Knowledge representation in Artificial Intelligence and structure of expert system with inference rules

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Abstract - Knowledge representation and reasoning are very important parts of an expert system as well as artificial intelligence. Knowledge is based on facts and rules, which we can accumulate through education and experience. Humans understand and interpret knowledge easily. Reasoning all about the processing of knowledge. Expert systems are designed as human experts to make decisions and solve complex problems in any specific field. If we represent the knowledge in a wrong way, then the machine will also produce incorrect output. In knowledge representation, there are some components that help to make expert systems inference engine, knowledge base, and user interface. Basically, the inference engine and knowledge bases work in the backend of an expert system. The inference engine is set of rules and according to these rules, users can easily extract knowledge from the knowledge base. In this paper, we discuss why knowledge representation is so important, various components and methods. This paper will describe the use of inference rules in knowledge with examples such as college final examination of different methods (Logic, Semantic Nets, Frames Structures and Scripts). In logic, we will discuss propositional and predicate logic.

KEYWORDS: Knowledge Representation, Expert system, Inference engine/Inference Rules, Propositional Logic, Predicate logic, Semantic Nets, Frames, Scripts.

I. INTRODUCTION

Knowledge Representation(KR)

Knowledge representation is one of the important concepts of an expert system and the expert system of artificial intelligence. The expert system is a type of computer program designed to make decisions and solve complex and computational problems in specific areas such as health, games, banking sector, virus detection(COVID-19), airline and marketing. The first expert system was developed in 1965 by Edward Feigenbaum and Joshua Lederberg of Stanford University in California, USA[Islam ET AL., (2015)]. The knowledge representation is way to organize the knowledge in such a manner so that extract knowledge from its knowledge base by using inference rules and reasoning according to the user needs.

Expert system

Expert system can be a system, program, computer or robot, which is designed for specific field or a particular area like for medical health, entertainment, factory/ organization etc and they perform particular task according to the user needs. It gives us expert advise[Durgaprashad, eta al., (2021)].A simple example grammar checker or spelling checker is a expert system. Another example of expert system, suppose we need to check the blood pressure or sugar level of the user at that time we can use the expert system because it will give us expert result. Nowadays expert system is available in user's smartphone.[Durgaprashad, eta al., (2021)]

Characteristics of Expert System

(1) Ease to understand, (2) Highly responsive (3) Very Flexible (3) Produce accurate results (4) Reliable
(5) Security[7][8]

Applications of Expert System

Broadly, there are so many applications of expert system, which are given: (1)Financial, (2)Law, (3)Medical, (4)Agriculture, (5)Transportation, (6)Mechanical Engineering, (7)Tele-Communication[8]

There are so many components of expert system which are used to make the structure of expert system. These components are: Inference engine, Knowledge base(Database) and user-interface.[Durgaprashad, eta al., (2021)] Let's understand the components of Expert system structure using the diagram which is given below:

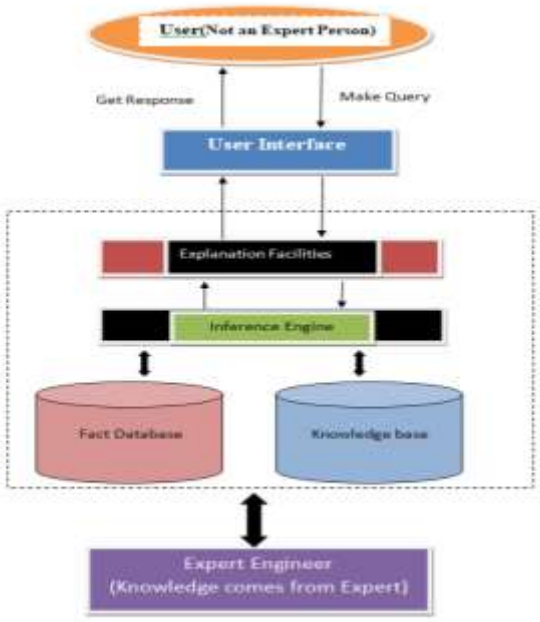

Fig.1.0 Structure of Expert System

User(Non Expert Person)

In the above mentioned diagram fig 1.0, first component is User. Users have no knowledge about the inference rules or anything about the expert system. A user interacts with expert system with the help of user interface. It will helps in many tasks of user. It will give best result according to users need[Durgaprashad, eta al., (2021)].

Users make query and get responses from the expert system. For example, user needs to ask about his health issues. Expert system will observe the problem and get the solution from the knowledge base. Here, expert system works as expert doctor which one suggests us best solution. For this kind of problem, expert system can use the sensors so that observe the problem like Blood Pressure, heart disease and diabetes etc with the better way and give the best advice.[Durgaprashad, eta al., (2021)]

User Interface(UI)

In the above mentioned diagram, second component is User Interface. Basically, user interface helps users so that they can interact with expert system. There will be use the front-end languages such as HTML, CSS, JavaScript, XML. These are only used for the designing of the user interface But for the backend, we are mostly used Python because of the rich library or package. These packages help to make the better expert system. User only interacts with the User Interface[Edward et al., (2020)]. There will be three types of interface- Graphical User interface, Command line interface and Form based interface. There will be widely used two general-purpose

and symbol manipulation programming language such as PROLOG and LISP, or there will two problem-oriented programming languages such as FORTRAN and PASCAL.

II. EXPLANATION FACILITIES

In the above mentioned diagram, third component is Explanation facilities.A component which provides the explanation of the question why is it asked and how to reach the solution to the user. Basically, it helps to understand the meaning of the question asked. According the question which rule will be applied on this and what will be the result or conclusions. So this is also most important component of the expert system. This is also helps to generate the report[Edward et al., (2020)]. Here, we are using the backend programming languages such as Python and Java. If we need to make the login of the user then we can easily create. But we need the database for the users so that we can store the all data of the user. It works like human mind.[Edward et al., (2020)]

Inference engine

Inference is intelligent computer program which create the new logic from the old logic. There are so many predefined rules. Inference Engine is a piece of software or program which uses the knowledge base and database to make the decisions or give the advice according the areas such as account, games, medical diagnosis and grammar checker etc. Main work of the inference engine is acquiring the information from the knowledge base and fact database. It applies the best rule for the given problem and produces the results. At the time of calculation of the conclusions of the problem, If there is need of information of the user then we can get from the database but if we want knowledge regarding problem we can get from the knowledge base[Napela et al., 2016].

There are so many agents with help of the agents; we can easily diagnosis the problem. The Agents can have minds or we can say mental properties because they sense the environment from the sensor and act in the environment with the help of actuators. There is a circle of agent. Here we have some phases of circle which are given below. Let's understand them one by one with example:

1. Preceiving/Sensing: With the help of sensors, we can sense the environment and send the report to the electronic machine. Let's take one example of weather forecasting. There are so many sensors are using for weather forecasting which are hygrometer, thermometer, pressure sensor, anemometer, rain gauge and wind vane. It is very important because it's take input through the sensors. Without input expert system can't work[Davenport et al., 2020].

2. Understanding/Controlling: In this phase, we are using actuators, it converts energy into motion. It is actually controlling system. How it will work and move. For example, every human having brains, so brains work as actuators [Davenport et al., 2020]. Brain is controlling body of human. Another example, gears also work as actuators. It is working as a processor in the computer.

3. Acting/Effecting: With the help of effectors, agents can give their output or effect in the environment. Effectors can be anything who gives us the output. For example, Monitor is also give us output. Another example is human arms and legs.

Types of Agents:

1. **Software agent:** They have own files contents, keystrokes and sensory inputs. For example we want to check the spelling or grammar mistakes in the given inputs. There are so many software are available for this one of the simplest is Ms.word and most popular online AI which is **Trinka.ai**[Napela et al., 2016].
2. **Robot Agent:** Robot agents having camera, infrared range finder, biometrics and microphone(NLP), with the help these we can do so many things. For example we are camera in the mobile phone. Another one GPS, with this we can get info of the location. Now we having new mobile app which is GPS Map camera, it is taking picture with date, time and location[Napela et al., 2016].
3. **Human Agent:** Nose, ear, eyes and other organs of human works as a sensors and legs,arms works as effectors. For example, we having any injury on hands, that injury see from eyes and brain send the messages to the hand to do something so that injury can heal[Napela et al., 2016].

III. FACT DATABASE

Fact database is a component of the expert system. Database is a structured set of data which is stored in the computer. Fact is all about the universal truths, and they apply according to the current situations. We have set of observations which are applied according to current situations. This is machine-readable. In this we are using both data old and current[Napela et al., 2016].

Knowledge Base

It is same as the fact database but in this we apply rules of inference and according to these rules we can get the output. These rules are defined by the expert(Intelligent) person. Inference engines take the input from the user and get the information from fact database and knowledge base. According to those input it apply the best suitable rule to the condition and send the output to the explanatory system and this system show the output on the user interface[Abbot et al., 2020]. So, knowledge base performs the very important role in the expert system because it helps to solve the complex computation in very less time. We have inference rules which are given below. Let's understand them one by one:

1. **ModusPonens:** This is most important rule of the inference engine. Here we have two statements A and B. If A →B and A is true then B will be true.

   Example:
   Statement-I(A →B) If I want to buy some cloths then I go to the shopping mall.
   Statement-II(A)I want to buy some cloths.
   Statement-III(B) I go to the shopping mall.
   Explanation: If Statement-I(A →B) and Statement-II both are two then Statement-III will also be true.

2. **Modus Tollens:** In this we have two statements one is A and another one is B. This rules tells if A →B and ¬B statements are true then ¬A will also true.

   Example:
   Statement-I(A →B) If I want to buy some cloths then I go to the shopping mall.
   Statement-II(¬B) I do not go to the shopping mall.
   Statement-III(¬A)I do not want to buy some cloths.
   Explanation: If Statement-I(A →B) and Statement-II both are two then Statement-III will also be true.

3. **Hypothetical Syllogism:** In this we have three statements A, B, C. It states that if A →B is true and B →C is true then A →C will be true.

   Example:
   Statement-I(A →B) If you have admit card then you can sit in the examination.
   Statement-II(B →C) If you can sit in the examination then you can give your exam.
   Statement-III(A →C) If you have admit card then you can give your examination.

4. **Disjunctive Syllogism:** This rule states that if A∨ B and ¬A will true then B will also be true.

   Example:
   Statement-I(A∨ B): This month is August or September.
   Statement-II(¬A): This month is not August.
   Statement-III(B): This month is September.

5. **Addition:** This rule is very basic and common rule of inference. This rule tells If A is true, then A∨ B will be true.

Example:
Statement-I(A): I have Chocolates.
Statement-II(B): I have Candies.
Statement-III(A∨ B): I have Chocolates or Candies.

6. **Simplification:** This is also important rule. This rule tells if A∧B is true, then A or B will be also true.

   Example:
   Statement-I(A∧ B): I have Chocolates and Candies.
   Statement-II(A): I have Chocolates.
   Statement-II(B): I have Candies.

7. **Resolution:** This is also important and common rule. This rule tells if A∨ B and ¬A∧C is true, then B∨ C.

   Example:
   Statement-I(A∨ B): This month is August or September.
   Statement-II(¬A∧ C): This month is not August and this month is October.
   Statement-III(B∨ C): This month is September or October.

Expert Person

This person can be computer or human, but that one expert in his own specialized field. But mostly human expert preferred, and all over success of the expert system depends on the expert person or we can say depend of accuracy of expert.

Methods of knowledge representation

There are so many methods of Knowledge Representation and each method having their own qualities. Let's understand them one by one.

LOGIC

Logic made with two things one is syntax which is used to define the structure and second is semantic which is used to define the meaning of each sentence or statement in their own possible world. Possible world is just like the model from which world that sentence belong. For example, when user defines a relation between the siblings then that sentence belongs to the family relationship, so here model apply parent and child relationship. There are two types of logic: Proposition Logic and Predicate Logic.[Agrawal et al., 2019]

Proposition Logic

It is an important type of logic, where all the statements either true or false but not both. All the statements which come under true or false are proposition logic. Proposition logic is like Boolean logic because it takes produce output 0 or 1. Here 0 for false and 1 for true, but we can't be define in both. These types of statement are both mathematical and logical[Agrawal et al., 2019].

We have two types of proposition sentence which are simple and complex sentences. Simple sentences are also called atomic sentences. In the simple sentence, there is only one statement. For example, "**Today is very rainy**". This is simple sentence. Complex sentences are also called compound sentences. In the complex statement, we have two or more statements. For example, "**I have vanilla ice-cream and chocolate ice-cream". Here, All and Some word are not used in proposition logic**

Here are some rules of proposition logic:

- It is just like the Boolean logic because it takes 0 or 1 value.

- We can connect two or more sentences with logical connectives.
- If proposition logic or formula always true then that logic is called tautology.
- If proposition logic or formula always false then that logic is called contradiction.
- This proposition logic consists of a functions and object. For example "**Rita is ram's Sister**". Here Rita and Ram is object and relation is Sister.
- Any Question or opinion sentence is not proposition. For example "**I think this is good.**" This is opinion so this is not a proposition sentence.

Let's understand them with example:

- Today is Wednesday.
- 2+2=4.
- This month is august.

Predicate Logic

It is also called first order logic. In this we are using "some" and "all" sentences. In this, we are not talking about the truth and false value. Those sentences which are not come in the proposition logic, that all come under the first order logic(FOL). For example, "Some students are intelligent." This statement not comes under the proposition logic.

Semantic nets

We are making the small-small nets. Basically it is a graphically representation of first order logic sentences. It is very easy to understand. This is basically consists of object and arcs. Semantic nets can be easily extended. This is representing the relation between the things or entity in graphically way.[Nalepa et al., 2016]

Scripts

It describes the sequence of steps of an event. For example, users are talking with Google assistant in natural language. There are two ways one is speech, another is written text. Scripts are basically described the step under the some circumstances[Nalepa et al., 2016]. For example, one student is going to give the paper. There can be happens so many events before exam, during examination and after examination. There are so many components of events, which are before, during and after events:

- **Starting condition:** It is happens before the events or we can say at the starting of the event. For example, firstly check the admit card and I-card.
- **Condition Apply:** if the condition will be true then events can be occurred. For example, if student having I-card then student can enter in the examination hall.
- **Props:** All the objects come under props. For example, I-Card and Admit card.
- **Actors:** All the participants of the events are the actors. For example, Student, invigilator, Checker. Some participants are active and some are passive.
- **Track:** Tracks are the variations of the script. All the different components are sharing track according to the events occurring.
- **Scenes:** Scenes are the sequence of steps of the events. For example, according this example we have various events.

1. First check the admit card and I-card of the student.
2. If the condition is true then student enter in the examination hall.
3. Student takes the sheet from the invigilator and question paper**.**
4. After that student fill his sheet and also mark the attendance
5. Then submit the sheet and leave the examination hall.

Frames

Frames define the events or store the information in the table form. Every data stored in structured form. It is basically collection of the attributes and values. For example, we want to store the data of the book, so we can use the frames for this.

IV. CONCLUSION

This study is about the knowledge representation and expert system. Around us everywhere is expert system and these are present in every field. Expert system is all about to do specific work in the specific field. It is now become very important part of our. In this paper, we understood about how expert system works. So if anyone wants to understand about expert system, so they can use it as reference. Nowadays, Developers are focus on the expert system. But the way of represent of knowledge is very important. It is also show the growth of IT sector. This study can be helpful for users also.

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