

AI Assignment

Question 1 ;

Let Suppose:-

at time t green light glow $\rightarrow g_t$

at time t yellow light glow $\rightarrow y_t$

at time t red light glow $\rightarrow r_t$

• At any given moment, the traffic light is either green, yellow, and red:-

$$- \exists t (g_t \vee y_t \vee r_t)$$

$$- g_t \vee y_t \vee r_t$$

• The traffic light switches from green to yellow, yellow to red, red to green.

$$- \exists t ((g_t \wedge y_{t+1}) \vee (y_t \wedge r_{t+1}) \vee (r_t \wedge g_{t+1}))$$

$$- (g_t \rightarrow y_{t+1}) \vee (y_t \rightarrow r_{t+1}) \vee (r_t \rightarrow g_{t+1})$$

• The traffic light cannot remain in the same state for more than 3 consecutive cycles:

$$- (g_t \wedge g_{t+1} \wedge g_{t+2}) \vee (y_t \wedge y_{t+1} \wedge y_{t+2}) \vee (r_t \wedge r_{t+1} \wedge r_{t+2})$$

$\text{con}(x_1, x_2) \rightarrow x_1 \text{ connects with } x_2$
Question 2: $\text{NC}(x, c) \rightarrow x \text{ has color } c$

$$1. \forall x \in N, \{x_1, x_2\} \in N, \{c_1, c_2\} \in C$$

$$- \{ \text{NC}(x_1) \wedge \text{NC}(x_2) \wedge \text{NC}(x_1, c_1) \wedge \text{NC}(x_2, c_2) \wedge \text{con}(x_1, x_2) \rightarrow x_1, c_1 \neq c_2 \}$$

$$= \text{con}(x_1, x_2) \rightarrow \neg (\text{NC}(x_1, c_1) \wedge \text{NC}(x_2, c_2))$$

$$2. (x_1 \neq x_2) \wedge \text{NC}(x_1, c_1) \wedge \text{NC}(x_2, c_1) \wedge (c_1 = \text{'yellow'}) \wedge (z \in N: \text{NC}(z, c_1)) \rightarrow (z = x_1 \vee z = x_2)$$

$$3. \forall x_1 \in N \{ \text{NC}(x_1, c_1 = r) \rightarrow \text{NC}(x_2, c_2 = g) \wedge \text{Steps}(x_1, x_2) \leq 4 \}$$

$$\exists x_2 \in N$$

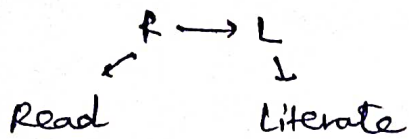
$$4. (\exists c, c \in C, \{ \text{NC}(x, c) \}) \vee (\exists x, x \in N)$$

Question 3:
 Let's define statements:

- $R(x) \rightarrow \text{Read, } x$
- $L(x) \rightarrow x \text{ is Literate}$
- $D(x) \rightarrow x \text{ is Dolphin}$
- $I(x) \rightarrow x \text{ is Intelligent}$

- whoever can read is literate.

• PL: \rightarrow

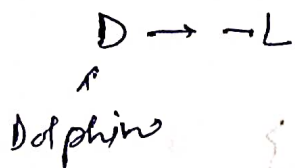


• FOL: \rightarrow

$$\forall x \{ R(x) \rightarrow L(x) \}$$

- Dolphins, unfortunately, are not literate.

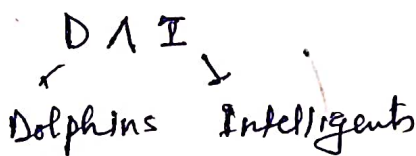
• PL: \rightarrow



$$\forall x \{ D(x) \rightarrow \neg L(x) \}$$

- Some dolphins are intelligent.

• PL: \rightarrow



• FOL: \rightarrow

$$\begin{aligned} & \neg \forall x (D(x) \wedge \neg I(x)) \quad (\text{or}) \\ & \exists x (D(x) \wedge I(x)) \end{aligned}$$

- Some who are not intelligent cannot read.

• PL: \rightarrow

$$I \wedge \neg R$$

• FOL: \rightarrow

$$\exists x (I(x) \wedge \neg R(x))$$

$$\neg \forall x (I(x) \wedge R(x))$$

- There exist a dolphin who is both intelligent and can read, but Every intelligent, if it can read, it must be that it not literate.

• PL: \rightarrow

$$(D \wedge I \wedge R) \wedge (D \wedge I \wedge R \wedge \neg L)$$

• FOL: \rightarrow

$$\exists x (D(x) \wedge I(x) \wedge R(x)) \wedge$$

$$\forall x (D(x) \wedge I(x) \wedge R(x) \rightarrow \neg L(x))$$

→ Satisfiability:

$$① \neg R \vee L \quad (L \rightarrow L)$$

$$② \neg D \vee \neg L \quad (D \rightarrow \neg L)$$

$$③ D \wedge I$$

$$④ I \wedge \neg R$$

$$⑤ (D \wedge I \wedge R) \wedge (\neg I \vee \neg R \vee \neg D \vee \neg L)$$

②

③

④

$$\neg D \vee \neg L$$

$$D \wedge I = \{D, I\}$$

$$\neg R \vee I = \{R, L\}$$

$$D \wedge I \wedge L = \{D, I, L\} \quad \neg(D \wedge I \wedge R) \wedge L = \{D, I, R, L\}$$

①

⑤

$$I \wedge R = \{I, R\}$$

$$(I, L, R)$$

$$L \wedge \neg L$$

Empty clause

how do you know that it is not satisfiable? ...

$$(D \wedge I \wedge R) \wedge (\neg I \vee \neg R \vee \neg D \vee \neg L)$$

Computation:-

Q.2 (a) Time Complexity

Initialize
dataLog()

$$O(n+m)$$

m - no. of stops
 m - no. of routes.

add route
data()

$$O(m \times n)$$

m - no. of routes.
 n - avg. stop/route

Query
direct routes()

$$O(1)$$

$$O(k)$$

k - direct no. of routes.

(b) Intermediate Step Comparison,

Brute force:-

- ↳ Iterate through each route
- ↳ Check if both stops exist in the route
- ↳ Verify the order of stops.

FOL Approaches:-

- ↳ Create terms & predicates
- ↳ Add facts to knowledge base
- ↳ Define relationship rules

Memory Usage

$$O(n+m)$$

$$O(m)$$

m - no. of routes.

Q.3) (a)

Time Complexity

Space Complexity

forward chaining

$$O(n \times m^2)$$

n - no. of rules

m - avg. stop/rule.

$$O(n \times m) + P$$

P - no. of potential paths.

backward chaining

$$O(n \times m)$$

$$O(n \times m + G)$$

G - no. of goal-directed paths

(b) forward chaining:-

- Initialize knowledge base with route data.
- Generate Connected stops relationships
- Build paths forward from start stop.
- Going apply via stop constraints.
- Return paths.

Backward chaining:-

- Same as above (forward chaining)

but here we moves ~~start~~ end \rightarrow end start rather than start \rightarrow end.