Unit-05: Expert Systems

Artificial Intelligence

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Where are we ?

Introduction

What is an Expert System ?

i. An expert system is computer software program that exhibits intelligent behavior and also that attempts to act like a human expert on a particular subject area
ii. It in-corporates the concepts and methods of symbolic inference reasoning and the use of knowledge for making these inferences.
iii. Expert systems also called as knowledge based expert system.
iv. Expert systems are often used to advise non-experts in situations where a human expert in unavailable (for example it may be too expensive to employ a human expert, or it might be a difficult to reach location).

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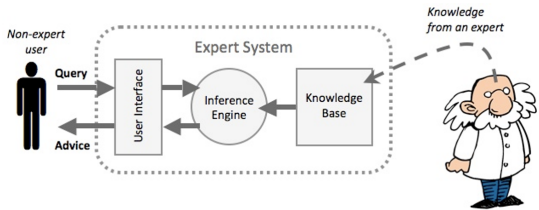
How Do Expert Systems work ?

An expert system is made up of three parts:

I. A user interface - This is the system that allows a non-expert user to query (question) the expert system, and to receive advice. The user-interface is designed to be a simple to use as possible.

II. A knowledge base - This is a collection of facts and rules. The knowledge base is created from information provided by human experts

III. An inference engine - This acts rather like a search engine, examining the knowledge base for information that matches the user's query



Where are we ?

Where are Expert Systems Used ?

i. Medical diagnosis (the knowledge base would contain medical information, the symptoms of the patient would be used as the query, and the advice would be a diagnose of the patient's illness)
ii. Playing strategy games like chess against a computer (the knowledge base would contain strategies and moves, the player's moves would be used as the query, and the output would be the computer's 'expert' moves)
iii. Providing financial advice - whether to invest in a business, etc. (the knowledge base would contain data about the performance of financial markets and businesses in the past)
iv. Helping to identify items such as plants / animals / rocks / etc. (the knowledge base would contain characteristics of every item, the details of an unknown item would be used as the query, and the advice would be a likely identification)
v. Helping to discover locations to drill for water / oil (the knowledge base would contain characteristics of likely rock formations where oil / water could be found, the details of a particular location would be used as the query, and the advice would be the likelihood of finding oil / water there)

Phases in building Expert System

There are different interdependent and overlapping phases in building an expert system as follows:

I. Identification Phase:
- Knowledge engineer finds out important features of the problem with the help of domain expert (human)
- He tries to determine the type and scope of the problem, the kind of resources requried, goal and objectives of the ES

II. Conceptualization Phase:
- In this phase, knowledge engineer and domain expert decide the concepts, relations and control mechanism needed to describe a problem solving

III. Formalization Phase:
- It involves expressing the key concepts and relations in some framework supported by ES building tools
- Formalized knowledge consists of data structures, inference rules, control strategies and languages for implementation

IV. Implementation Phase:
- During this phase, formalized knowledge is converted to working computer program initially called prototype of the whole system

V. Testing Phase:
- It involves evaluating the performance and utility of prototype systems and revising it if need be
- Domain expert evaluates the prototype system and his feedback help knowledge engineer to revise it

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Knowledge Engineering

i. The process of gathering knowledge from a domain expert and codifying it according to the formalism is called knowledge engineering
ii. The tasks and responsibilities of a knowledge engineering involve the following:
   - Ensuring that the computer has all the knowledge needed to solve a problem
   - Choosing one or more forms to represent the required knowledge.
   - Ensuring that the computer can use the knowledge efficiently by selecting some of the reasoning methods.

Interaction between Knowledge engineer and domain expert for creating an ES

i. The main role in knowledge engineer begins only once the problem of some domain for developing an ES is decided. The job of the knowledge engineer involves close collaboration with the domain expert and end user.

ii. The next step of the process involves a more systematic interviewing of the expert. The knowledge engineer will then extract general rules from the discussion and interview held with expert and get them checked by the expert for correctness.

iii. The domain knowledge consisting of both formal, textbook knowledge and experiential knowledge is entered into the program piece by piece

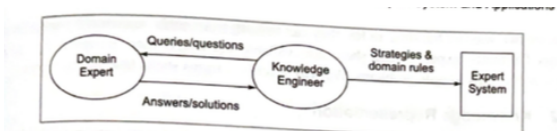

Figure 8.1 Interaction between Knowledge Engineer and Domain Expert for Creating an ES

Expert System Architecture

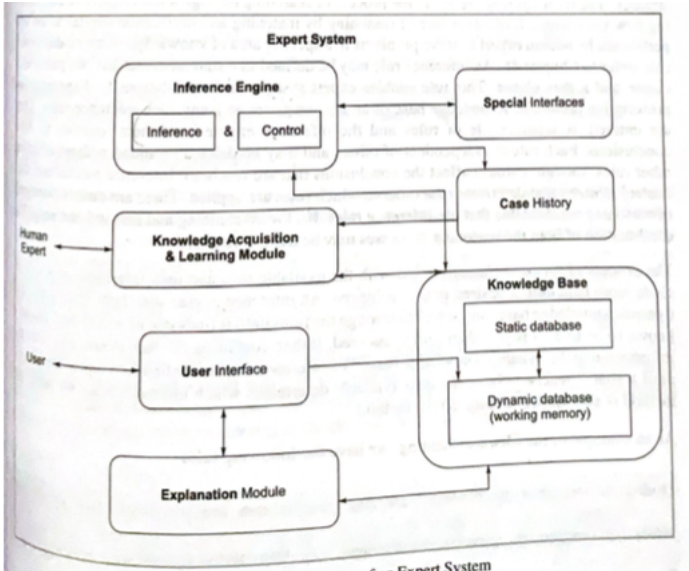

Figure 8.2 Architecture of an Expert System

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Knowledge Base

i. KB consists of knowledge about the problem domain in the form of static and dynamic databases
ii. Static knowledge consists of
    - Rules and facts which is complied as a part of the system and does not change during execution of the system
iii. Dynamic knowledge consists of facts related to a particular consultation of the system
    - At the beginning of the consultation, the dynamic knowledge base often called working memory is empty
    - As a consultation progresses, dynamic knowledge base grows and is used along with static knowledge in decision making
iv. Working memory is deleted at the end of consultation of the system

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Inference Engine

i. It consists of inference mechanism and control strategy
ii. Inference means search through knowledge base and derive new knowledge
iii. It involve formal reasoning involving matching and unification similar to the one performed by human expert to solve problems in a specific area of knowledge
iv. Inference operates by using modus ponen rule
v. Control strategy determines the order in which rules are applied
vi. There are mainly two types of control mechanism viz., forward chaining and backward chaining

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Knowledge Acquisition

i. Knowledge acquisition module allows system to acquire knowledge for ES
   - text books, reports, case studies,
   - empirical data and
   - domain expert experience

ii. Updation of knowledge can be done using knowledge acquisition module of the system
   - insertion,
   - deletion and
   - updation of existing knowledge

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Case History

i. Case History stores the file created by inference engine using the dynamic database created at the time of consultation
ii. Useful for learning module to enrich its knowledge base
iii. Different cases with solutions are stored in Case Base system
iv. Tese cases are used for solving problem using Case Base Reasoning (CBR)

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User Interfaces

- Allows user to communicate with system in interactive mode and helps system to create working knowledge for the problem to be solved

Table 8.1 Dialogue Module of a User Interface

System	Do you have fever?
User	Yes
System	Do you have sore throat?
User	No
System	Do you have cough?
User	Yes
System	Are you suffering from running nose?
User	Yes
System	Are you suffering from headache?
User	No

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Explanation module

i. Most expert systems have explantion facilities that allow the user to ask the system **why** it asked some question, and **how** it reached to conclusion
ii. It contains **'How'** and **'Why'** modules attached to it
    - The sub-module **'How'** telss the user about the process through which system has reached to a particular solution
    - **'Why'** sub-module tells that why is that particular solution offered
iii. It explains user about the reasoning behind any particular problem solution
iv. Questions are answered by referring to the system goals, the rules being used, and any existing problem data

Invoke	Why/How modules
System	Do you have running nose?
User	Yes
System	I am trying to prove that you have cold. Do you have headache?
User	Yes
System	Do you have sore throat?
User	No
System	Then you do not have cold. Do you have fever?
User	Yes
System	Now I am looking at the possibility of measles. Do you have cough?
User	Yes
System	I can infer measles using the rule "If symptoms are fever, cough, running_nose, then patient has measles". Measles is concluded.
User	**How?**
System	Since you have fever, running_nose, and cough and there is a rule "If symptoms are fever, cough, running_nose, then patient has measles". So, measles is concluded for you.

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Special Interfaces

i. It may be used for specialized activities such as handling uncertainty in knowledge
ii. This is a major area of expert systems research that involves methods for reasoning with uncertain data and uncertain knowledge
iii. Knowledge is generally incomplete and uncertain
iv. To deal with uncertain knowledge, a rule may have associated with it a **confidence factor** or a weight
v. The set of methods for using uncertain knowledge in combination with uncertain data in the reasoning process is called **reasoning with uncertainty**

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Traditional System vs Expert Systems

Conventional Systems	Expert Systems
Information and processing combined in a single sequential program	Knowledge base separate from the mechanism processing (inference)
The program is never wrong	The program could have made a mistake
Need all the input data	Not necessarily need all inputs data or facts
Changes to the program inconvenient	Changes in the rules can be made with ease
The system works if it is complete	The system can work only with the rules a little
Efficiency is the main objective	Effectiveness is the main objective
Quantitative data	Qualitative data
Representation of data is numerical	Representation symbols

Characteristics of Expert Systems

i. The highest level of expertise
ii. Right on time reaction
iii. Accepting the incorrect reasoning
iv. Good reliability
v. Easily understood
vi. Flexible
vii. Symbolic reasoning
viii. Heuristic reasoning
ix. Making mistakes
x. Expanding with tolerable difficulties

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Advantages of Expert System

i. Helps in preservation scarce expertise
ii. Provides consistent answers for repetitive decisions process and tasks.
iii. Fastens the pace of human professional or semi-professional work
iv. Holds and maintains significant levels of information.
v. Provides improved quality of decision making
vi. Domain experts are not always able to explain their logic and reasoning unlike ES
vii. Encourages organizations to clarify the logic of decision making
viii. Leads to major internal cost savings within companies
ix. Causes introduction of new products
x. Never forgets to ask questions, unlike human.

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Disadvantages of Expert System

i. Unable to make creative response as human experts would in unusual circumstances.
ii. Lacks common sense needed in some decision making.
iii. May cause errors in the knowledge base, and lead to wrong decisions.
iv. Cannot adapt to changing environments. Unless knowledge base in changed

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List of Shells and Tools

I. Acquire: It is primarily a knowledge-acquisition system and ES shell. Which provides a complete development environment for the building and maintenance of knowledge-based application.

II. MYCIN: MYCIN was an early backward chaining expert system that used artificial intelligence to identify bacteria causing severe infections, such as bacteremia and meningitis, and to recommend antibiotics, with the dosage adjusted for patient's body weight — the name derived from the antibiotics themselves, as many antibiotics have the suffix "-mycin".

- The Mycin system was also used for the diagnosis of blood clotting diseases. MYCIN was developed over five or six years in the early 1970s at Stanford University.

Text Books

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Third Edition, The McGraw Hill Publications, 2009.

[3] G. F. Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*.
Sixth Edition, Pearson Education, 2009.

[4] S. Kaushik, *Artificial Intelligence*.
Cengage Learning, 2016.

Thank you