Artificial Intelligence

Open Elective

Module 5: Expert Systems CH20

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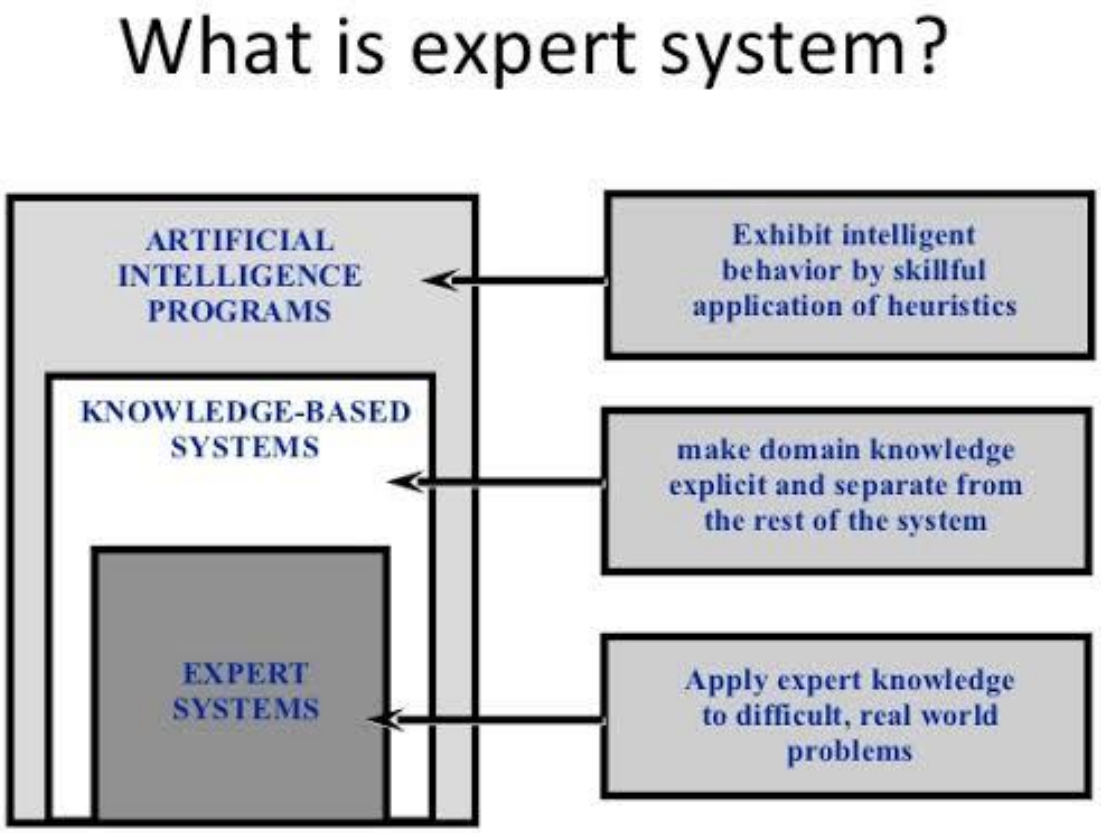
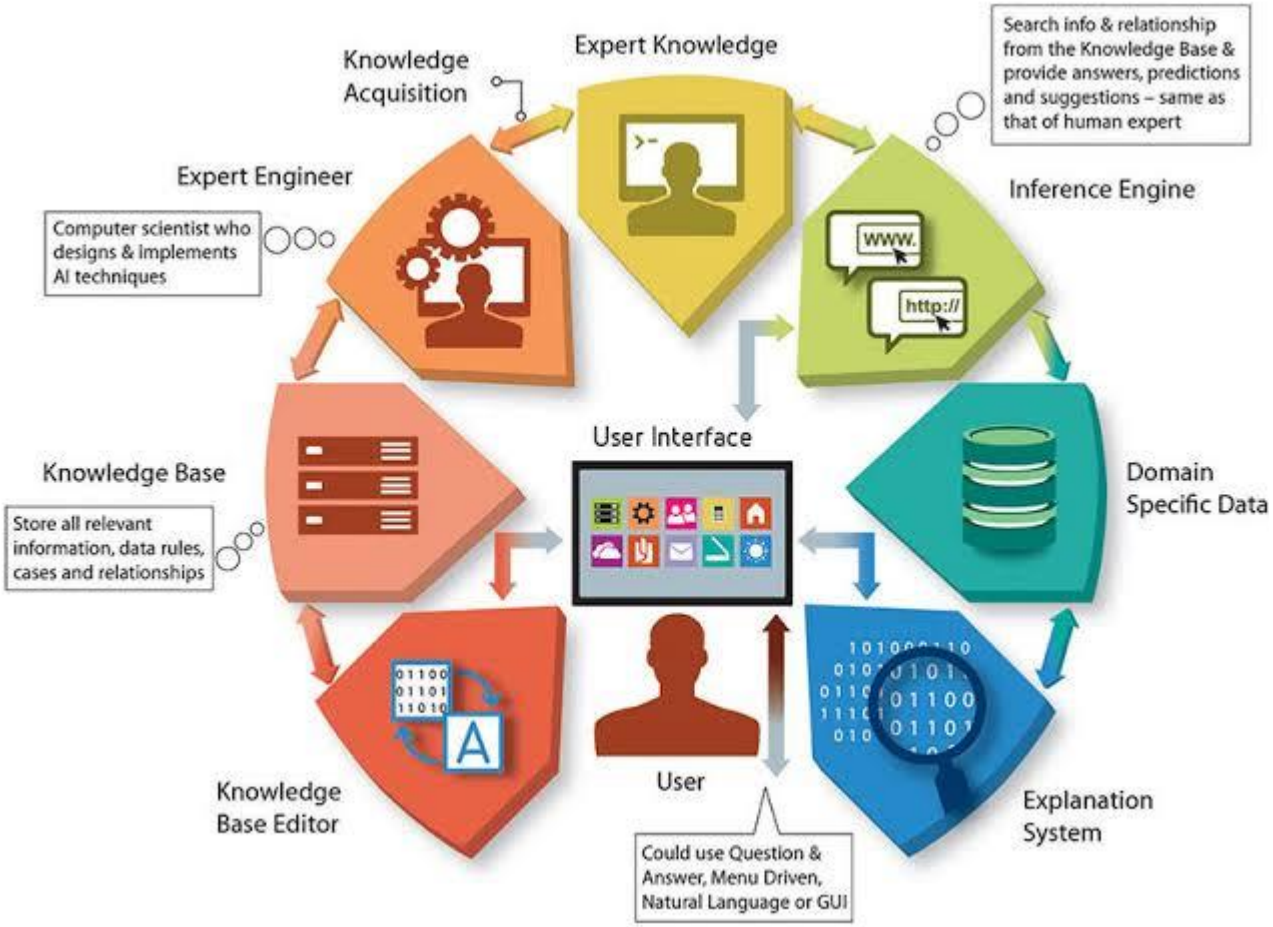
What is an Expert System



What is an Expert System

- An Expert System is defined as an interactive and reliable computer-based decision-making system which uses both facts and heuristics to solve complex decision-making problems.
- It is considered at the highest level of human intelligence and expertise. It is a computer application which solves the most complex issues in a specific domain.
- The expert system can resolve many issues which generally would require a human expert.
- It is based on knowledge acquired from an expert.
- It is also capable of expressing and reasoning about some domain of knowledge.
- Expert systems were the predecessor of the current day artificial intelligence, deep learning and machine learning systems.

Data Flow in Expert Systems



What is Expertise?

- *Expertise:* extensive knowledge in a narrow field
  - Gained by making mistakes
  - Arrive at solutions through logic
  - Logic establishes the True/Falsity of assertions
  - IF-THEN to arrive at conclusions
  - Derive new information from existing to arrive at conclusions
  - Deductions and inference are used to establish how well facts “fit” a scenario
  - Experts use this “information fit” to arrive at their decisions

Information Fit

- ***Known information***
  - John is Sam's son
  - John is the eldest child
  - Mary is Sam's daughter
  - John and Mary's mother is called Anna
  - Sam has been married to Anna for 50 years
- ***Derived information***
  - If John is Sam's son, THEN John must be a boy
  - If Sam and Anna have been married for 50 years, THEN John and Mary are their children by either birth or adoption

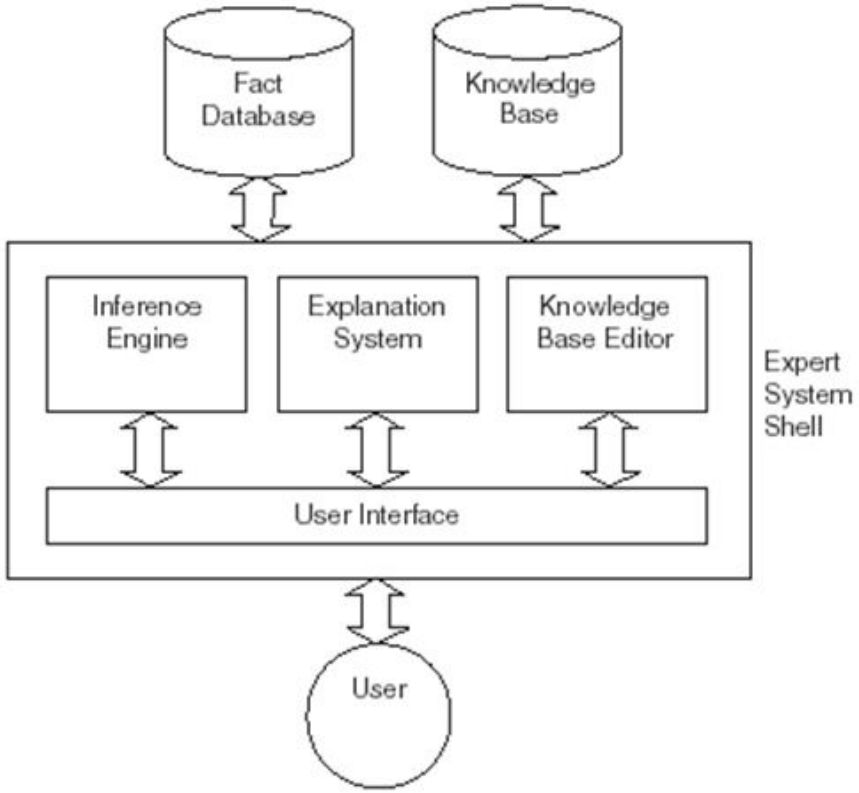
The Basic Structure

- Basic structure of an ES follows the generic structure of a DSS
  - User interface, Knowledge base, inference engine
- The knowledge base is specific to a particular problem domain associated with the ES
- The main difference between an ES and DSS is that the ES contains knowledge acquired from experts in the application domain

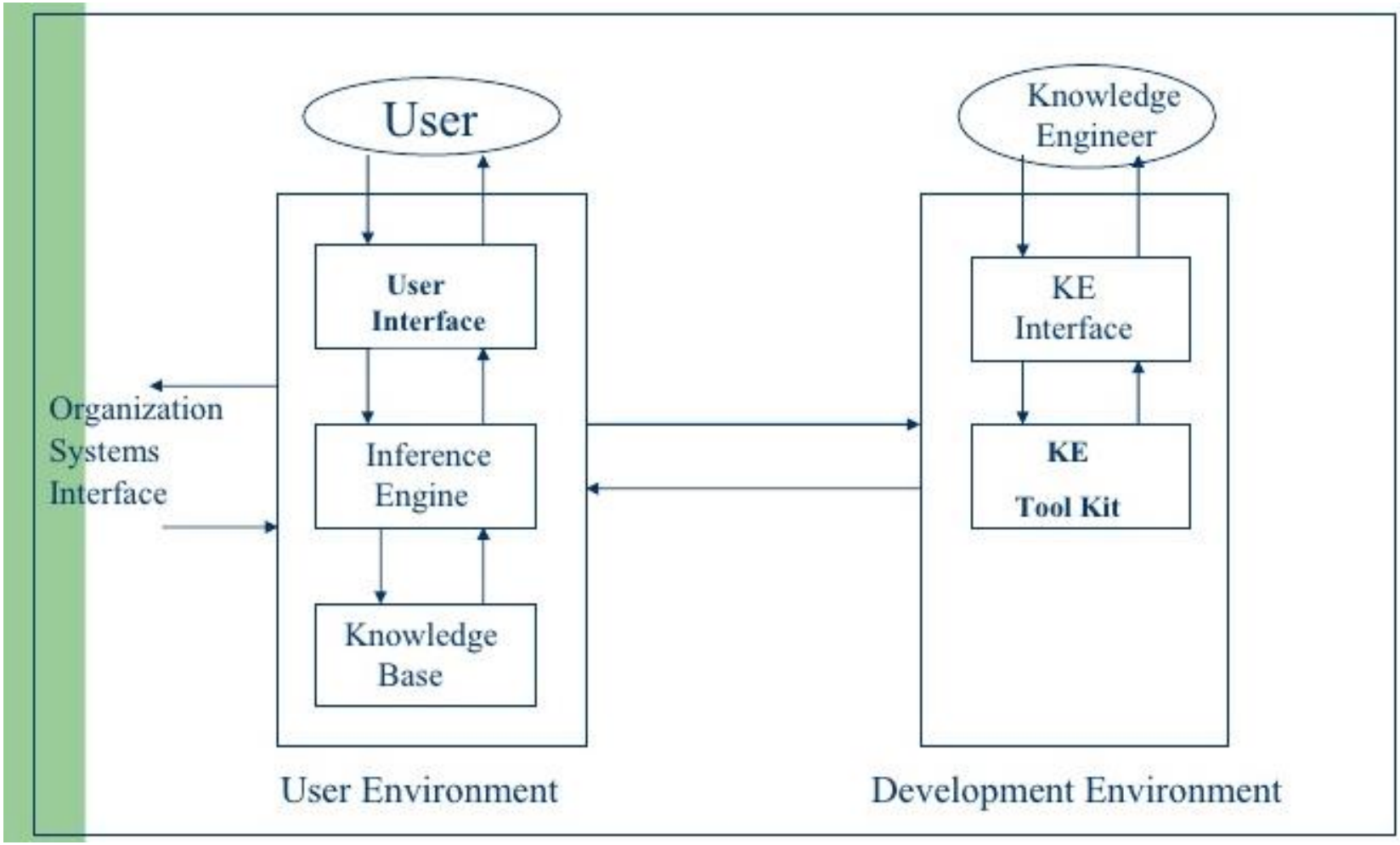
Expert System Architecture

The Architecture of Expert Systems

- An expert system uses expert knowledge derived from human experts to diagnose illnesses, provide recommendations and solve other problems.



Expert System Architecture



Expert System Shells

- Expert System Shells: generic systems that contain reasoning mechanisms but not the problem-specific knowledge
- Early shells were cumbersome but still allowed the user to avoid having to completely program the system from scratch
- Modern shells contain two primary modules: a rule set builder (to construct the initial knowledge base) and an inference engine (as the vehicle for arriving at conclusions)

Expert System Shells

- An Expert system shell is a software development environment. It contains the basic components of expert systems.

- A shell is associated with a prescribed method for building applications by configuring and instantiating these components.

- The generic components of a shell :
  - The knowledge acquisition
  - The knowledge Base
  - The reasoning
  - The explanation
  - The user interface
  - .
- The knowledge base and reasoning engine are the core components.

Expert System Shells

- **Knowledge**
  - A store of factual and heuristic knowledge. Expert system tool provides one or more knowledge representation schemes for expressing knowledge about the application domain. Some tools use both Frames (objects) and IF-THEN rules. In PROLOG the knowledge is represented as logical statements.

- **Reasoning**
  - Inference mechanisms for manipulating the symbolic information and knowledge in the knowledge base form a line of reasoning in solving a problem. The inference mechanism can range from simple modus ponens backward chaining of IF-THEN rules to Case-Based reasoning.

- **Knowledge Acquisition subsystem**
  - A subsystem to help experts in build knowledge bases. However, collecting knowledge, needed to solve problems and build the knowledge base, is the biggest bottleneck in building expert systems.

Expert System Shells

- **Explanation**
  - A subsystem to help experts in build knowledge bases. However, collecting knowledge, needed to solve problems and build the knowledge base, is the biggest bottleneck in building expert systems.

- **User Interface**
  - A means of communication with the user. The user interface is generally not a part of the expert system technology. It was not given much attention in the past. However, the user interface can make a critical difference in the perceived utility of an Expert system.

User Interface

- Design of the UI focuses on human concerns such as ease of use, reliability and reduction of fatigue
  - Critical to its success
  - Balance with storage capacity / hardware constraints
- Design should allow for a variety of methods of interaction (input, control and query)
- UI should allow for a variety of interactive mechanisms:
  - touch screen, keypad, light pens, voice command, hot keys

The Knowledge Base

- Contains the domain-specific knowledge acquired from the domain experts
- Can consist of object descriptions, problem-solving behaviors, constraints, heuristics and uncertainties
- The success of an ES relies on the completeness and accuracy of its knowledge base
  - Distinguish a database (data facts) from a knowledge base (experts' rules, cases, etc)

Knowledge Acquisition

- A knowledge engineer interview a domain expert to elucidate expert knowledge
- This is then translated into rules
- After building initial system, it is iteratively refined until it approximates expert-level performance.
- Process can be automated with support for:
  - Entering knowledge
  - Maintaining KB consistency
  - Ensuring KB completeness
- Problem paradigms are typically diagnosis, design etc

Knowledge Acquisition

- **MOLE: cover and differentiate**
  - **knowledge acquisition system for heuristic classification problems like diagnosis**
  - **An expert system produced by MOLE performs the following as an iterative process:**
    - ✓ **Accepts input data**
    - ✓ **Comes up with a set of candidate explanations and classifications that cover the data**
    - ✓ **Uses differentiating knowledge to determine which classification is the best.**
  - **MOLE interacts with domain expert to produce a knowledge base that a system called MOLE-p (MOLE performance) uses to solve problems.**
  - **To use MOLE, it must be possible to pre-enumerate solutions or classifications.**
  - **We should be able to encode the knowledge in terms of covering and differentiating.**

Knowledge Acquisition

- **SALT: propose and revise**
  - **Incremental design and building of systems**
  - **Operations**
    - ✓ **System proposes an extension to current design**
    - ✓ **Checks whether the extension violates any global or local constraints**
    - ✓ **Fix constraint violations and repeat the process**
  - **Provides mechanisms for elucidating global and local constraints related knowledge from the expert.**
  - **Builds a dependency network while conversing with the expert.**
  - **Each node stands for a value of parameter that must be acquired or generated.**

Knowledge Acquisition

- **SALT: propose and revise**
  - **Three types of links in dependencies:**
    - ✓ **Contributes to: procedures that allow SALT to generate a value for one parameter based on the value of another.**
    - ✓ **Constrains: rules out certain parameter values**
    - ✓ **Suggests-revisions of : points to ways in which constraint violation can be fixed.**
  - **Control knowledge: propose extensions and revisions that lead toward a design solution.**
  - **SALT compiles its dependency network into a set of production rules.**
  - **An expert can watch the production system solve problems and can override the system's decision.**

The Inference Engine

- Here, the knowledge is put to use to produce solutions
- The engine is capable of performing deduction or inference based on rules or facts
- Also capable of using inexact or fuzzy reasoning based on probability or pattern matching
- Cycle consists of:
  1. Match rules with given facts
  2. Select the rule that is to be executed
  3. Execute the rule by adding the deduced fact to the working memory

The Expert System Examples

Following are examples of Expert Systems:

MYCIN: It was based on backward chaining and could identify various bacteria that could cause acute infections. It could also recommend drugs based on the patient's weight.

DENDRAL: Expert system used for chemical analysis to predict molecular structure.

PXDES: Expert system used to predict the degree and type of lung cancer

CaDet: Expert system that could identify cancer at early stages

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The Expert System Characteristics

Following are Important characteristic of Expert System:

The Highest Level of Expertise: The expert system offers the highest level of expertise. It provides efficiency, accuracy and imaginative problem-solving.

Right on Time Reaction: An Expert System interacts in a very reasonable period of time with the user. The total time must be less than the time taken by an expert to get the most accurate solution for the same problem.

Good Reliability: The expert system needs to be reliable, and it must not make any a mistake.

Flexible: It is vital that it remains flexible as it the is possessed by an Expert system.

Effective Mechanism: Expert System must have an efficient mechanism to administer the compilation of the existing knowledge in it.

Capable of handling challenging decision & problems: An expert system is capable of handling challenging decision problems and delivering solutions.

The Expert System Participants

Participant	Role
Domain Expert	He is a person or group whose expertise and knowledge is taken to develop an expert system.
Knowledge Engineer	Knowledge engineer is a technical person who integrates knowledge into computer systems.
End User	It is a person or group of people who are using the expert system to get to get advice which will not be provided by the expert.

Conventional Vs Expert Systems

Conventional System	Expert System
Knowledge and processing are combined in one unit.	Knowledge database and the processing mechanism are two separate components.
The programme does not make errors (Unless error in programming).	The Expert System may make a mistake.
The system is operational only when fully developed.	The expert system is optimized on an ongoing basis and can be launched with a small number of rules.
Step by step execution according to fixed algorithms is required.	Execution is done logically & heuristically.
It needs full information.	It can be functional with sufficient or insufficient information.

Human Vs Expert Systems

Human Expert	Artificial Expertise
Perishable	Permanent
Difficult to Transfer	Transferable
Difficult to Document	Easy to Document
Unpredictable	Consistent
Expensive	Cost effective System

Benefits of Expert Systems

- It improves the decision quality
- Cuts the expense of consulting experts for problem-solving
- It provides fast and efficient solutions to problems in a narrow area of specialization.
- It can gather scarce expertise and used it efficiently.
- Offers consistent answer for the repetitive problem
- Maintains a significant level of information
- Helps you to get fast and accurate answers
- A proper explanation of decision making
- Ability to solve complex and challenging issues
- Expert Systems can work steadily work without getting emotional, tensed or fatigued.

Limitations of Expert Systems

- Unable to make a creative response in an extraordinary situation
- Errors in the knowledge base can lead to wrong decision
- The maintenance cost of an expert system is too expensive
- Each problem is different therefore the solution from a human expert can also be different and more creative

Applications of Expert Systems

- Information management
- Hospitals and medical facilities
- Help desks management
- Employee performance evaluation
- Loan analysis
- Virus detection
- Useful for repair and maintenance projects
- Warehouse optimization
- Planning and scheduling
- The configuration of manufactured objects
- Financial decision making Knowledge publishing
- Process monitoring and control
- Supervise the operation of the plant and controller
- Stock market trading
- Airline scheduling & cargo schedules