CS 710 - Artificial Intelligence

Homework 3

Logics and Logics Programming

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1 Question 1

1.1

Question 1a:

The suspects in a robbery are Anne, Betty, and Chloe. Exactly one of the suspects is guilty. When questioned, a guilty suspect might lie or tell the truth, but an innocent one always tells the truth. Anne tells the police that Betty is innocent. Betty tells them that she was out of town the day the robbery occurred. Chloe says that Betty was in town the day of the robbery. If a suspect is out of town the day of the robbery, then she must be innocent.

Facts

$$\neg Guilty(Anne) \Rightarrow \neg Guilty(Betty) \tag{1}$$
$$\neg Guilty(Betty) \Rightarrow OutOfTown(Betty) \tag{2}$$
$$\neg Guilty(Chloe) \Rightarrow \neg OutOfTown(Betty) \tag{3}$$
$$OutOfTown(x) \Rightarrow \neg Guilty(x) \tag{4}$$
$$\neg OutOfTown(x) \Rightarrow Guilty(x) \tag{5}$$
$$Guilty(Anne) \vee Guilty(Chloe) \vee Guilty(Betty) \tag{6}$$

Facts in CNF

$$Guilty(Anne) \vee \neg Guilty(Betty) \tag{7}$$
$$Guilty(Betty) \vee OutOfTown(Betty) \tag{8}$$
$$Guilty(Chloe) \vee \neg OutOfTown(Betty) \tag{9}$$
$$\neg OutOfTown(x) \vee \neg Guilty(x) \tag{10}$$
$$Guilty(x) \vee OutOfTown(x) \tag{11}$$
$$Guilty(Anne) \vee Guilty(Chloe) \vee Guilty(Betty) \tag{12}$$

Proof - Find who is guilty
Using Answer Extraction find $\neg Guilty(x) \vee Answer(x)$ I was unable to find a proof using answer extraction.

1.2

Question 1b:
Prolog Representation
I was unable to find a working solution using prolog. Code can be found in file `suspects_kb.pl`

2 Question 2

Knowledge Base Stuff Note, the KB makes use of the following roles:

has-part

is-part-of the inverse of has-part; they are both transitive manages

is-managed-by (the inverse of manages)

employs

is-employed-by (the inverse of employs)

Properties:

a. An enterprise is managed by someone and employs someone.

b. A department is a part of an enterprise.

c. An office is a part of a department.

d. If someone manages some entity then he is an employee.

Definitions:

e. The departments are exactly: Production, Research, Ad ministration, Trade, HumanResources, and PublicRelations.

f. An employee is someone who is employed by an enterprise or by some part of an enterprise.

g. An administrative-employee is someone who is employed by an administration department or by some part of an administration department.

h. A high-tech enterprise is an enterprise which has a research department.

i. An industrial enterprise is an enterprise which has a production department and has at least 100 employees.

j. A small enterprise is an enterprise which employs at most 20 employees.

k. A big enterprise is an enterprise which employs at least 80 employees.

l. A family-based enterprise is an enterprise with at most 4 employees.

m. A top manager is someone who manages a big enterprise.

n. A manager is someone who manages a department.

o. A boss is someone who manages an office.

Facts (assertions):

p. Alcatel is an enterprise which has 2000 employees.

q. Alcatel has a research department RD1, an administratio

n. department AD1, and a HumanResources department HRD1; it has also a production department

r. OFF1 and OFF2 are offices and are part of RD1.

s. OFF3 and OFF4 are offices and are part of AD1.

t. Joe and Anne are employed by OFF3.

u. Jim manages the department AD3.

v. Bob manages OFF3.

w. Jim manages Alcatel.

x. SmithBrothers is a family-based enterprise.

y. Frank, Lea, Dave, Kate, Dino are employed by SmithBrothers.

2.1

Question 2a: Represent Knowledge base as a prolog program.

Please see `ents_kb.pl`

2.2

Question 2b: Represent Knowledge base as a set of Description logic expressions.

Properties

$$\begin{aligned} enterprise &\rightarrow [EXISTS\ 1 : is-managed-by] \\ enterprise &\rightarrow [EXISTS\ 1 : employs] \\ department &\rightarrow [FILLS : is-a-part-of\ enterprise] \\ office &\rightarrow [FILLS\ \ : is-a-part-of\ department] \\ employee &\rightarrow [EXISTS\ 1 : manages] \end{aligned}$$

Definitions

$$Departments:$$
$$Production \equiv department$$
$$Research \equiv department$$
$$Administration \equiv department$$
$$Trade \equiv department$$
$$HumanResources \equiv department$$
$$PublicRelations \equiv department$$

$$employee \equiv [SOME-OF\ :is-employed-by\ [UNION\ enterprise\ [ALL\ :is-part-of\ enterprise]]]$$

$$admin-employee \equiv [SOME-OF\ :is-employed-by\ [UNION\ admin-department\ [ALL\ :is-part-of\ admin-department]]]$$

$$hitech-ent \equiv [FILLS\ :has-part\ research-department]$$

$$indust-ent \equiv [FILLS\ :has-part\ prod-department\ [EXISTS\ 100\ :employs]$$

$$small-ent \equiv [AND\ enterprise\ [AT-MOST\ 20\ :employs]]$$

$$big-ent \equiv [AND\ enterprise\ [EXISTS\ 80\ :employs]]$$

$$fam-based-ent \equiv [AND\ enterprise\ [AT-MOST\ 4\ :employs]]$$

$$top-manager \equiv [AND\ :manages\ [ONE-OF\ big-ent]]$$

$$manager \equiv [AND\ [AT-LEAST\ 1\ :manages]\ [ALL\ :manages\ departments]]$$

$$boss \equiv [AND\ [AT-LEAST\ 1\ :manages]\ [ALL\ :manages\ office]]$$

Facts(assertions):

$$\begin{aligned}
Alcatel &\rightarrow [AND\ big-ent\ [EXISTS\ 2000\ :employs]\\
Alcatel &\rightarrow [FILLS : has-part\ [RD1,\ AD1,\ HRD1,\ [ONE-OF\ Production]]\\
OFF1 &\rightarrow [AND\ office\ [FILLS\ :is-part-of\ RD1]]\\
OFF2 &\rightarrow [AND\ office\ [FILLS\ :is-part-of\ RD1]]\\
OFF3 &\rightarrow [AND\ office[FILLS\ :is-part-of\ AD1]]\\
OFF3 &\rightarrow [AND\ office[FILLS\ :is-part-of\ AD1]]\\
Joe &\rightarrow [FILLS\ :is-employed-by\ OFF3]\\
Anne &\rightarrow [FILLS\ :is-employed-by\ OFF3]\\
Jim &\rightarrow [FILLS\ :manages\ AD3]\\
Bob &\rightarrow [FILLS\ :manages\ OFF3]\\
Jim &\rightarrow [FILLS\ :manages\ Alcatel]\\
SmithBrothers &\rightarrow [AND\ fam-based-ent]\\
Frank &\rightarrow [FILLS\ :is-employed-by\ SmithBrothers]\\
Lea &\rightarrow [FILLS\ :is-employed-by\ SmithBrothers]\\
Dave &\rightarrow [FILLS\ :is-employed-by\ SmithBrothers]\\
Kate &\rightarrow [FILLS\ :is-employed-by\ SmithBrothers]\\
Dino &\rightarrow [FILLS\ :is-employed-by\ SmithBrothers]
\end{aligned}$$

2.3

Question 2c: For each representation framework, provide at least 2 interesting conclusions that can be drawn from the KB (possibly the same for both frameworks.)

Description Logic

- Given that SmithBrothers is an enterprise with 6 departments and only 4 employees, several employees must work in several departments.
- Since Jim manages Alcatel and Alcatel is a big enterprise, Jim manages at least 100 employees.

Prolog

- Joe and Anne are employees of Alcatel.
- Since Jim manages Alcatel and Alcatel is a big enterprise, Jim manages at least 100 empl

2.4

Contrast between description logic and prolog:

In prolog, I found it difficult to not be able *remember* values inferenced by clauses - instead I found I had to change my normal way of thinking and pass values as parameters to other clauses.

I had a hard time wrapping my head around the description logic syntax. In my current internship, I regularly work with bio-medical ontologies in OWL and SKOSXL format and for some reason I had a difficult time transferring that knowledge to description logic. Once overcoming the syntax, I found it quite nice to work with; I especially liked being able to compartmentalize knowledge and facts as *definitions*, *roles*, and *properties*.

One thing that I found myself getting hung up on with both prolog and description logic was not defining certain predicates and properties, respectively.

3 Files of interest in this directory

- `suspects_kb.pl` - Knowledge base for question 1B
- `ent_kb.pl` - Knowledge for question 2B