Basics Of Artificial Intelligence

Case Study on an Expert System

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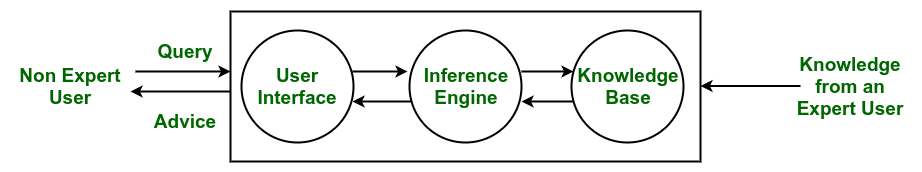
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**Expert System**

An expert system is an 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.

The data in the knowledge base is added by humans that are expert 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.

**Components of 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 -
  + 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.
* Explanation Module -
  + This module helps the expert system to give the user an explanation about how the expert system reached a particular conclusion.

**DENDRAL**

It was an influential pioneer project in artificial intelligence (AI) of the 1960s, and the computer software expert system that it produced. Its primary aim was to study hypothesis formation and discovery in science. For that, a specific task in science was chosen: help organic chemists in identifying unknown organic molecules, by analyzing their mass spectra and using knowledge of chemistry. It was done at Stanford University by Edward Feigenbaum, Bruce G. Buchanan, Joshua Lederberg, and Carl Djerassi, along with a team of highly creative research associates and students. It began in 1965 and spans approximately half the history of AI research .The software program Dendral is considered the first expert system because it automated the decision-making process and problem-solving behavior of organic chemists. The DENDRAL project is a good example of the rising innovation

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| |  |  | | --- | --- | | **Domain** | Organic chemistry – mass spectrometry | | **Task** | To identify molecular structure of unknown compounds from mass spectra data | | **Input** | Histogram giving mass numbers | | **Output** | Description of structure of the compound | | **Architecture** | Plan-generate-test with constrained heuristic search | |

DENDRAL stands for DENDRitic Algorithm. It is a procedure for thoroughly and non-repetitively specifying all the topologically distinct arrangements of any given set of atoms, as per the rules of chemical valence.

The project consisted of research on two main programs Heuristic Dendral and Meta-Dendral and several sub-programs. It was written in the Lisp programming language, which was considered the language of AI because of its flexibilty

**Heuristic Dendral -**

Heuristic Dendral is a program that uses mass spectra or other experimental data together with a knowledge base of chemistry to produce a set of possible chemical structures that may be responsible for producing the data.

A mass spectrum of a compound is produced by a mass spectrometer, and is used to determine its molecular weight.

For example, the compound water (H2O), has a molecular weight of 18 since hydrogen has a mass of 1.01 and oxygen 16.00, and its mass spectrum has a peak at 18 units. Heuristic Dendral would use this input mass and the knowledge of atomic mass numbers and valence rules, to determine the possible combinations of atomic constituents whose mass would add up to 18.

As the weight increases and the molecules become more complex, the number of possible compounds increases drastically. Thus, a program that is able to reduce this number of candidate solutions through the process of hypothesis formation is essential.

**Meta Dendral -**

Meta-Dendral is a machine learning system that receives the set of possible chemical structures and corresponding mass spectra as input, and proposes a set of rules of mass spectrometry that correlate structural features with processes that produce the mass spectrum. These rules would be fed back to Heuristic Dendral (in the planning and testing programs described below) to test their applicability.

Thus, **Heuristic Dendral** is a performance system and **Meta-Dendral** is a learning system.

The program is based on two important features -

* The plan-generate-test paradigm
* Knowledge Engineering

**The plan-generate-test paradigm -**

The plan-generate-test paradigm is the basic organization of the problem-solving method, and is a common paradigm used by both Heuristic Dendral and Meta-Dendral systems.

The **generator** (later named CONGEN) generates potential solutions for a particular problem, which are then expressed as chemical graphs in Dendral. However, this is feasible only when the number of candidate solutions is minimal.

When there are large numbers of possible solutions, Dendral has to find a way to put constraints that rules out large sets of candidate solutions.

This is the primary aim of Dendral **planner**, which is a “hypothesis-formation” program that employs “task-specific knowledge to find constraints for the generator”.

Last but not least, the **tester** analyzes each proposed candidate solution and discards those that fail to fulfill certain criteria. This mechanism of plan-generate-test paradigm is what holds Dendral together.

**Knowledge Engineering -**

The primary aim of knowledge engineering is to attain a productive interaction between the available knowledge base and problem solving techniques. This is possible through development of a procedure in which large amounts of task-specific information is encoded into heuristic programs. Thus, the first essential component of knowledge engineering is a large “knowledge base.” Dendral has specific knowledge about the mass spectrometry technique, a large amount of information that forms the basis of chemistry and graph theory, and information that might be helpful in finding the solution of a particular chemical structure elucidation problem. (the process of determination of the structure of a compound.)

This “knowledge base” is used both to search for possible chemical structures that match the input data, and to learn new “general rules” that help prune searches. The benefit Dendral provides the end user, even a non-expert, is a minimized set of possible solutions to check manually.

**Conclusion:**

We have identified and discussed the Expert Systems with its architecture and case study of its first success- DENDRAL. Expert System can be an extremely valuable extension of Artificial Intelligence. It can provide tremendous commercial applications in the field of medicine, agriculture, education, business accounting, legal systems, nuclear industry, and weather prediction and so on.

As a first success, DENDRAL became the stepping stone in the field of Expert System. In the future, scientists all over the world are expecting advanced developments in the field of Expert System in commercial as well as personal territories, which is the need of the hour.