Knowledge Representation

(Examples of Resolution)

1. Solve the example by using the concept of Resolution

(a) Marcus was a man.

(b) Marcus was a Roman.

(c) All men are people.

(d) Caesar was a ruler.

(e) All Romans were either loyal to Caesar or hated him (or both).

(f) Everyone is loyal to someone.

(g) People only try to assassinate rulers they are not loyal to.

(h) Marcus tried to assassinate Caesar.

Prove: hate(Marcus, Caesar)

Convert to First Order Logic

(a) Marcus was a man.

(b) Marcus was a Roman.

(c) All men are people.

(d) Caesar was a ruler.

(e) All Romans were either loyal to Caesar or hated him (or both).

(f) Everyone is loyal to someone.

(g) People only try to assassinate rulers they are not loyal to.

(h) Marcus tried to assassinate Caesar.

(a) $man(marcus)$

(b) $roman(marcus)$

(c) $\forall X.\ man(X) \rightarrow person(X)$

(d) $ruler(caesar)$

(e) $\forall X.\ roman(x) \rightarrow loyal(X,caesar) \vee hate(X,caesar)$

(f) $\forall X \exists Y.\ loyal(X,Y)$

(g) $\forall X \forall Y.\ person(X) \wedge ruler(Y)$ $tryassasin(X,Y) \rightarrow \neg loyal(X,Y)$

(h) $tryassasin(marcus,caesar)$

Negate!

$\neg hate(X,caesar)$

Convert to Clausal Form

(a) man(marcus)
(b) roman(marcus)
(c) $\forall X.\ man(X) \rightarrow person(X)$
(¬man(X), person(X))
(d) ruler(caesar)
(e) $\forall X.\ roman(X) \rightarrow loyal(X,caesar) \vee hate(X,caesar)$
(¬roman(X), loyal(X,caesar), hate(X,caesar))
(f) $\forall X \exists Y.\ loyal(X,Y)$
(loyal(X,f(X)))
(g) $\forall X \forall Y.\ person(X) \wedge ruler(Y) \wedge tryassasin(X,Y) \rightarrow \neg loyal(X,Y)$
(¬person(X), ¬ruler(Y), ¬tryassasin(X,Y), ¬loyal(X,Y))
(h) tryassasin(marcus,caesar)

Negate!

¬hate(X,caesar)

$\neg man(x) \vee person(x)$ $\quad$ $man(marcus)$ $\quad$ $x/marcus$

$person(marcus)$ $\quad$ $\neg person(marcus) \vee \neg ruler(Y)$
$\vee \neg tryass(marcus, Y)$
$\vee \neg loyal(marcus, Y)$

$Y/Caesar$

$\neg ruler(Y) \vee \neg tryass(marcus, Y) \vee \neg loyal(marcus, Y)$ $\quad$ $ruler(Caesar)$

$\neg tryass(marcus, caesar) \vee \neg loyal(marcus, Y)$

$tryass(marcus, Caesar)$

$\neg loyal(marcus, Caesar)$ $\quad$ $\square$ $\quad$ $loyal(marcus, Caesar)$

2. Solve the example by using the concept of Resolution

1. Gita likes all kinds of food.

2. Mango and chapatti are food.

3. Gita eats almond and is still alive.

4. Anything eaten by anyone and is still alive is food.

- **Goal:** Gita likes almond.

1. ∀x: food(x) → likes(Gita,x)
2. food(Mango),food(chapati)
3. ∀x∀y: eats(x,y) ∧ ¬ killed(x → food(y)
4. eats(Gita, almonds) ∧ alive(Gita)
5. ∀x: ¬killed(x) → alive(x)
6. ∀x: alive(x) → ¬killed(x)

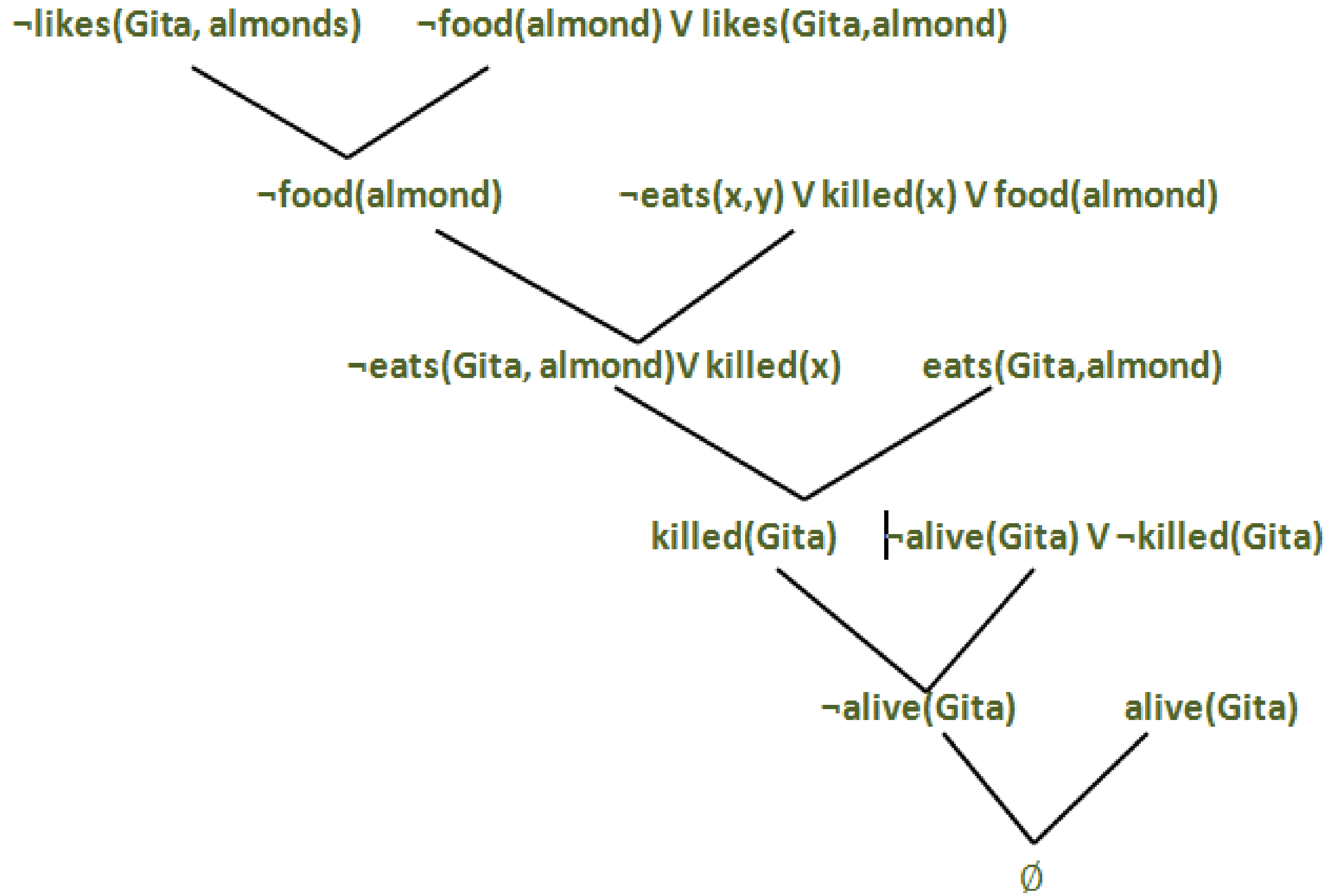
Goal: likes(Gita, almond)

Negated goal: ¬likes(Gita, almond)

Now, rewrite in CNF form:

1. ¬food(x) V likes(Gita, x)
2. food(Mango),food(chapati)
3. ¬eats(x,y) V killed(x) V food(y)
4. eats(Gita, almonds), alive(Gita)
5. killed(x) V alive(x)
6. ¬alive(x) V ¬killed(x)

Finally, construct the resolution graph:



3. Solve the example by using the concept of Resolution

All oversmart persons are stupid. Children of oversmart persons are naughty. Ram is children of Hari. Hari is oversmart. Show that Ram is naughty.

Axioms in FOPL

1. $\forall x : Oversmart(x) \rightarrow Stupid(x)$
2. $\forall x : \forall y : Oversmart(x) \wedge Child\text{-}of(y, x) \rightarrow Naughty(y)$
3. $Child\text{-}of(Ram, Hari)$
4. $Oversmart(Hari)$

Clause Form

1. $\neg Oversmart(x_1) \vee Stupid(x_1)$
2. $\neg Oversmart(x_2) \vee \neg Child\text{-}of(y_2, x_2) \vee Naughty(y_2)$
3. $Child\text{-}of(Ram, Hari)$
4. $Oversmart(Hari)$

Resolution

$\neg Naughty(Ram)$

2

Ram/y_2 , $Hari/x_2$

$\neg Oversmart(Hari) \vee \neg Child\text{-}of(Ram, Hari)$

3

$\neg Oversmart(Hari)$

4

$\square$

Example

Assume the following facts:

i. "Steve only likes easy courses.

ii. Science courses are hard.

iii. All the courses in Humanities Department are easy.

iv. HM101 is a course in Humanities".

Convert the above statements into appropriate wffs so that the resolution can be performed to answer the question. " what course would steve like?"

First we will convert it into FOPL (First order predicate logic)

i. “Steve only likes easy courses.

$\forall$x: easy(x) -> likes(steve,x)

ii. Science courses are hard.

$\forall$x: science(x) -> ~easy(x)

iii. All the courses in Humanities Department are easy.

$\forall$x: humanities(x) -> easy(x)

iv. HM101 is a course in Humanities”.

humanities(HM101)

The conclusion is encoded as likes(steve , x).

- First we put our premises in the clause form and the negation of conclusion to our set of clauses (we use numbers in parentheses to number the clauses):

(1) ~easy(x) $\vee$ likes(steve,x)

(2) ~science(x) $\vee$ ~easy(x)

(3) ~humanities (x) $\vee$ easy(x)

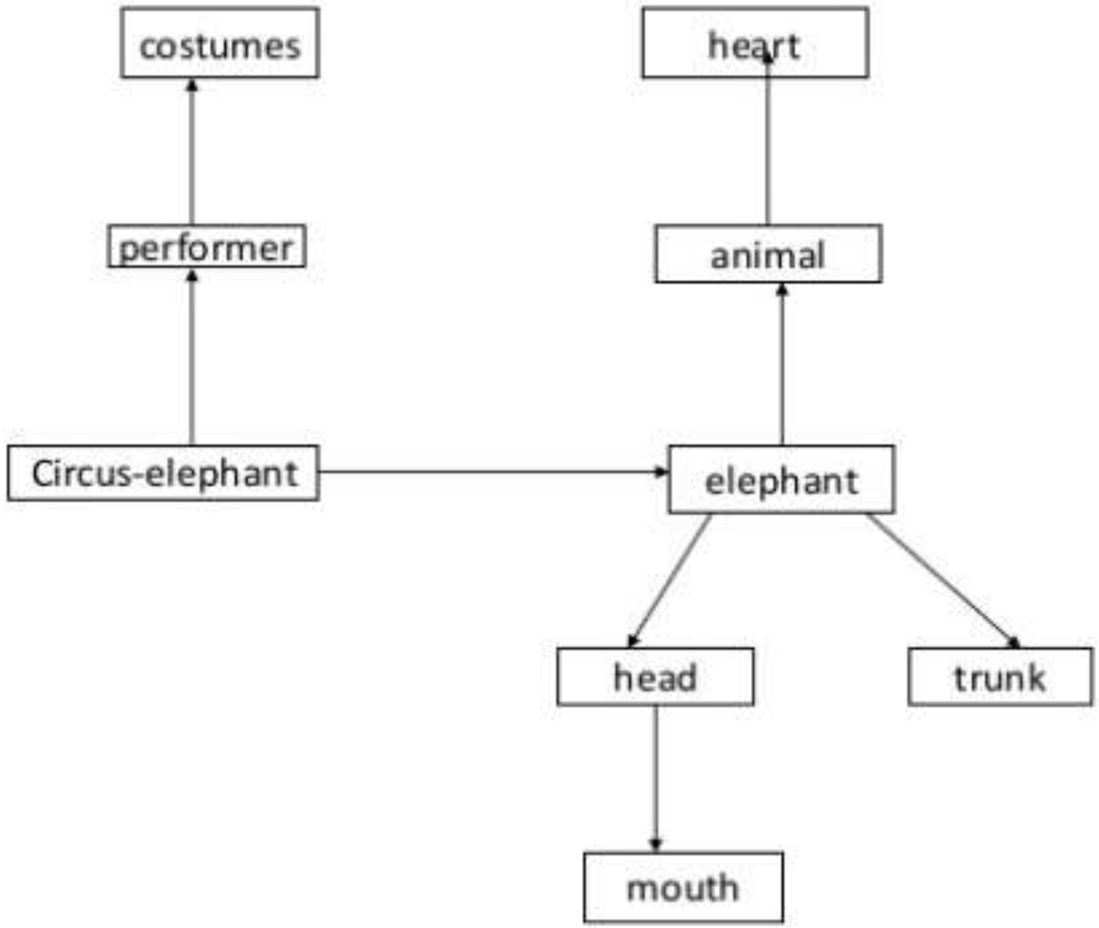
(4) humanities(HM101)

(5) ~likes(steve,x)

St	Clauses	Note
1	~easy(x) $\vee$ likes(steve,x)	P
2	~science(x) $\vee$ ~easy(x)	P
3	~humanities (x) $\vee$ easy(x)	P
4	humanities(HM101)	P
5	~likes(steve,x)	P
6	~easy(x)	1 & 5
7	~humanities (x)	3 & 6
8	NIL	4 & 7, x=HM101

Represent following information in Semantic net

- (is_a circus-elephant elephant)
- (has elephant head)
- (has elephant trunk)
- (has head mouth)
- (is_a elephant animal)
- (has animal heart)
- (is_a circus-elephant performer)
- (has performer costumes)


costumes
heart
performer
animal
Circus-elephant
elephant
head
trunk
mouth

Solve By using Resolution, Forward Chaining and Backward Chaining

1. India is a Team
2. Australia is a Team
3. Match between India and Australia
4. India scores 350 runs and Australia scores 350 runs, India lost by 5 wickets and Australia lost by 7 wickets
5. The team which scored the maximum runs wins
6. If the scores are then the team which lost minimum wickets wins the match

Prove by resolution that:

India wins the match

Step-1: Conversion of Facts into FOL

1. Team(India)
2. Team(Australia)
3. Team(India) ∧ Team(Australia)→Match(India, Australia)
4. Score(India, runs(350)) ∧ Score(Australia, runs(350)) ∧ lost(India, wickets(5)) ∧ lost(Australia, wickets(7))
5. ∀x : Team(x) ∧ Score(x, max(runs)) → wins(x, match)
6. ∀x , ∀y : Team(x) ∧ Team(y) ∧ Score(x, y, equal(runs)) ∧ lost(x, min(wickets)) → wins(x, match)

added predicates

7. Score(India, runs(350)) ∧ Score(Australia, runs(350)) → Score(India, Australia, equal(runs))
8. lost(India, wickets(5)) ∧ lost(Australia, wickets(7)) → lost(India, min(wickets))

To Prove

wins(India, match)

Step-2: Conversion of FOL into CNF

2.1 Eliminate all implication (→) and rewrite

1. Team(India)
2. Team(Australia)
3. ¬ (Team(India) ∧ Team(Australia)) V Match(India, Australia)
4. Score(India, runs(350)) ∧ Score(Australia, runs(350)) ∧ lost(India, wickets(5)) ∧ lost(Australia, wickets(7))
5. ∀x : ¬ (Team(x) ∧ Score(x, max(runs))) V wins(x, match)
6. ∀x , ∀y : ¬ (Team(x) ∧ Team(y) ∧ Score(x, y, equal(runs)) ∧ lost(x, min(wickets))) V wins(x, match)

$P \rightarrow Q = \neg P \vee Q$

added predicates

7. ¬ (Score(India, runs(350)) ∧ Score(Australia, runs(350))) V Score(India, Australia, equal(runs))
8. ¬ (lost(India, wickets(5)) ∧ lost(Australia, wickets(7))) V lost(India, min(wickets))

To prove

wins(India, match)

Forward Chaining

Backward Chaining