A

REPORT

ON

INTRODUCTION TO FIRST ORDER PREDICATE LOGIC (FOPL)

(ARTIFICIAL INTELLIGENCE)

LAB- III

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Theory:

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

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

Monkey- Banana Problem

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)
can_climb(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,apple).
```

OUTPUT:

No

DISCUSSION:

Here the in_room(symbol) predicate ensures that the chair, bananas and the monkey are in the room by passing them in the predicate as an argument. The monkey cannot reach the apple since apple is not in the room. But, the monkey can reach bananas and the output is 'yes' for bananas.

In the program, monkey can reach the chair if monkey is dexterous and the chair to be reached is closer to the monkey. For the chair to be close to the monkey, monkey should be able to get on the chair and it should be under bananas and the chair should be tall. For the chair to be under bananas, all the three should be in room and the monkey be able to move to bananas through chair which is provided in the fact. So the monkey can reach bananas but not apple (which is not in the room).

ASSIGNMENT – 1:

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. Iraq has some missiles.
4. All missiles of Iraq were sold by George.
5. George is an American.
6. Iraq is a country.
7. Iraq is the enemy of America.
8. Missiles are weapons.

PROGRAM:

```
PREDICATES
hostile(STRING)
enemy_of_america(STRING)
american(STRING)
criminal(STRING)
sells_missiles(STRING, STRING)
has_missile(STRING)
country(STRING)

CLAUSES
criminal(X):- american(X),
sells_missiles(X, Y),
hostile(Y).
enemy_of_america(X) :-
hostile(X).
enemy_of_america("Iraq").
hostile(X):- country(X).
has_missile("Iraq").
sells_missiles("George", "Iraq").
american("George").
country("Iraq").

GOAL criminal("George").
```

OUTPUT:

Yes

DISCUSSION:

We have the goal to prove George as criminal with the help of clauses defined. Initially, criminal is defined in the predicate section criminal (STRING) as every American who sells missiles to the hostile nation. Every enemy of America is considered hostile as defined in the predicate section enemy_of_america (STRING). Iraq is considered as enemy of America. Country is recognized as hostile if it is the enemy of America. Iraq has weapons as missiles as stated in the section has_missile (STRING). George sells missiles to Iraq as defined in the predicate section sells_missiles (STRING). George is an American as defined in the clause section american (STRING) passing George as argument. Iraq is recognized as the hostile nation in the clause section country (STRING) with Iraq as argument passed. Since we passed “George” as argument and from the above sequence of clauses, this statement turns out to be true.

ASSIGNMENT – 2:

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

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

Now check, **is Charlie a horse?**

PROGRAM:

```
PREDICATES
horse (STRING) mammals
(STRING) offspring
(STRING, STRING)
parent (STRING, STRING)

CLAUSES
parent ("Bluebeard", "Charlie").
horse ("Bluebeard"). horse (X):-
        mammals (X),
offspring (X),
horse (Y).
mammals(X):-     parent
(Y, X),  offspring (X,Y).
offspring (X, Y):-
parent (Y, X).

GOAL
horse ("Charlie").
```

OUTPUT:

Yes

DISCUSSION:

We are trying to show that Charlie is a horse. For this purpose, initially, we define Bluebeard as parent of Charlie in the clause section. Then Bluebeard is considered as horse with the predicate horse (STRING) instantiated with argument Bluebeard in the clause section. Then horse (STRING) predicate is defined in the clause section recursively since the offspring of horse is a horse. Besides, offspring and parent are the inverse relations defined in the clause section respectively showing bidirectional relationship between parent and the offspring. Every mammal has a parent, so while defining mammals (STRING) under the clause section both parent and offspring predicate is called.

CONCLUSION:

From the lab problems and some assignment it was clear that first order predicate logic (FOPL) can be used to realize various real life situations in logical form and prolog can be used to implement it. However, the order of the FOPL is of prime importance in drawing conclusion, inappropriate order might result in infinite loop. Here the logic offers the formal approach to reasoning that has a sound theoretical foundation. Next, the structure of FOPL is flexible enough to permit the accuracy representation of the natural language reasoning as well.