UNIT – V

Expert Systems: Architecture of expert systems, Roles of expert systems – Knowledge Acquisition, Meta knowledge Heuristics. Typical expert systems – MYCIN, DART, XCON: Expert systems shells.

What is an Expert System?

An expert system is a computer program that is designed to solve complex problems and to provide decision-making ability like a human expert. It performs this by extracting knowledge from its knowledge base using the reasoning and inference rules according to the user queries.

The expert system is a part of AI, and the first ES was developed in the year 1970, which was the first successful approach of artificial intelligence. It solves the most complex issue as an expert by extracting the knowledge stored in its knowledge base. The system helps in decision making for complex problems using **both facts and heuristics like a human expert**. It is called so because it contains the expert knowledge of a specific domain and can solve any complex problem of that particular domain. These systems are designed for a specific domain, such as **medicine, science,** etc.

The performance of an expert system is based on the expert's knowledge stored in its knowledge base. The more knowledge stored in the KB, the more that system improves its performance. One of the common examples of an ES is a suggestion of spelling errors while typing in the Google search box.

Below is the block diagram that represents the working of an expert system:

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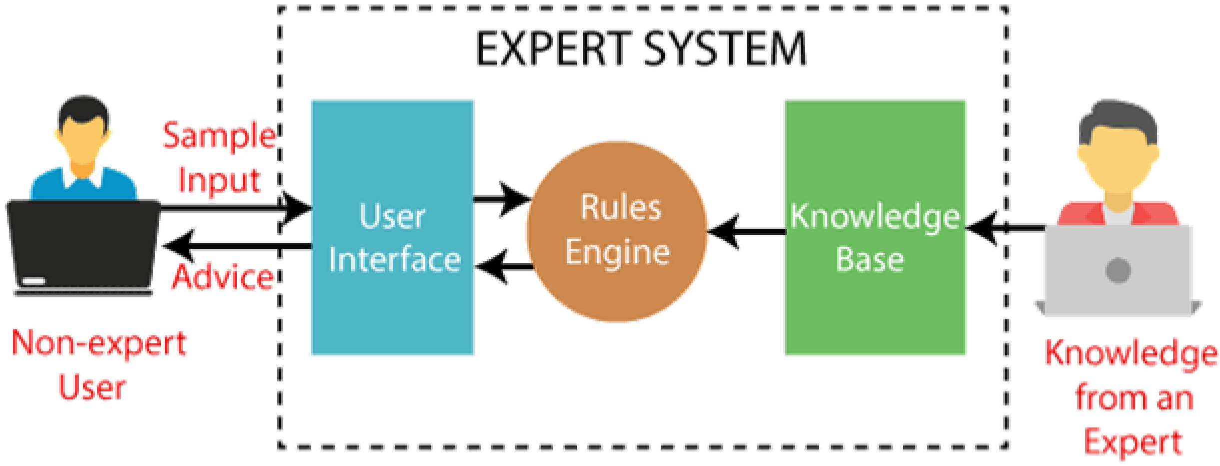


Note: It is important to remember that an expert system is not used to replace the human experts; instead, it is used to assist the human in making a complex decision. These systems do not have human capabilities of thinking and work on the basis of the knowledge base of the particular domain.

Below are some popular examples of the Expert System:

- **DENDRAL:** It was an artificial intelligence project that was made as a chemical analysis expert system. It was used in organic chemistry to detect unknown organic molecules with the help of their mass spectra and knowledge base of chemistry.
- **MYCIN:** It was one of the earliest backward chaining expert systems that was designed to find the bacteria causing infections like bacteraemia and meningitis. It was also used for the recommendation of antibiotics and the diagnosis of blood clotting diseases.
- **PXDES:** It is an expert system that is used to determine the type and level of lung cancer. To determine the disease, it takes a picture from the upper body, which looks like the shadow. This shadow identifies the type and degree of harm.
- **CaDeT:** The CaDet expert system is a diagnostic support system that can detect cancer at early stages.

Characteristics of Expert System

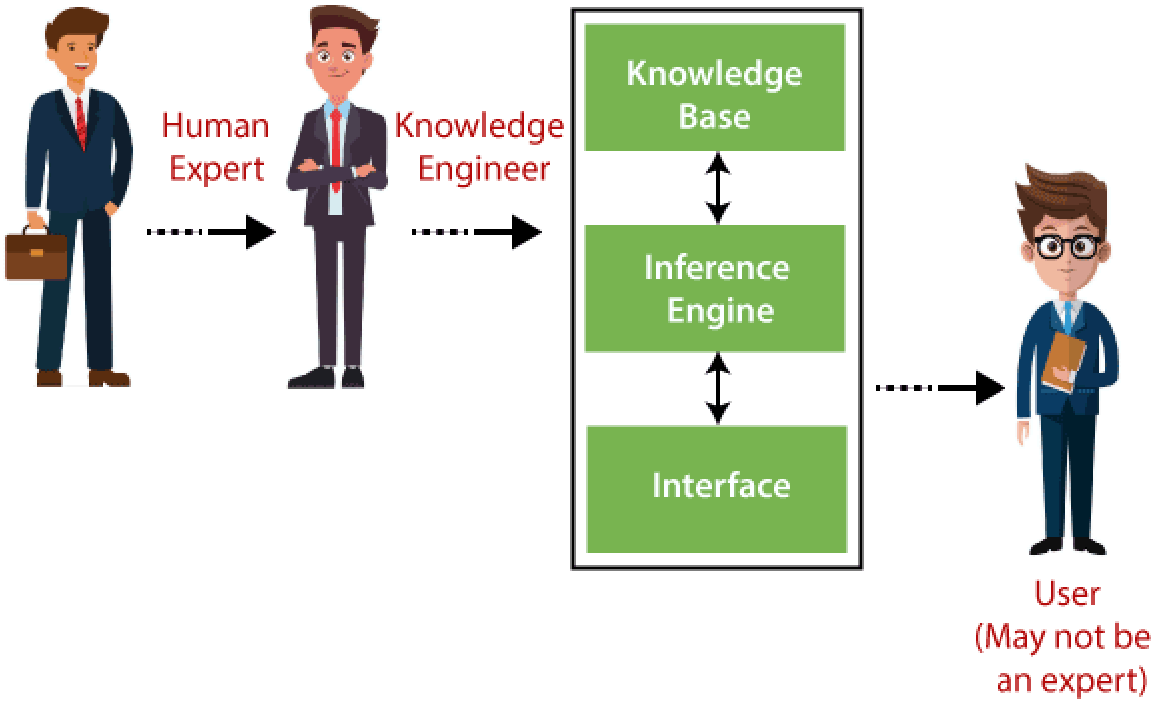
- **High Performance:** The expert system provides high performance for solving any type of complex problem of a specific domain with high efficiency and accuracy.
- **Understandable:** It responds in a way that can be easily understandable by the user. It can take input in human language and provides the output in the same way.
- **Reliable:** It is much reliable for generating an efficient and accurate output.
- **Highly responsive:** ES provides the result for any complex query within a very short period of time.

Components of Expert System

An expert system mainly consists of three components:

- **User Interface**

- **Inference Engine**
- **Knowledge Base**



1. User Interface

With the help of a user interface, the expert system interacts with the user, takes queries as an input in a readable format, and passes it to the inference engine. After getting the response from the inference engine, it displays the output to the user. In other words, **it is an interface that helps a non-expert user to communicate with the expert system to find a solution**.

2. Inference Engine(Rules of Engine)

- The inference engine is known as the brain of the expert system as it is the main processing unit of the system. It applies inference rules to the knowledge base to derive a conclusion or deduce new information. It helps in deriving an error-free solution of queries asked by the user.
- With the help of an inference engine, the system extracts the knowledge from the knowledge base.
- There are two types of inference engine:
- **Deterministic Inference engine:** The conclusions drawn from this type of inference engine are assumed to be true. It is based on **facts** and **rules**.
- **Probabilistic Inference engine:** This type of inference engine contains uncertainty in conclusions, and based on the probability.

Inference engine uses the below modes to derive the solutions:

- **Forward Chaining:** It starts from the known facts and rules, and applies the inference rules to add their conclusion to the known facts.
- **Backward Chaining:** It is a backward reasoning method that starts from the goal and works backward to prove the known facts.

3. Knowledge Base

- The knowledgebase is a type of storage that stores knowledge acquired from the different experts of the particular domain. It is considered as big storage of knowledge. The more the knowledge base, the more precise will be the Expert System.
- It is similar to a database that contains information and rules of a particular domain or subject.
- One can also view the knowledge base as collections of objects and their attributes. Such as a Lion is an object and its attributes are it is a mammal, it is not a domestic animal, etc.

Components of Knowledge Base

knowledge which is based on facts and accepted by knowledge engineers comes under factual knowledge.

Heuristic Knowledge: This knowledge is based on practice, the ability to guess, evaluation, and experiences.

Knowledge Representation: It is used to formalize the knowledge stored in the knowledge base using the If-else rules.

Knowledge Acquisitions: It is the process of extracting, organizing, and structuring the domain knowledge, specifying the rules to acquire the knowledge from various experts, and store that knowledge into the knowledge base.

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:

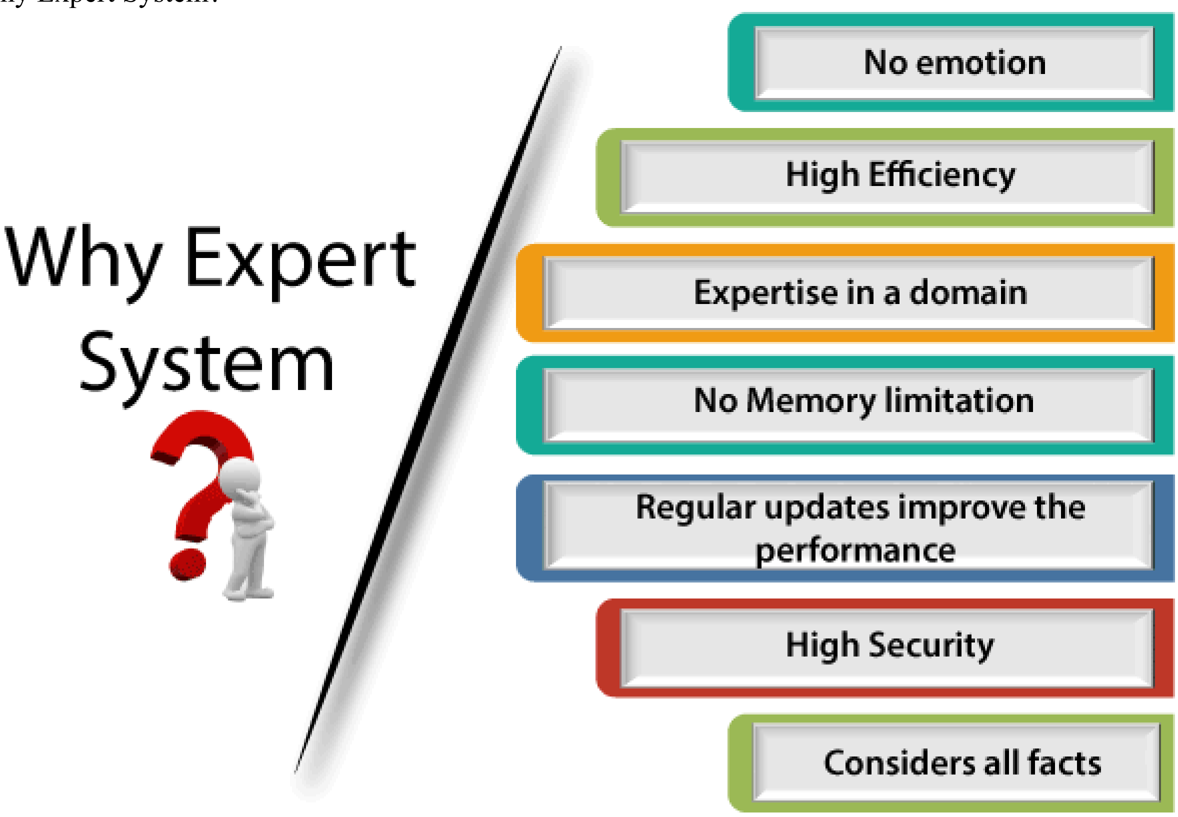
- Firstly, ES should be fed with expert knowledge. In the case of MYCIN, human experts specialized in the medical field of bacterial infection, provide information about the causes, symptoms, and other knowledge in that domain.
- The KB of the MYCIN is updated successfully. In order to test it, the doctor 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 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 memorize all things at every time.
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.

Architecture of expert systems

The knowledge base contains the specific domain knowledge that is used by an expert to derive conclusions from facts.

The Client Interface processes requests for service from system-users and from application layer components. The Knowledge-base Editor is a simple editor that enable a subject matter expert to compose and add rules to the Knowledge-base. Rule Translator converts rules from one form to another i.e; their original form to a machine-readable form. The Rule Engine(inference engine) is responsible for executing Knowledge-base rules. The shell component, Rule Object Classes, is a container for object classes supporting.

In the case of a rule-based expert system, this domain knowledge is expressed in the form of a series of rules. The explanation system provides information to the user about how the inference engine arrived at its conclusions. This can often be essential, particularly if the advice being given is of a critical nature, such as with a medical diagnosis system.

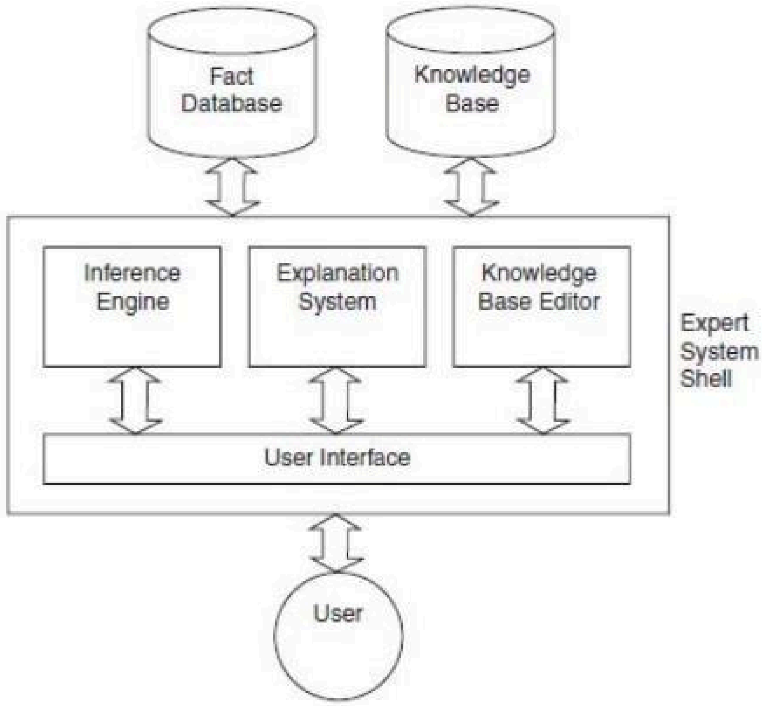


Fig Expert System Architecture

If the system has used faulty reasoning to arrive at its conclusions, then the user may be able to see this by examining the data given by the explanation system.

The fact database contains the case-specific data that are to be used in a particular case to derive a conclusion.

In the case of a medical expert system, this would contain information that had been obtained about the patient's condition.

The user of the expert system interfaces with it through a user interface, which provides access to the inference engine, the explanation system, and the knowledge-base editor.

The inference engine is the part of the system that uses the rules and facts to derive conclusions. The inference engine will use forward chaining, backward chaining, or a combination of the two to make inferences from the data that are available to it.
The knowledge-base editor allows the user to edit the information that is contained in the knowledge base. The knowledge-base editor is not usually made available to the end user of the system but is used by the knowledge engineer or the expert to provide and update the knowledge that is contained within the system.

The Expert System Shell

Note that in Figure, the parts of the expert system that do not contain domain-specific or case-specific information are contained within the **expert system shell**.

This shell is a general toolkit that can be used to build a number of different expert systems, depending on which knowledge base is added to the shell.
An example of such a shell is CLIPS (C Language Integrated Production System). Other examples in common use include OPS5, ART, JESS, and Eclipse.

Roles of expert systems

Expert systems are a significant branch of artificial intelligence (AI) that aim to emulate the decision-making abilities of a human expert in a specific domain. Here are the key roles and features of expert systems:

1. Knowledge Representation

- Expert systems utilize knowledge bases to store domain-specific information, rules, and heuristics that experts use in their decision-making processes. This knowledge can be represented in various forms, including rules, frames, or semantic networks.

2. Inference Engine

- The inference engine is the core component that applies logical rules to the knowledge base to deduce new information or make decisions. It can use methods such as forward chaining (data-driven) and backward chaining (goal-driven) to derive conclusions.

3. Problem Solving

- Expert systems are designed to solve complex problems by simulating the reasoning process of human experts. They can provide solutions, diagnoses, or recommendations in fields like medicine, engineering, finance, and customer support.

4. User Interaction

- Many expert systems include user interfaces that allow non-experts to interact with the system. This can involve asking questions, providing data, and receiving advice or solutions.

5. Consistency and Efficiency

- Expert systems can provide consistent answers to queries and perform tasks more efficiently than human experts, especially in high-volume or repetitive scenarios. They can process large amounts of data quickly and reduce the likelihood of human error.

6. Education and Training

- Expert systems can serve as educational tools, helping users learn about specific fields by providing insights and explanations based on stored knowledge. They can also assist in training new professionals by simulating expert reasoning.

7. Integration with Other Systems

- Many expert systems can be integrated with other AI technologies, such as machine learning and natural language processing, to enhance their capabilities and improve user experience.

Applications

Expert systems are used in various applications, including:
- **Medical Diagnosis**: Systems like MYCIN were developed to diagnose bacterial infections and recommend treatments.
- **Financial Services**: Used for credit assessment, fraud detection, and investment analysis.
- **Manufacturing**: Assisting in troubleshooting and maintenance of equipment.
- **Customer Support**: Automated help desks and chat-bots that provide technical support.

Knowledge Acquisition New: Building With AI knowledge acquisition

In AI, knowledge acquisition is the process of extracting knowledge from data. This can be done manually, through a process of observation and experimentation, or automatically, using a variety of techniques such as machine learning.

What is knowledge acquisition?

In artificial intelligence, knowledge acquisition is the process of gathering, selecting, and interpreting information and experiences to create and maintain knowledge within a specific domain. It is a key component of machine learning and knowledge-based systems.

There are many different methods of knowledge acquisition, including rule-based systems, decision trees, artificial neural networks, and fuzzy logic systems. The most appropriate method for a given application depends on the nature of the problem and the type of data available.

Rule-based systems are the simplest form of knowledge-based system. They use a set of rules, or heuristics, to make decisions. Decision trees are another common method, which use a series of if-then-else statements to arrive at a decision.

Artificial neural networks are a more complex form of knowledge-based system, which mimic the way the human brain learns. They are able to learn from data and make predictions based on that data. Fuzzy logic systems are another type of complex knowledge-based system, which use fuzzy set theory to make decisions.

The most important part of knowledge acquisition is the interpretation of information. This is where human expertise is required. Machines are not able to interpret information in the same way humans can. They can only make sense of data if it is presented in a certain way.

Humans need to select the right data and experiences to create knowledge. They also need to interpret that data correctly. This is where artificial intelligence can help. AI systems can automate the process of knowledge acquisition, making it faster and more accurate.

What are the goals of knowledge acquisition?

In artificial intelligence, knowledge acquisition is the process of gathering, selecting, and interpreting information that can be used to solve problems. The goals of knowledge acquisition are to reduce the amount of time and effort required to solve problems, and to improve the quality of the solutions.

One of the challenges in knowledge acquisition is that it is often difficult to know what information is relevant to the problem at hand. Another challenge is that the process of acquiring knowledge can be time-consuming and expensive.

Despite these challenges, knowledge acquisition is an essential part of artificial intelligence. By gathering and interpreting information, artificial intelligence can identify patterns and relationships that would be difficult for humans to find. This allows artificial intelligence to solve problems more efficiently and effectively.

What are the methods of knowledge acquisition?
There are a few methods of knowledge acquisition in AI:

1. Expert systems: In this method, experts in a particular field provide rules and knowledge to a computer system, which can then be used to make decisions or solve problems in that domain.

2. Learning from examples: This is a common method used in machine learning, where a system is presented with a set of training data, and it “learns” from these examples to generalize to new data.

3. Natural language processing: This is a method of extracting knowledge from text data, using techniques like text mining and information extraction.

4. Semantic web: The semantic web is a way of representing knowledge on the internet using standards like RDF and OWL, which can be processed by computers.

5. Knowledge representation and reasoning: This is a method of representing knowledge in a formal way, using logic or other formalisms, which can then be used for automated reasoning.

What are the challenges of knowledge acquisition?
One of the key challenges in AI is knowledge acquisition – that is, acquiring the right data and information to train AI models to be effective. This can be a challenge for a number of reasons.

First, data can be expensive to acquire. In some cases, it may be necessary to purchase data from third-party providers. This can be a significant cost, especially for small businesses or startups.

Second, data can be difficult to obtain. In some cases, it may be necessary to collect data manually. This can be time-consuming and expensive.

Third, data can be noisy. That is, it can contain errors or be incomplete. This can make it difficult to train AI models effectively.

Fourth, data can be biased. That is, it can be skewed to favor certain outcomes. This can lead to AI models that are not effective or that produce results that are unfair.

Finally, data can be dynamic. That is, it can change over time. This can make it difficult to keep AI models up-to-date.

These are just some of the challenges that can be associated with knowledge acquisition in AI. Overcoming these challenges is essential to developing effective AI models.

What is the role of knowledge acquisition in AI?
In AI, knowledge acquisition is the process of acquiring knowledge from data sources and then using that knowledge to improve the performance of AI systems. This process can be used to improve the accuracy of predictions made by AI systems, or to help them learn new tasks faster.

One of the most important aspects of knowledge acquisition is choosing the right data sources. This is because the quality of the data that AI systems use to learn is crucial to the performance of the system. For example, if an AI system is trying to learn how to identify objects in images, it will need to be trained on a dataset of high-quality images.

Once the data has been collected, it needs to be processed and converted into a format that can be used by AI systems. This process is known as feature engineering, and it is crucial to the success of AI systems. After the data has been processed, it can be used to train AI models.

Training AI models is a complex process, and it is important to choose the right algorithm for the task at hand. There is a wide range of different algorithms that can be used for training AI models, and each has its own strengths and weaknesses.

After the AI model has been trained, it can be deployed in a real-world environment. This is where knowledge acquisition can really help to improve the performance of AI systems. By constantly monitoring the data that is being generated by the system, knowledge acquisition can help to identify areas where the system can be improved.

Overall, knowledge acquisition is a vital part of AI. By carefully selecting data sources, processing that data, and then using it to train AI models, knowledge acquisition can help to improve the performance of AI systems.

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One of the key challenges in AI is knowledge acquisition – that is, acquiring the right data and knowledge to train AI models to be effective. This can be a challenge for a number of reasons.

First, acquiring accurate and representative data can be difficult. For example, if you're training an AI model to recognize objects in images, you need a large dataset of images that includes a wide variety of objects, lighting conditions, and backgrounds. It can be hard to find such a dataset, or to create one yourself.

Second, even if you have a good dataset, it can be hard to extract the right knowledge from it. For example, if you're training a model to identify faces in images, you need to somehow represent the knowledge of what a face is in a form that the AI model can understand. This can be a difficult task for even humans, let alone machines.

Third, even if you have the right data and can extract the right knowledge from it, acquiring that knowledge can be a slow and difficult process. For example, if you're training a model to identify objects in images, the model needs to "learn" by looking at a lot of images and gradually building up its knowledge. This process can take a lot of time and computing power.

Fourth, once you've acquired the knowledge, it can be hard to keep it up to date. For example, if you're training a model to identify faces in images, the model needs to be able to adapt as new types of faces (e.g., different races, ages, genders) are introduced. This can be a difficult task, as the model needs to constantly be "re-trained" on new data.

Overall, knowledge acquisition is a key challenge in AI, and one that can be difficult to overcome. However, it's important to remember that AI is constantly evolving, and new methods and techniques are being developed all the time that can help to address these challenges.

What is the role of knowledge acquisition in AI?
In AI, knowledge acquisition is the process of acquiring knowledge from data sources and then using that knowledge to improve the performance of AI systems. This process can be used to improve the accuracy of predictions made by AI systems, or to help them learn new tasks faster.

One of the most important aspects of knowledge acquisition is choosing the right data sources. This is because the quality of the data that AI systems use to learn is crucial to the performance of the system. For example, if an AI system is trying to learn how to identify objects in images, it will need to be trained on a dataset of high-quality images.

Once the data has been collected, it needs to be processed and converted into a format that can be used by AI systems. This process is known as feature engineering, and it is crucial to the success of AI systems. After the data has been processed, it can be used to train AI models.

There are many different types of AI models, and each has its own strengths and weaknesses. The type of model that is used will depend on the task that the AI system is trying to learn. For example, if the AI system is trying to learn how to identify objects in images, a convolutional neural network (CNN) might be used.

Once the AI system has been trained, it can be deployed into a real-world environment. This is where knowledge acquisition really comes into play. The AI system will need to be able to adapt to the new environment and learn from the data that it encounters. This process is known as transfer learning, and it is essential for AI systems that need to operate in the real world

Meta knowledge Heuristics

Meta-knowledge, as described in your statement, is a term used in the context of artificial intelligence and knowledge systems to refer to information that provides insight into the structure, organization, and characteristics of the data and knowledge contained within these systems. It is not specific to any particular domain or subject matter but rather focuses on the nature of knowledge itself. Here are some key points to further clarify the concept of meta-knowledge:

Description of Knowledge Structure: Meta-knowledge serves as a way to describe how the data and information within a knowledge system are organized and related to each other. It helps provide a higher-level understanding of the knowledge's structure.
User Interface Improvement: One of the main applications of meta-knowledge is in enhancing the design of user interfaces for AI systems. By understanding the structure of knowledge, designers can create more effective and intuitive interfaces for users to interact with the AI system.
Knowledge Base Maintenance: Meta-knowledge is also valuable for maintaining and managing knowledge bases that are used alongside inference engines. It helps in ensuring the quality, relevance, and consistency of the knowledge contained within these systems.

Inter-domain Communication: In complex AI systems that involve multiple modules or components, meta-knowledge can aid in facilitating communication between these modules. It helps different parts of the system understand and utilize the shared knowledge effectively.
Autonomous Operations: For AI systems to operate autonomously and efficiently, it's essential for them to have a clear understanding of the knowledge they rely on. Meta-knowledge can assist in this understanding and coordination, making autonomous operations smoother.
Future Trends: The statement suggests that as the complexity of problems AI systems need to tackle increases, the use of meta-knowledge is expected to become more prominent. This is because having a deep understanding of the knowledge structure becomes increasingly critical when dealing with complex, multi-faceted issues.

Overall, meta-knowledge plays a crucial role in enhancing the performance, usability, and coordination of AI systems by providing insights into the underlying knowledge and data structures. It helps bridge the gap between the complexity of real-world problems and the ability of AI systems to effectively solve them.

A heuristic is a function that determines how near a state is to the desired state. Heuristics functions vary depending on the problem and must be tailored to match that particular challenge. The majority of AI problems revolve around a large amount of information, data, and constraints, and the task is to find a way to reach the goal state. The heuristics function in this situation informs us of the proximity to the desired condition. The distance formula is an excellent option if one needed a heuristic function to assess how close a location in a two-dimensional space was to the objective point.

Properties of a Heuristic Search Algorithm

Heuristic search algorithms have the following properties:

- Admissible Condition: If an algorithm produces an optimal result, it is considered admissible.
- Completeness: If an algorithm ends with a solution, it is considered complete.
- Dominance Property: If A1 and A2 are two heuristic algorithms and have h1 and h2 heuristic functions, respectively, then A1 Will dominate A2 if h1 is superior to h2 for all possible values of node n.
- Optimality Property: If an algorithm is thorough, allowable, and dominates the other algorithms, that'll be the optimal one and will unquestionably produce an optimal result.

Types of Expert Systems in AI

In AI, expert systems are designed to emulate the decision-making abilities of human experts. They are categorized based on their underlying technology and application areas. Here are the primary types of expert systems in AI:

1. Rule-Based Expert Systems

- **Description**: Use a set of "if-then" rules to process data and make decisions. These rules are typically written by human experts and capture domain-specific knowledge.
- **Example**: **MYCIN**, an early system for diagnosing bacterial infections.

2. Frame-Based Expert Systems

- **Description**: Represent knowledge using frames, which are data structures similar to objects in programming. Each frame contains attributes and values related to a particular concept.
- **Example**: Systems used for knowledge representation in areas like natural language processing.

3. Fuzzy Logic Systems

- **Description**: Handle uncertain or imprecise information using fuzzy logic, which allows for partial truths rather than binary true/false values.
- **Example**: **Fuzzy control systems** for managing household appliances like washing machines and air conditioners.

4. Neural Network-Based Expert Systems

- **Description**: Use artificial neural networks to learn from data and make predictions or decisions based on learned patterns. They are often used for tasks involving pattern recognition and classification.
- **Example**: **Deep learning models** for image and speech recognition.

5. Neuro-Fuzzy Expert Systems

- **Description**: Integrate neural networks and fuzzy logic to combine the learning capabilities of neural networks with the handling of uncertainty and imprecision offered by fuzzy logic. This hybrid approach helps in dealing with complex problems where both pattern recognition and uncertain reasoning are required.
- **Example:** Automated control systems that adjust based on uncertain environmental conditions or financial forecasting models that handle both quantitative data and fuzzy inputs.

Examples of Expert Systems in AI

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

1. MYCIN

- **Overview**: MYCIN is one of the earliest and most influential expert systems developed in the 1970s. It was specifically designed for medical diagnosis.
- **Functionality**: MYCIN uses **backward chaining** to diagnose bacterial infections, such as meningitis and bacteremia. It identifies the bacteria causing the infection by asking the doctor a series of questions about the patient's symptoms and test results.

- **Significance**: Although not used clinically, MYCIN greatly influenced the development of medical expert systems.

2. DENDRAL

- **Overview**: DENDRAL is another pioneering expert system, developed in the 1960s, and is regarded as one of the first successful AI systems in the field of chemistry.
- **Functionality**: DENDRAL was designed to analyze chemical compounds. It uses **spectrographic data** (data obtained from spectroscopy) to predict the molecular structure of a substance.
- **Significance**: DENDRAL revolutionized chemical research by automating the analysis of mass spectrometry data.

3. R1/XCON

- **Overview**: R1, also known as XCON, was developed in the late 1970s by Digital Equipment Corporation (DEC) and is one of the most commercially successful expert systems.
- **Functionality**: R1/XCON was used to configure orders for new computer systems. It would select the appropriate hardware and software components based on the customer's requirements.
- **Significance**: R1/XCON streamlined system configuration, saving DEC millions by reducing errors and improving efficiency.

4. PXDES

- **Overview**: PXDES is an expert system designed for the medical field, particularly in the diagnosis of lung cancer.
- **Functionality**: PXDES could analyze patient data, including imaging results, to determine both the type and the stage of lung cancer. It helps in deciding the best course of treatment based on the patient's specific condition.
- **Significance:** PXDES aids in accurate, timely diagnoses, improving treatment decisions in oncology.

5. CaDet

- **Overview**: CaDet is a clinical support system developed to assist in the early detection of cancer.
- **Functionality**: CaDet can identify potential signs of cancer in its early stages by analyzing patient data and symptoms. It works by comparing patient data with known patterns and indicators of cancer.
- **Significance**: Early detection by CaDet enhances survival rates by enabling prompt treatment.

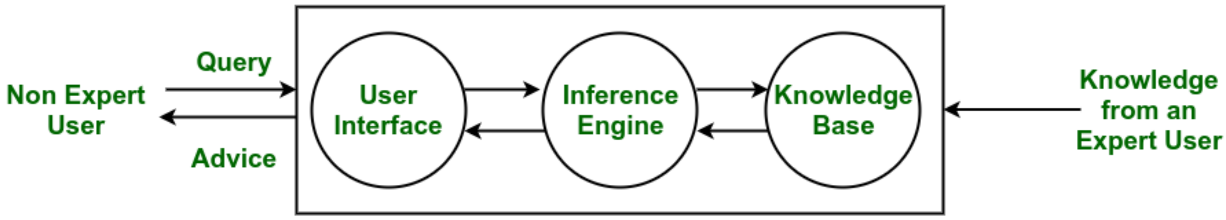
6. DXplain

- **Overview**: DXplain is a medical expert system developed at Massachusetts General Hospital, used as a clinical decision support tool.
- **Functionality**: DXplain suggests possible diseases based on the symptoms and findings provided by a doctor. It acts as a reference tool, offering a differential diagnosis list that doctors can use to check their own diagnoses.
- **Significance:** DXplain broadens diagnostic possibilities, helping medical professionals consider rare conditions.

Components and Architecture of an Expert System

1. **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.
2. **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.
3. **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.

4. **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.
5. **Explanation Module:** This module helps the expert system to give the user an explanation about how the expert system reached a particular conclusion.



Architecture of an Expert System

How Expert Systems Work?

Expert systems operate by following a structured approach:

1. **Input Data**: Users provide data or queries related to a specific problem or scenario.
2. **Processing**: The inference engine processes the input data using the rules in the knowledge base to generate conclusions or recommendation's.
3. **Output**: The system presents the results or solutions to the user through the user interface.
4. **Explanation**: If applicable, the system explains how the conclusions were reached, providing insights into the reasoning process.

MYCIN

MYCIN, an early expert system, or artificial intelligence (AI) program, for treating blood infections. In 1972 work began on MYCIN at Stanford University in California. MYCIN would attempt to diagnose patients based on reported symptoms and medical test results. The program could request further information concerning the patient, as well as suggest additional laboratory tests, to arrive at a probable diagnosis, after which it would recommend a course of treatment. If requested, MYCIN would explain the reasoning that led to its diagnosis and recommendation. Using about 500 production rules, MYCIN operated at roughly the same level of competence as human specialists in blood infections and rather better than general practitioners.

expert system, a computer program that uses artificial-intelligence methods to solve problems within a specialized domain that ordinarily requires human expertise. The first expert system was developed in 1965 by Edward Feigenbaum and Joshua Lederberg of Stanford University in California, U.S. Dendral, as their expert system was later known, was designed to analyse chemical compounds. Expert systems now have commercial applications in fields as diverse as medical diagnosis, petroleum engineering, and financial investing.

In order to accomplish feats of apparent intelligence, an expert system relies on two components: a knowledge base and an inference engine. A knowledge base is an organized collection of facts about the system's domain. An inference engine interprets and evaluates the facts in the knowledge base in order to provide an answer.

Typical tasks for expert systems involve classification, diagnosis, monitoring, design, scheduling, and planning for specialized endeavours.

Facts for a knowledge base must be acquired from human experts through interviews and observations. This knowledge is then usually represented in the form of "if-then" rules (production rules): "If some condition is true, then the following inference can be made (or some action taken)." The knowledge base of a major expert system includes thousands of rules. A probability factor is often attached to the conclusion of each production rule and to the ultimate recommendation, because the conclusion is not a certainty. For example, a system for the diagnosis of eye diseases might indicate, based on information supplied to it, a 90 percent probability that a person has glaucoma, and it might also list conclusions with lower probabilities. An expert system may display the sequence of rules through which it arrived at its conclusion; tracing this flow helps the user to appraise the credibility of its recommendation and is useful as a learning tool for students.

Human experts frequently employ heuristic rules, or “rules of thumb,” in addition to simple production rules, such as those gleaned from engineering handbooks. Thus, a credit manager might know that an applicant with a poor credit history, but a clean record since acquiring a new job, might actually be a good credit risk. Expert systems have incorporated such heuristic rules and increasingly have the ability to learn from experience. Expert systems remain aids to, rather than replacements for, human experts.

DART:

DART is a joint project of the Stanford University and IBM that explores the application of artificial intelligence techniques to the diagnosis of computer faults. It assists a technician in finding the faults in a computer system. (hardware and software)

DART uses a device-independent language for describing devices and device-independent inference procedure for diagnosis.

The primary goal of the DART Project is to develop programs that capture the special design knowledge and diagnostic abilities of these experts and to make them available to field engineers. The practical goal is the construction of an automated diagnostician capable of pinpointing the functional units responsible for observed malfunctions in arbitrary system configurations.

Like the MIT system, DART exploits deep knowledge. In diagnosing malfunctioning digital logic systems, the structure (components and their interconnections) and the signal behavior of the circuit (equations, rules or procedures that relate circuit inputs, outputs and states) must be described in a suitable description language. DART accepts a statement of a system malfunction in a formal language, suggests tests and accepts the results, and ultimately pinpoints the components responsible for the failure. The diagnosis is based on the occurrence of a single non-intermittent fault.

The hierarchical levels inherent in complex logic systems are exploited by restricting the diagnosis at one level at a time, thus keeping the diagnosis manageable. Starting at a high level of abstraction to determine the module in which the fault lies, the diagnosis is repeated at lower levels, until a replaceable faulty module is identified. All symptoms are expressed as violations of the expected behavior. At each level of the hierarchy, DART uses a general deductive inference procedure to analyze suspect components and generate discriminatory tests from information about the circuit being diagnosed. The program first computes a set of suspect propositions. If the set contains only one element, the diagnosis is done. Otherwise, DART tries to generate a test to discriminate the suspects. This process is continued until the faulty component has been found.

DART has been implemented in Common LISP and uses MRS as the inference engine. It runs on a VAX-11/780.

Expert System Shell

An Expert system shell is the skeleton of an expert system with the knowledge removed. To build a new expert system application, all the user has to do is add knowledge in the form of rules and provide relevant data.

or

An expert system shell in AI refers to the framework or software platform that provides the infrastructure for building and running expert systems. It serves as a foundation for developing customized expert systems by providing tools and functionalities to represent knowledge, make inferences, and deliver intelligent advice.

- Expert system shell provides a user-friendly software environment to knowledge engineers for building an expert system. This contains all the expert system generic logic system logic required to build an expert system.

- An Expert system shell can greatly facilitate the development. It means it makes development very easy. But this often reduces flexibility, The developer is limited to using the knowledge representation mechanism, inference technique, and ways to handle the uncertainty and user interface that the system shell provides. The problem of making an expert system can be solved to a good extent. but a great product can not be made. A plethora of expert system shell exists in today's market.

Components of Expert System shell

Some main or generic components of the expert system are:

- Knowledge Base
- Knowledge Acquisition System
- Reasoning or Inference Engine
- User Interface
- Explanation Facilities
- Maintenance and Adaptation Tools

There can be many components of an expert system shell may be it can provide debugging facilities, an editor and learning modules but those were the main ones. Let's see those one by one.

Knowledge Base

This is where the domain-specific knowledge is stored. It includes facts, rules, and relationships relevant to the problem domain. The knowledge base acts as the repository of expertise that the expert system relies on to make decisions.

Knowledge Acquisition System

Developing an expert system requires capturing and encoding the knowledge of human experts into the system. A knowledge acquisition system facilitates this process by providing tools and methodologies to elicit, represent, and organize expert knowledge effectively.

Reasoning or Inference Engine

inference engine is the core component responsible for reasoning and making inferences based on the information in the knowledge base. It applies logical rules and inference mechanisms to draw conclusions and generate recommendations or solutions.

User Interface

The user interface allows users to interact with the expert system. It can take various forms such as a command-line interface, graphical user interface (GUI), or even a chatbot-like interface. The user interface enables users to input information, receive recommendations, and query the system for explanations.

Explanation Facilities

An expert system shell often includes an explanation mechanism to provide justifications for its recommendations or decisions. This helps users understand why a certain conclusion was reached, making the system more transparent and trustworthy.

Maintenance and Adaptation Tools

ls: Expert systems may require updates and adjustments over time to incorporate new knowledge or address changing requirements. The expert system shell may include tools for maintaining and adapting the system, allowing knowledge engineers to modify or extend the knowledge base and rules.