Inro to AI Assignment-5

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December 2022

1 Question 1

In the last paragraph of Ch.8.3.2, it says Often, one finds that the expected answers are not forthcoming, for example, from Spouse(Jim;Laura) one expects (under the laws of many countries) to be able to infer that ¬ Spouse(George;Laura); but this does not follow from the axioms given earlier - even after we add Jim /= George as suggested in Section 8.2.8. This is a sign that an axiom is missing.

Based on this paragraph,
1. It mentions "axioms given earlier", collect and show the axioms.
2. Does the fact ¬Spouse(George,Laura) follow from the facts Jim /= George and Spouse(Jim,Laura)? If so, give a proof; if not, supply additional axioms as needed.
3. What happens if we use Spouse as a unary function symbol instead of a binary predicate? How will this change affect the axioms you provide and what will be the new set of axioms if it affects?

Answer
1) Axioms are given below:

a) A sibling is a parent's other child

b) Men and women belong to separate/disjoint categories.

c) One's mother is one's female parent

d) One's husband is one's, male spouse

e) Parent and child relationship is an inverse relation

f) A grandparent is a parent of one's parent

2) ¬Spouse (George, Laura) follows from Jim+ George and Spouse(Jim, Laura)
No, it does not follow; to support the claim, we still require one more fact.
i.e. **∀x, y, z Spouse (x,z) ∧ Spouse(y,z)**

As a result, we can say that
Spouse (Jim, Laura) ∧ Spouse (George, Laura)→ Jim = George
But Jim != George => **Spouse (George, Laura)**

3) "Spouse as a unary function"
We know that
Jim! = George and Spouse(Laura) = Jim
From the above statements, we can say that: **¬Spouse (Laura) = Jim**

Therefore, even if a spouse is a unary function rather than a binary predicate, the solution is still correct.

2 Question 2

In Ch.9.3.1, the AI textbook describes an example when explaining first- order definite clauses, as shown in Fig. 1 Construct a model such that the sentences from (9.3) to (9.10) in Fig. 1 are all true (recall what a mode is in FOL and what are the components of a model).

Answer
Given below is an example (Figure 1.) from the Ch 9.3.1 in the AI textbook explaining about the first-order definite clauses.

Constructing a model (Figure 2.) such that the sentences from (9.3) to (9.10) in Figure 1 are all true.

Level 3 statements are by default true.

Because they are derived from the claims in level 3, statements at level 2 are true.

Statements at levels 2 and 3 are generated from the statement at level 1.

Let us put definite clauses to work in representing the following problem:

> The law says that it is a crime for an American to sell weapons to hostile nations. The country Nono, an enemy of America, has some missiles, and all of its missiles were sold to it by Colonel West, who is American.

First, we will represent these facts as first-order definite clauses:

"... it is a crime for an American to sell weapons to hostile nations":

$$American(x) \land Weapon(y) \land Sells(x,y,z) \land Hostile(z) \Rightarrow Criminal(x)\,. \tag{9.3}$$

"Nono ... has some missiles." The sentence $\exists x\ Owns(Nono,x) \land Missile(x)$ is transformed into two definite clauses by Existential Instantiation, introducing a new constant M_1:

$$Owns(Nono,M_1) \tag{9.4}$$

$$Missile(M_1) \tag{9.5}$$

"All of its missiles were sold to it by Colonel West":

$$Missile(x) \land Owns(Nono,x) \Rightarrow Sells(West,x,Nono)\,. \tag{9.6}$$

We will also need to know that missiles are weapons:

$$Missile(x) \Rightarrow Weapon(x) \tag{9.7}$$

and we must know that an enemy of America counts as "hostile":

$$Enemy(x,America) \Rightarrow Hostile(x)\,. \tag{9.8}$$

"West, who is American ...":

$$American(West)\,. \tag{9.9}$$

"The country Nono, an enemy of America ...":

$$Enemy(Nono,America)\,. \tag{9.10}$$

Figure 1: 9.3.1 First-order definite clauses

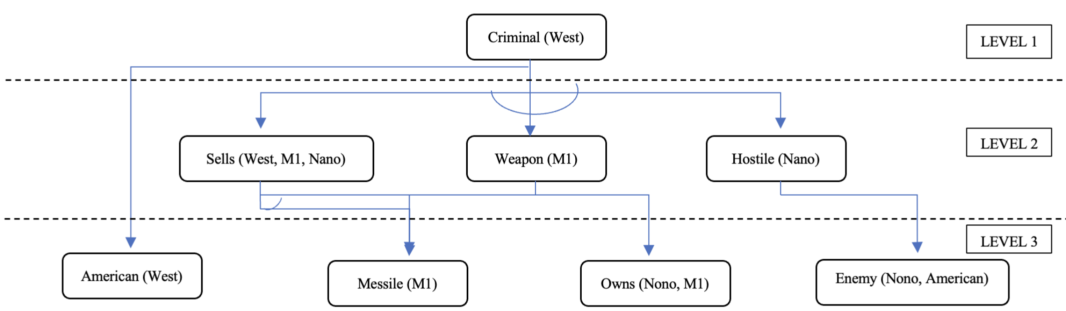

Figure 2: Model of First-order definite clauses

3 Question 3

Read Ch.9.5.3 and any other relevant sections to understand how resolution is used to prove ¬Criminal(West). Then use what you learned to prove Evil(John) with respect to the knowledge base in (9.1), shown in Fig. 2.
Answer

∀ King (n) ∧ greedy (n) => Evil (n)

STEP 1 → Convert to CNF form
¬ (King (n) ∧ greedy (n)) V Evil (n)

Apply demorgans
(¬ King (n) ∧ ¬ greedy (n)) V Evil (n)

Distribution Law
(¬King (n) V Evil (n)) ∧ (¬ greedy (n) V Evil (n))

STEP 2 → List all the statements and negated goals

King (n) V Evil (n)
A2 – ¬ (greedy (n) V Evil (n))
B - King (Jhon)
C - greedy (Jhon)
D - Brother (Richard, Jhon)
¬E - ¬ Evil (Jhon)

We can prove the negation first and prove that John is King, and John is greedy

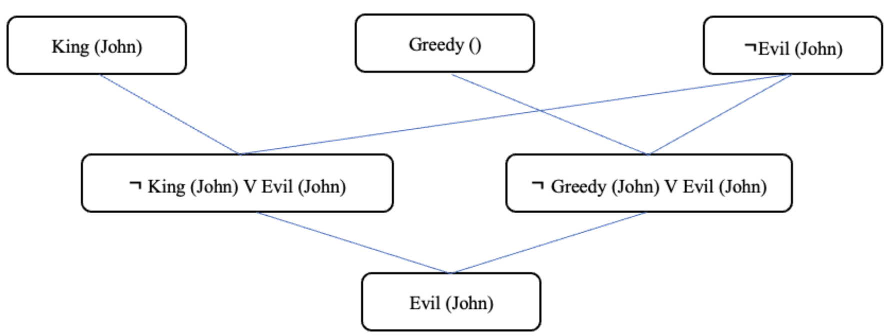

Figure 3: This model shows that the John is king and John is Greedy.

4 Question 4.

Let $\mathcal{L}$ be the first-order language with a single predicate S (p, q), meaning "p shaves q". Assume a domina of people.

a. Consider the sentence "There exists a person P who shaves everyone who does not shave themselves, and only people that do not shave themselves." Express this in L.
b. Convert the sentence you just obtained to clausal form.
c. Construct a resolution proof to show that the clauses just obtained are inherently inconsistent.

(Note: you do not need any additional axioms.)

Answer

Given to us:
Considering the statement "There exists a person P who shaves everyone who does not shave themselves, and only people that do not shave themselves."

a. Express the sentence in $\mathcal{L}$.

∃p ∀ q person(p) ∧ person(q) ∧ (¬S(q,q) ←→ S (p,q)) ....eq 1

b. Converting the above sentences into casual form

First-order formula:

From equation 1,

∃p ∀ q person(p) ∧ person(q) ∧ (¬S(q,q) ←→ S (p,q)) (1)

∃p ∀ q person(p) ∧ person(q) ∧ (¬S(q,q) → S (p,q)) ∧ (S(p,q) → ¬S (q,q)) (2)

By removing implications:

∃p ∀ q person(p) ∧ person(q) ∧ (¬S(q,q) V S (p,q)) ∧ (¬S(p,q) V ¬S (q,q)) (3)

Skolemize off the existence:

∀ q person(p) ∧ person(q) ∧ (¬S(q,q) V S (p,q)) ∧ (¬S(p,q) V ¬S (q,q)):{p=P} (4)

By dropping the universal qualifier:

person(p) ∧ person(q) ∧ (¬S(q,q) V S (p,q)) ∧ (¬S(p,q) V ¬S (q,q)) (5)

References

[RN22] Stuart J. Russell and Peter Norvig. Artificial intelligence: A modern approach. pages 299–322, 2022.