Batch: A2   **Roll No.: 1911027**
Experiment / assignment / tutorial No. 3
Grade: AA / AB / BB / BC / CC / CD /DD
Signature of the Staff In-charge with date

Title: Implementation of Goal based agent architecture using PROLOG.

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Objective: To use the concepts of knowledge engineering to design and solve moderate complex problem.

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Expected Outcome of Experiment:

Course Outcome	After successful completion of the course students should be able to
CO1	Understand the history & various application of AI and choose appropriate agent architecture to solve the given problem.

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Books/ Journals/ Websites referred:

1. **https://www.csupomona.edu/~jrfisher/www/prolog_tutorial/contents.html**
2. **http://www.csupomona.edu/~jrfisher/www/prolog_tutorial/pt_framer.html**
3. **http://www.doc.gold.ac.uk/~mas02gw/prolog_tutorial/prologpages/**
4. **http://classes.soe.ucsc.edu/cmps112/Spring03/languages/prolog/PrologIntro.pdf**
5. **"Prolog: Programming for Artificial Intelligence" by Ivan Bratko, Pearson education Publications**
6. **"Artificial Intelligence: a Modern Approach" by Russel and Norving, Pearson education Publications**
7. **"Artificial Intelligence" By Rich and knight, Tata Mcgraw Hill Publications**

Pre Lab/ Prior Concepts:
Agents, Agent Architecture, Programming with PROLOG

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Historical Profile:

Knowledge is vast, uncertain and continuously changing. These properties of knowledge make it difficult to arrive at a result. A murder mystery is a kind of situation which depicts the uncertain nature of knowledge and also emphasizes the need of choosing right clauses from entire knowledgebase to make a decision. He goal based agent architecture and some knowledge engineering can help in solutioning of such problems.

The logical agents are complex but they can reason and learn from the actions and new precepts. They are less like acting and think like humans but more like acting and thinking rational agents.

Knowledge and reasoning play a crucial role in dealing with partially observable environments. A knowledge based agent can combine the general knowledge with current percept to infer the hidden aspects of the current state prior to selecting actions.

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New Concepts to be learned:
Knowledge engineering, implementing complex agent architecture, uncertainty in knowledge.

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The Knowledge Engineering Process
1. Identify the task
2. Assemble the relevant knowledge
3. Decide on vocabulary of predicates, functions and constants
4. Encode general knowledge about the domain
5. Encode description of specific problem instance
6. Pose queries to the inference procedure and get answers
7. Debug the knowledge base

Algorithm for KB-Agent:

```
function KB-AGENT( percept) returns an action
    static: KB, a knowledge base
            t, a counter, initially 0, indicating time

    TELL(KB, MAKE-PERCEPT-SENTENCE( percept, t))
    action ← ASK(KB, MAKE-ACTION-QUERY(t))
    TELL(KB, MAKE-ACTION-SENTENCE(action, t))
    t ← t + 1
    return action
```

Problem Statement:

There was a rich businessman Raj who consumed excessive alcohol. He was from a poor family but he married a rich woman Prerana and also had a daughter Reshma. Raj killed his wife and took all the money and properties. He sent his daughter to an orphanage after her mother's murder, following which he remarried and had a son Monty. Raj, his current wife Kaya, and his son Monty lived together. They had a maid who worked for the entire day in his house. One day Raj was found dead in his room and the room was locked from inside. When the police inspector Ayush and his team investigated the crime scene they found that Raj was shot dead and a bullet was found in his chest. A gun was also there in the hands of Raj and also the room key was found in his pocket with a fishing wire piece attached to it. The day before his murder, he fought with his wife as he found her cheating with Mayank who was a fisherman. A week ago Raj also fought with his son because he went fishing without his permission. On the day of the murder, the maid was doing her job, Monty was playing PUBG with his friends in his room and there was a kitty party near their place so Raj's wife was attending it. It was informed to police that Raj's room keys are there with his son, his wife and maid. When police interrogated Monty, he said that he was playing PUBG and due to headphones, he didn't hear the voice of the bullet. The maid said that she also didn't hear the voice of the bullet as she was not at home for a while. Some members of the kitty party said that Raj's wife was not there at the party for 1 hour. After that police confirmed that all three of them were right. On the gun that found with Raj, has fingerprints of all the people living with Raj. Then police started finding other pieces of evidence and first visited Mayank's residence where they found the fishing wire. They also investigated the maid's house where they found Raj's photo with another lady in her house and also fishing wire. The Police were confused whether the case was a murder or a suicide.

Knowledge Engineering steps applied to chosen problem:

A knowledge base in artificial intelligence aims to capture human expert knowledge to support decision-making, problem-solving, and more. In simplest terms, AI provides the mechanisms that enable machines to "gain knowledge." It allows them to acquire, process, and use knowledge to perform tasks that display "intelligent" behaviour, such as: Perception, Learning, Knowledge representation and reasoning, Planning and Execution. For the crime mystery problem statement given above knowledge was gathered by reading the entire story and writing down the all the characters, evidences, and investigation findings. After that rules were specified which was used for deriving something from the given scenario for e.g. if a person is found dead in his room which is locked from outside/inside we can derive that murderer was a relative of victim. At the end rules for murderer and suspects were gathered.

1. Identify the task

The main task of the crime mystery problem solver agent is to find who is the murderer and who are the suspects, with this it is also important to find the motive of the murder. For the problem given above tasks include:

- To find whether it was a murder or suicide
- To find motive of the murder
- To find all the suspects
- To find the murderer

2. Assemble the relevant knowledge

While solving any problem with artificial intelligence it is very important to have all the relevant knowledge of the problem so that the AI agent solving the problem will get a clear idea about the scenario and the environment in which it will be working. For the problem given above gathering relevant knowledge include

Identifying all the characters (Raj, Kaya, Reshma, Prerana, Monty, Ayush, Mayank, Tina).

Identifying evidences (gun, fishing wire, photo of Raj with a lady(not his current wife), room keys).

Identifying relations between different actors (Raj and Kaya: husband – wife, Raj and Monty: father – son, Raj and Reshma: owner – maid, Mayank and Kaya: Lovers).

Identifying objects related to evidences (fingerprints on murder weapon, fishing wire in Reshma and Mayank's house).

Identifying who all have access to the room keys where dead body was found (as Raj found dead in his room which was locked from inside someone must have his room keys).

3. Decide on vocabulary of predicates, functions and constants

The constants used for the problem given above are male, female, friend, victim, murder_weapon, bullet_mark and police. The predicates will be used to find the murderer and the suspects. The predicates which are used are as follows:

- male(name).

- female(name).
- friend(name, name).
- victim(name).
- murder_weapon(weapon_name).
- bullet_mark(body_part).
- police(name).
- motive(name, name, motive_description).
- had_room_key(name).
- location(name, place).
- relation(name, name).
- affair(name, name).
- evidence(object_name).
- evidence_related_material_found_from(place, name, object_name).

4. Encode general knowledge about the domain

By using the following rules agent can fulfil the task for which it is designed. From this rules motive, suspect, murderer, etc. can be easily found out.

has_objects_related_to_evidence(X):- evidence_related_material_found_from(_,X,A), evidence(A).

fingerprints_on_murder_weapon(X,Y):- murder_weapon(Y), relation(raj,X).

suicide(X):- victim(X), bullet_mark(head), had_room_key(X), \+motive(X, _, _).

murder(X):- victim(X), \+bullet_mark(head), had_room_key(X), motive(X, _, _).

suspect(X):- motive(raj, X, _); fingerprints_on_murder_weapon(X, _); relation(raj,X), affair(_,X); has_objects_related_to_evidence(X).

murder_motive(X):- motive(C, D, X), victim(C), murder_weapon(A), fingerprints_on_murder_weapon(D,A), had_room_key(D), (location(D,home);\+location(D,home)), has_objects_related_to_evidence(D).

murderer(X):- motive(C, X, _), victim(C), murder_weapon(A), fingerprints_on_murder_weapon(X,A), had_room_key(X), (location(X,home);\+location(X,home)), has_objects_related_to_evidence(X).

5. Encode description of specific problem instance

For the given murder mystery problem statement the following facts will be used:

male(raj).
male(monty).
male(mayank).
male(ayush).

female(prerana).
female(kaya).
female(tina).
female(reshma).

friend(mayank,kaya).
friend(tina,kaya).

victim(raj).

murder_weapon(gun).

bullet_mark(chest).

police(ayush).

motive(raj, reshma, mothers_murder).
motive(raj, monty, revenge_of_fight).
motive(raj, mayank, jealousy).
motive(raj, kaya, cheating).

had_room_key(raj).
had_room_key(monty).
had_room_key(reshma).
had_room_key(kaya).

location(reshma, home).
location(monty, home).
location(kaya, kitty_party).
location(raj, home).

relation(raj,monty).
relation(raj,kaya).

relation(raj,reshma).

affair(mayank,kaya).

evidence(fishing_wire).

evidence_related_material_found_from(home, reshma, fishing_wire).
evidence_related_material_found_from(home, mayank, fishing_wire).

6. Pose queries to the inference procedure and get answers

The following queries will be used for finding different things related to given problem statement:

has_objects_related_to_evidence(X):- evidence_related_material_found_from(_,X,A),
  evidence(A).

fingerprints_on_murder_weapon(X,Y):- murder_weapon(Y), relation(raj,X).

suicide(X):- victim(X), bullet_mark(head), had_room_key(X), \+motive(X, _, _).

murder(X):- victim(X), \+bullet_mark(head), had_room_key(X), motive(X, _, _).

suspect(X):- motive(raj, X, _); fingerprints_on_murder_weapon(X, _);
  relation(raj,X), affair(_,X); has_objects_related_to_evidence(X).

murder_motive(X):- motive(C, D, X), victim(C), murder_weapon(A),
  fingerprints_on_murder_weapon(D,A), had_room_key(D),
  (location(D,home);\+location(D,home)),
  has_objects_related_to_evidence(D).

murderer(X):- motive(C, X, _), victim(C), murder_weapon(A),
  fingerprints_on_murder_weapon(X,A), had_room_key(X),
  (location(X,home);\+location(X,home)),
  has_objects_related_to_evidence(X).

7. Debug the knowledge base

As the knowledge based formed using above steps may contain some loopholes so we must have to remove it. Agent works fine with the predefined knowledge base so any other processing with knowledge base is not required.

Code:

```
 1  %Raj : - Businessman%
 2  %Prerana : - Raj's first wife%
 3  %Kaya : - Raj's second wife%
 4  %Monty : - Raj's son%
 5  %Reshma : - Maid and prerana's daughter%
 6  %Mayank : - Kaya's friend%
 7  %Tina : - Kaya's kitty party friend%
 8  %ayush : - Police inspector%
 9
10  male(raj).
11  male(monty).
12  male(mayank).
13  male(ayush).
14
15  female(prerana).
16  female(kaya).
17  female(tina).
18  female(reshma).
19
20  friend(mayank,kaya).
21  friend(tina,kaya).
22
23  victim(raj).
24
25  murder_weapon(gun).
26
27  bullet_mark(chest).
28
29  police(ayush).
```

```
29  police(ayush).
30
31  motive(raj, reshma, mothers_murder).
32  motive(raj, monty, revenge_of_fight).
33  motive(raj, mayank, jealousy).
34  motive(raj, kaya, cheating).
35
36  had_room_key(raj).
37  had_room_key(monty).
38  had_room_key(reshma).
39  had_room_key(kaya).
40
41  location(reshma, home).
42  location(monty, home).
43  location(kaya, kitty_party).
44  location(raj, home).
45
46  relation(raj,monty).
47  relation(raj,kaya).
48  relation(raj,reshma).
49
50  affair(mayank,kaya).
51
52  evidence(fishing_wire).
53
54  evidence_related_material_found_from(home, reshma, fishing_wire).
55  evidence_related_material_found_from(home, mayank, fishing_wire).
56
57  has_objects_related_to_evidence(X):- evidence_related_material_found_from(_,X,A),
58      evidence(A).
59
```

```
60  fingerprints_on_murder_weapon(X,Y):- murder_weapon(Y), relation(raj,X).
61
62  suicide(X):- victim(X), bullet_mark(head), had_room_key(X), \+motive(X, _, _).
63
64  murder(X):- victim(X), \+bullet_mark(head), had_room_key(X), motive(X, _, _).
65
66  suspect(X):- motive(raj, X, _); fingerprints_on_murder_weapon(X, _);
67      relation(raj,X), affair(_,X); has_objects_related_to_evidence(X).
68
69  murder_motive(X):- motive(C, D, X), victim(C), murder_weapon(A),
70      fingerprints_on_murder_weapon(D,A), had_room_key(D),
71      (location(D,home);\+location(D,home)),
72      has_objects_related_to_evidence(D).
73
74  murderer(X):- motive(C, X, _), victim(C), murder_weapon(A),
75      fingerprints_on_murder_weapon(X,A), had_room_key(X),
76      (location(X,home);\+location(X,home)),
77      has_objects_related_to_evidence(X).
78
```

Output:

1) Suicide or murder:-
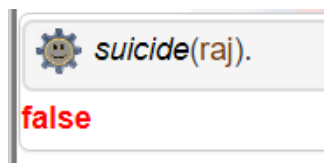
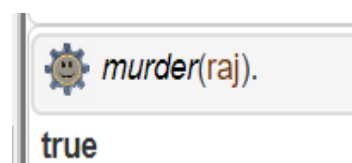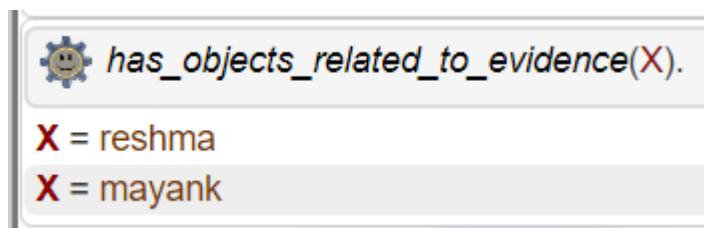|	
Query:	Query:
suicide(raj).	murder(raj).
Output:	Output:

2) Who has objects related to evidence:
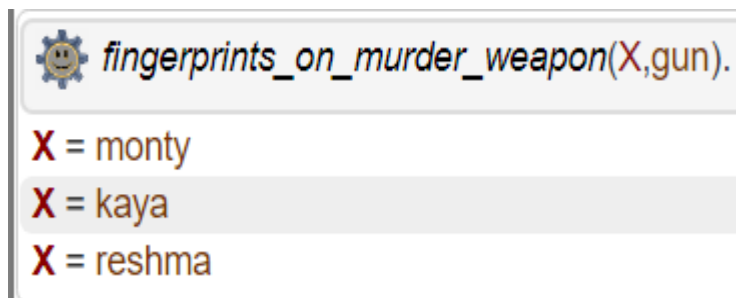
Query:

has_objects_related_to_evidence(X).

Output:

3) Fingerprints on murder weapon:
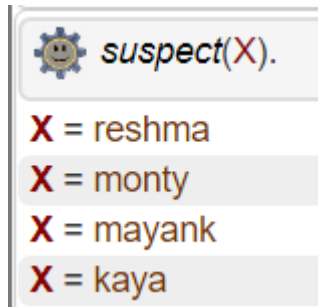
Query:

fingerprints_on_murder_weapon(X,gun).

Output:

4) Suspects:

Query:
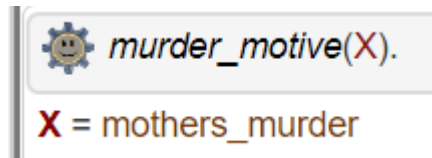
suspect(X).

Output:

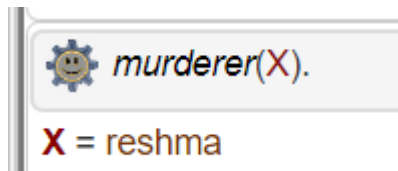5) Murder motive:

Query:

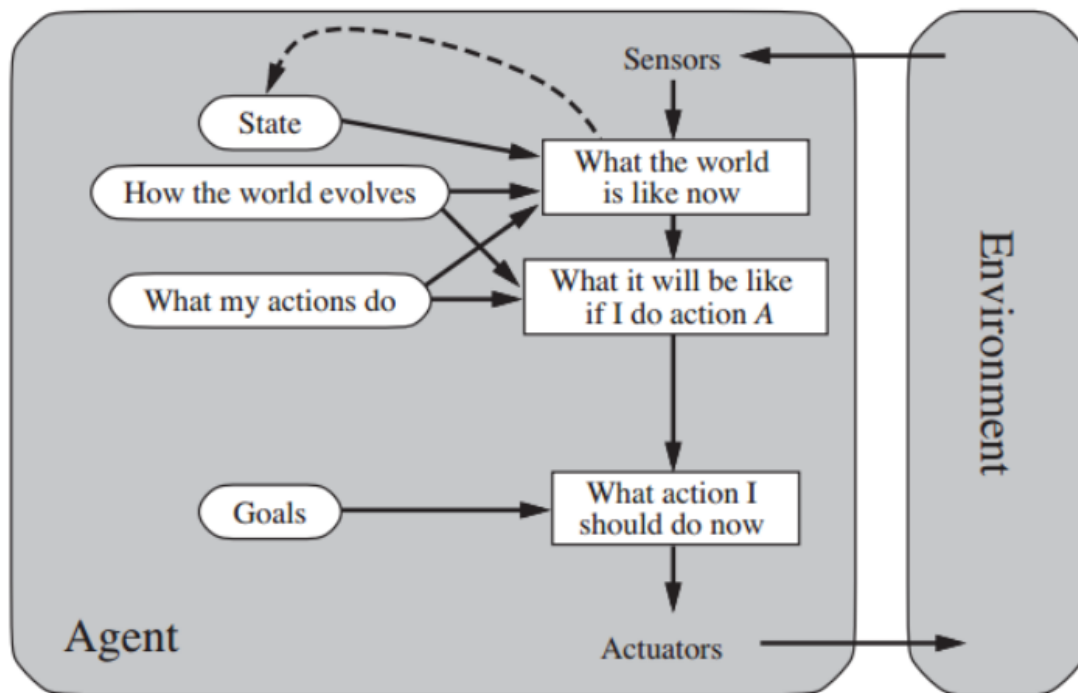murder_motive(X).

Output:

6) Murderer:

Query:

murderer(X).

Output:

Agent Architecture *(Justify the blocks)*:

The best agent architecture which will be used to solve the above problem is goal based agent architecture.

The agent which will be working on the grounds will be solving the murder mystery. The agent mainly tries to find what are the evidences, who are the suspects and finally who is the murderer. Knowing just the current state is sometimes not enough to decide the actions to be performed. The agent needs some sort of goal information that indicates the desirable states in the environment. It keeps track of the world state as well as a set of goals it's trying to achieve, and chooses an action that will (eventually) lead to the achievement of its goals.

Environment: The environment will be the crime scene from where the agent has to collect the knowledge. For the problem statement given above environment will be the room where the Raj was found dead. Environment contains dead body of Raj, gun(murder_weapon), fishing wire attached with room keys inside Raj's pocket.

Sensors: Cameras, position sensors, sensors to get position of bullet on the body.

State: As this agent has to solve the murder mystery and to find who is the murderer. For this agent must have stored something in the knowledge base so that it will be useful in finding murderer. The state is nothing but the knowledge of the entire crime screen when sensed by the agent. For the problem given above state stored in the knowledge base would be the Raj found dead at some position in his room and a mullet

mark found in his head. This state will change as and when agent senses new percepts from the environment. Also based on this state the how the world is right now will be derived.

What the world is like right now: This will give the different evidences found in the room, what all the things present in the room, what was the room conditions, and Raj's dead body. As for the given problem statement Raj found dead in his room which was locked from inside. Also a bullet mark found on his head and a gun was present in his hand. Room keys were attached with a fishing wire and found in Raj's pocket. What the world is like right now contains the facts which can be derived by sensing the environment and also the state will be updated by using this. This can be changed when agent performs some action.

How the world evolves: This will give how the world changes without agent.

- Different murder motives which are discovered during investigation.
- Kaya and Mayank in relation with each other.
- Monty was angry on Raj as Raj was not happy when Monty went to fishing without his permission.
- Raj was angry on Kaya, as she was in good relation with Mayank.
- Reshma angry on Raj, because Raj killed his mother.
- Family members fingerprints found on murder weapon
- Raj's photo with another lady and fishing wire police got from Reshma's home.
- Police also got fishing wire from Mayank's home as he was a fisherman.

What my actions do: This shows the effect of the agent's action on the environment. The agent's action will be mainly in the direction where it can find the murderer. Suppose if agent is showing the results that the maid was the murderer because her fingerprints are there on the murder weapon, then this action may change the world as the maid can try to erase her fingerprints from the murder weapon. All the actions will directly lead to achieve the goal.

What it will be like after agent performs some action: In the scenario given above agent predicts some suspects based on knowledge base available to it. But as the agent performs this action it may happen that suspects tries to mislead the investigation. If suspects tries something it may change the environment.

Goals: The primary goal of the agent is to find the murderer. But agent also has to find what was the motive of the murder and who are the suspects. Goals will be used to decide the actions that agent has to perform so that the actual murderer can be found out.

What action should agent do now: After deciding the action from the percept and the state, goals of the agent will be considered and appropriate actions will be done by the agent using actuators. Suppose that from the state agent gets the knowledge that Reshma's mother was killed by Raj and from the goal it can get that this can be the motive of the murder which will lead to the murderer so agent may perform an action which will show that Reshma was the murder and the motive of the murder is the revenge.

Actuators: Screen which will show motive of the murder, suspects and murderer.

Post Lab Objective Questions

1. Which is not a Goal-based agent?
   a. Inference
   b. Search
   c. Planning
   d. Conclusion
   e. Dynamic search.
Answer: d. Conclusion

2. Which were built in such a way that humans had to supply the inputs and interpret the outputs?
   a. Agents
   b. Sensor
   c. AI System
   d. Actuators
Answer: c. AI System

Post Lab Subjective Questions
Explain the role of PEAS and task environment in choosing the agent architecture. Justify your answer with an example.
ANS) We know that there are different types of agents in AI. PEAS System is used to categorize similar agents together. The PEAS system delivers the performance measure with respect to the environment, actuators, and sensors of the respective agent. Most of the highest performing agents are Rational Agents. The rational agent considers all possibilities and chooses to perform the highly efficient action. For example, it chooses the shortest path with low cost for high efficiency. PEAS stands for a Performance measure, Environment, Actuator, Sensor.

Performance Measure: Performance measure is the unit to define the success of an agent. Performance varies with agents based on their different precepts.

Environment: Environment is the surrounding of an agent at every instant. It keeps changing with time if the agent is set in motion.

Actuator: An actuator is a part of the agent that delivers the output of action to the environment.

Sensor: Sensors are the receptive parts of an agent that takes in the input for the agent.

A task environment refers to the choices, actions and outcomes a given user has for a given task. Formally speaking, a task environment can be described as a directed graph where the nodes are states and the links are actions. Some links will lead to final states that represent completion of the task. Note that task environments themselves can be changed by actors, i.e. he can redesign the task itself. In addition the debate is open to what exactly is inside or outside the task environment. An environment in artificial intelligence is the surrounding of the agent. The agent takes input from the environment through sensors and delivers the output to the environment through actuators. There are several types of environments:

- Fully Observable vs Partially Observable
- Deterministic vs Stochastic
- Competitive vs Collaborative
- Single-agent vs Multi-agent
- Static vs Dynamic
- Discrete vs Continuous

Based on PEAS and task environment we can easily determine the type of agent architecture to be used for solving a particular problem. Suppose we only want to fulfil a particular task than we can use a goal based agent. But if we want to fulfil a particular task but in an optimal way than we can use a utility based agent. Now suppose if agent is working in an environment where agent doesn't want any previous knowledge and decision must be made based on current precepts than a reflex agent can also be used.

For e.g. Suppose we want to make a crime investigation agent then we can make use of goal based agent architecture as the main aim of the agent is to find who is the criminal.