Artificial Intelligence (AI)

Lab Sheet No: 3

Introduction to First Order Predicate Logic (FOPL)

The use of symbolic logic to represent knowledge is not new in that it predates the modern computer by a number of decades. Even so, the application of logic as a practical means of representing and manipulating knowledge was not demonstrated until the early 1960s. Today First Order Predicate Logic (FOPL) or predicate calculus has assumed one of the important roles in AI for representing the knowledge.

The understanding of FOPL for AI student has several benefits. One, logic offers the formal approach to reasoning that has a sound theoretical foundation. Next, the structure of FOPL is flexible enough to permit the accurate representation of the natural language reasonably well.

For Example:

- Ram loves all animals.

  $\forall x Animals(x) \Rightarrow Loves(ram, x)$

- Poppy is a dog.

  $Dog\ (Poppy)$

- Grandparent is a parent of one's parent

  $\forall x, y Grandparent(x, y) \Leftrightarrow \exists z Parent(x, z) \cap Parent\ (z, y)$

- Parent and child are inverse relation.

  $\forall x, y Parent(x, y) \Leftrightarrow Child\ (y, x)$

- Rules combine facts to increase knowledge of the system

  son(X,Y):-male(X),child(X).

  X is a son of Y if X is male and X is a child of Y.

Conversion of Prolog into FOPL:

Prolog clauses can be directly translated into FOPL, except for a few exceptions like write, !, is, assert, retract, ...

The three simple rules for conversion are:

- **"," corresponds to "&"**
- **":-" corresponds to "<-"**
- All variables are universally quantified.

Examples

1. grandfather(X,Y) :- father(X,Z),parent(Z,Y).

In FOPL:
Ax,Ax,Az (grandfather(x,y) <- (father(x,z)&parent(z,y)))

2. uncle(X,Y) :- parent(Z,Y),brother(X,Z).

In FOPL:
Ax,Ay,Az (uncle(x,y) <- (parent(z,y)&brother(x,z)))

3. member(X,[X|T]).

In FOPL:
Ax,Ay,At (member(x,[x|t]))

4. member(X,[Y|T]) :- member(X,T).

In FOPL:
Ax,Ay,At (member(x,[y|t]) <- member(x,t))

5. a :- b,c,d,e.

In FOPL:
a <- (b & c & d & e)

Example 1: Monkey- Banana Problem

Monkey-Banana Problem is the famous problem in AI. Where there is a room containing a monkey, a chair, and bananas that have been hung from the center of the ceiling of the room; out of reach from monkey. If the monkey is clever enough, he can reach the bananas by placing the chair directly below the bananas and climbing on the top of the chair.

Now the problem is to use FOPL to represent this monkey-banana problem and prove that monkey can reach the bananas.The program is given below. Before running the program, think carefully what are the essential objects of the problem and how should them be arranged in predicate logic.

```
PREDICATES

in_room(symbol)

dexterous(symbol)

tall(symbol)

can_move(symbol,symbol,symbol)

can_reach(symbol,symbol)

get_on(symbol,symbol)

can_climb(symbol,symbol)

close(symbol,symbol)

under(symbol,symbol)

CLAUSES

in_room(bananas).

in_room(chair).

in_room(monkey).

dexterous(monkey).

tall(chair).

can_move(monkey,chair,bananas).

can_climb(monkey,chair).

can_reach(X,Y):-
      dexterous(X),close(X,Y).

close(X,Z):-
      get_on(X,Y),
      under(Y,Z),
      tall(Y).

get_on(X,Y):-
      can_climb(X,Y).

under(Y,Z):-
      in_room(X),
      in_room(Y),
      in_room(Z),
      can_move(X,Y,Z).

GOAL

can_reach(monkey,appple)
```

Example 2:

Write the following statements in FOPL form and by converting them into prolog program test the given goal.

1. Every American who sells weapons to hostile nations is a criminal.
2. Every enemy of America is a hostile.
3. Iraque has some missiles.
4. All missiles of Iraque were sold by George.
5. George is an American.
6. Iraque is a country.
7. Iraque is the enemy of America.
8. Missiles are weapens.

PROGRAM

```
PREDICATES

hostile(STRING)

enemy_of_america(STRING)

american(STRING)

criminal(STRING)

sells_missiles(STRING, STRING)

has_missile(STRING)

country(STRING)

hostile(X):-

country(X).

has_missile("Iraq").

sells_missiles("George", "Iraq").

american("George").
```

```
CLAUSES

criminal(X):-

american(X), sells_missiles(X, Y),
hostile(Y).

enemy_of_america(X) :-

hostile(X).

enemy_of_america("Iraq").


country("Iraq").

GOAL

criminal("George").
```

Assignments

PREMISES 1

1. Horses, cows, pigs are mammals.
2. An offspring of a horse is a horse.
3. Bluebeard is a horse.
4. Bluebeard is Charlie's parent.
5. Offspring and parent are inverse relations.
6. Every mammal has a parent.

QUERY

1. Is Charlie a horse?

PREMISES 2

1. All people who are not poor and are smart are happy.
2. Those people who read are not stupid.
3. John can read and is wealthy.
4. Happy people have exciting lives.

QUESTION

1. Can anyone be found with an exciting life?"?

PREMISES 3

1. All pompeians are romans.
2. all romans were either loyal to Caesar or hated him.
3. everyone is loyal to someone.
4. people only try to assassinate rulers they are not loyal to.
5. marcus tried to assassinate Caesar.
6. marcus was Pompeian.

QUESTION

1. did marcus hate Caesar?

PREMISES 4

Bhogendra likes all kinds of food. Oranges are food. Chicken is food. Anything anyone eats and isn’t killed by is food. If a person likes a food means that person has eaten it. Jogendra eats peanuts and is still alive. Shailendra eats everything Bhogendra eats.

QUESTION

Does Shailendra like chicken.

PREMISES 5

Dave and Fred are members of a dancing club in which no member can both waltz and jive. Fred"s dad can"t waltz and Dave can do whatever fred can"t do. If a child can do something, then their parents can do it also.

PROVE that there is a member of the dancing club who can"t jive