stored in the learner's existing knowledge base.
- This form of learning requires the learning system to transform and supplement its existing knowledge from one domain or problem area into new domain.
- This strategy requires more inferencing by the learning system than previous strategies. Relevant knowledge must be found in the systems existing knowledge by using induction strategies.

- This knowledge must then be transformed to the new problem using deductive inference. Example of learning by analogy may include the driving technique of vehicles.
- If we know the driving procedure of a bike, then when we will drive a car then some sort of previous learning procedures we may employ.
- Similarly for driving a bus or truck, we may use the procedure for driving a car.

Learning from Observations and Discovery

- Using this strategy, the learning system must either induce class descriptions from observing the environment or manipulate the environment to acquire class descriptions or concepts.
- This is an unsupervised learning technique.
- It requires the greatest amount of inferencing among all of the different forms of learning.
- From an existing knowledge base, some new forms of discovery of knowledge may formed.
- The learning discovery process is very important in the respect of constructing new knowledge base.

Expert systems:

Expert system = knowledge + problem-solving methods.

A knowledge base that captures the domain-specific knowledge and an inference engine that consists of algorithms for manipulating the knowledge represented in the knowledge base to solve a problem presented to the system.

What are Expert Systems?

The expert systems are the computer applications developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise.

Expert systems ES are one of the prominent research domains of AI. It is introduced by the researchers at Stanford University, Computer Science Department.

Characteristics of Expert Systems

- High performance
- Understandable
- Reliable
- Highly responsive

Capabilities of Expert Systems

The expert systems are capable of −

- Advising
- Instructing and assisting human in decision making
- Demonstrating
- Deriving a solution
- Diagnosing

- Explaining
- Interpreting input
- Predicting results
- Justifying the conclusion
- Suggesting alternative options to a problem

They are incapable of −

- Substituting human decision makers
- Possessing human capabilities
- Producing accurate output for inadequate knowledge base
- Refining their own knowledge

Components of Expert Systems

The components of ES include −

1. Knowledge Base
2. Inference Engine
3. User Interface

Let us see them one by one briefly −

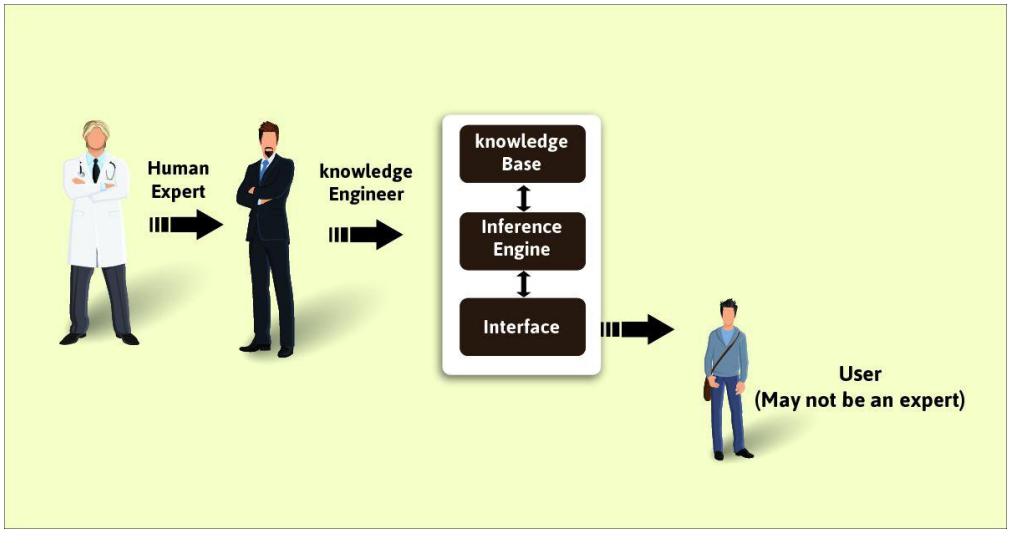


Figure 3: Components of Expert System

Knowledge Base

It contains domain-specific and high-quality knowledge. Knowledge is required to exhibit intelligence. The success of any ES majorly depends upon the collection of highly accurate and precise knowledge.

What is Knowledge?

The data is collection of facts. The information is organized as data and facts about the task domain. Data, information, and past experience combined together are termed as knowledge.

Components of Knowledge Base

The knowledge base of an ES is a store of both, factual and heuristic knowledge.

1. Factual Knowledge − It is the information widely accepted by the Knowledge Engineers and scholars in the task domain.
2. Heuristic Knowledge − It is about practice, accurate judgement, one's ability of evaluation, and guessing.

Knowledge representation

It is the method used to organize and formalize the knowledge in the knowledge base. It is in the form of IF-THEN-ELSE rules.

Knowledge Acquisition

The success of any expert system majorly depends on the quality, completeness, and accuracy of the information stored in the knowledge base. The knowledge base is formed by readings from various experts, scholars, and the Knowledge Engineers. The knowledge engineer is a person with the qualities of empathy, quick learning, and case analyzing skills. He acquires information from subject expert by recording,

interviewing, and observing him at work, etc. He then categorizes and organizes the information in a meaningful way, in the form of IF-THEN-ELSE rules, to be used by interference machine. The knowledge engineer also monitors the development of the ES.

Inference Engine

Use of efficient procedures and rules by the Inference Engine is essential in deducting a correct, flawless solution. In case of knowledge-based ES, the Inference Engine acquires and manipulates the knowledge from the knowledge base to arrive at a particular solution.

In case of rule based ES, it −

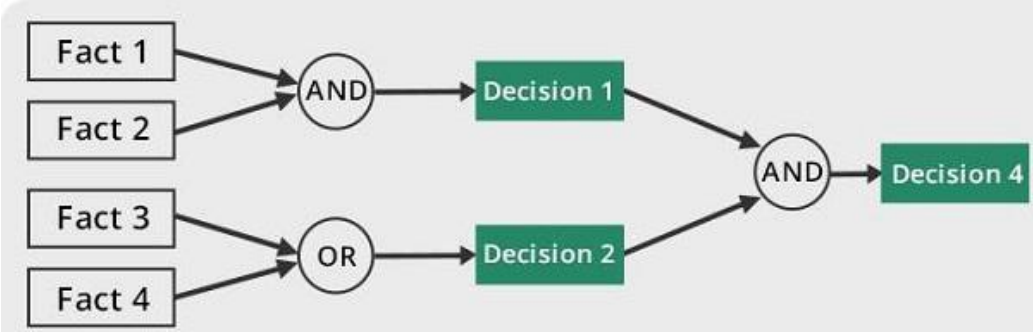
1. Applies rules repeatedly to the facts, which are obtained from earlier rule application.
2. Adds new knowledge into the knowledge base if required.
3. Resolves rules conflict when multiple rules are applicable to a particular case.

To recommend a solution, the Inference Engine uses the following strategies −

1. Forward Chaining
2. Backward Chaining

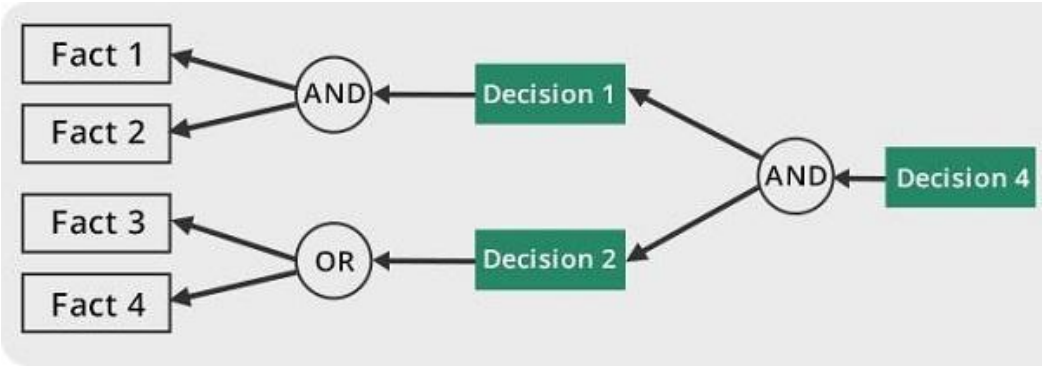
Forward Chaining

It is a strategy of an expert system to answer the question, “What can happen next?” Here, the Inference Engine follows the chain of conditions and derivations and finally deduces the outcome. It considers all the facts and rules, and sorts them before concluding to a solution. This strategy is followed for working on conclusion, result, or effect. For example, prediction of share market status as an effect of changes in interest rates.



Backward Chaining

With this strategy, an expert system finds out the answer to the question, "Why this happened?" On the basis of what has already happened, the Inference Engine tries to find out which conditions could have happened in the past for this result. This strategy is followed for finding out cause or reason. For example, diagnosis of blood cancer in humans.



User Interface

User interface provides interaction between user of the ES and the ES itself. It is generally Natural Language Processing so as to be used by the user who is well-versed in the task domain. The user of the ES need not be necessarily an expert in Artificial Intelligence.

It explains how the ES has arrived at a particular recommendation. The explanation may appear in the following forms −

- Natural language displayed on screen.
- Verbal narrations in natural language.
- Listing of rule numbers displayed on the screen

The user interface makes it easy to trace the credibility of the deductions.
Requirements of Efficient ES User Interface

- It should help users to accomplish their goals in shortest possible way.
- It should be designed to work for user's existing or desired work practices.
- Its technology should be adaptable to user's requirements; not the other way round.
- It should make efficient use of user input.

Development of Expert Systems:General Steps

The process of ES development is iterative.
Steps in developing the ES include −

1. Identify Problem Domain
    - The problem must be suitable for an expert system to solve it.
    - Find the experts in task domain for the ES project.
    - Establish cost-effectiveness of the system.
2. Design the System
    - Identify the ES Technology
    - Know and establish the degree of integration with the other systems and databases.
    - Realize how the concepts can represent the domain knowledge best.
3. Develop the Prototype From Knowledge Base:

The knowledge engineer works to −

- Acquire domain knowledge from the expert.
- Represent it in the form of If-THEN-ELSE rules.

4. Test and Refine the Prototype
   - The knowledge engineer uses sample cases to test the prototype for any deficiencies in performance.
   - End users test the prototypes of the ES.
5. Develop and Complete the ES
   - Test and ensure the interaction of the ES with all elements of its environment, including end users, databases, and other information systems.
   - Document the ES project well.
   - Train the user to use ES.
6. Maintain the ES
   - Keep the knowledge base up-to-date by regular review and update.
   - Cater for new interfaces with other information systems, as those systems evolve.

Benefits of Expert Systems

1. Availability − They are easily available due to mass production of software.

2. Less Production Cost − Production cost is reasonable. This makes them affordable.

3. Speed − They offer great speed. They reduce the amount of work an individual puts in.

4. Less Error Rate − Error rate is low as compared to human errors.

5. Reducing Risk − They can work in the environment dangerous to humans.

6. Steady response − They work steadily without getting motional, tensed or fatigued.

Applications of Expert System

Application	**Description**
Design Domain	Camera lens design, automobile design.
Medical Domain	Diagnosis Systems to deduce cause of disease from observed data, conduction medical operations on humans.
Monitoring Systems	Comparing data continuously with observed system or with prescribed behavior such as leakage monitoring in long petroleum pipeline.
Process Control Systems	Controlling a physical process based on monitoring.
Knowledge Domain	Finding out faults in vehicles, computers.
Finance/Commerce	Detection of possible fraud, suspicious transactions, stock market trading, Airline scheduling, cargo scheduling.

Expert Systems Limitations

No technology can offer easy and complete solution. Large systems are costly, require significant development time, and computer resources. ESs have their limitations which include-

- Limitations of the technology
- Difficult knowledge acquisition
- ES are difficult to maintain
- High development costs