Artificial Intelligence (AI)
Lab Sheet No: 3
Introduction to First Order Predicate Logic (FOPL)

BEI III/I

December, 2025

Introduction

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.

Examples

- Ram loves all animals.

$$\forall x \in \text{Animals}(x) \Rightarrow \text{Loves}(\text{ram}, x)$$

- Poppy is a dog.

$$\text{Dog}(\text{Poppy})$$

- Grandparent is a parent of one's parent.

$$\forall x, y, z : \text{Grandparent}(x, y) \Leftrightarrow \exists z : \text{Parent}(x, z) \cap \text{Parent}(z, y)$$

- Parent and child are inverse relation.

$$\forall x, y : \text{Parent}(x, y) \Leftrightarrow \text{Child}(y, x)$$

- Rules combine facts to increase knowledge of the system

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

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

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.

Prolog Program

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,apple).
```

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").
```

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.

Check: Is Charlie a horse?

Note: Try all the assignments in python or other languages and discuss the pros and cons with respect to PROLOG.