Knowledge Representation and Semantic Technologies – 23/7/2018

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Exercise 1 Given the following $\mathcal{ALC}$ TBox:

$$\begin{array}{lcl} A & \sqsubseteq & \exists R.C \\ B & \sqsubseteq & \forall R.D \\ D & \sqsubseteq & \neg C \\ E & \sqsubseteq & A \sqcup \forall R.G \\ F & \sqsubseteq & B \sqcup \exists R.C \\ G & \sqsubseteq & D \end{array}$$

(a) tell whether the TBox $\mathcal{T}$ is satisfiable, and if so, show a model for $\mathcal{T}$;

(b) tell whether the concept E is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where E is satisfiable;

(c) tell whether the concept $E \sqcap F$ is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where $E \sqcap F$ is satisfiable;

(d) given the ABox $\mathcal{A} = \{E(a), R(a, b)\}$, tell whether the knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$ entails the assertion $C(b)$, explaining your answer.

Exercise 2 Given the following ASP program P:

```
r(x,y) :- p(x,y,z).
s(x,y) :- p(z,x,y).
t(x,y) :- r(x,y), s(y,z).
v1(x,y,z) :- r(x,y), s(y,z).
v2(x,y,z) :- v1(x,y,z), not p(x,y,z).
w(x,y) :- t(x,y), not s(x,y).
w(x,y) :- t(x,y), not r(x,y).
w(x,y) :- t(x,y), not v1(x,y,z).
w(x,y) :- t(x,y), not v2(x,y,z).
p(a,b,c). p(b,c,d). p(c,d,e). p(e,f,g).
```

(a) tell whether P is stratified;

(b) compute the answer sets of P.

Exercise 3

We want to formalize knowledge about the domain of movies. In particular, we want to formalize the following statements:

1. every director is a person;
2. every actor is a person;
3. the property "worked in" has domain person and range movie;
4. the property "acted in" has domain actor and range movie;
5. the property "directed by" has domain movie and range director;
6. the property "acted in" is a subproperty of "worked in";
7. if a director was born in Italy, she/he is an Italian director;
8. if a director was born in a European country, she/he is a European director;
9. an actor-director is a director who is also an actor;
10. every movie directed by an actor-director is a special movie;
11. every movie directed by a European director is a European movie.

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following ones: $\mathcal{ALC}$, Datalog, Datalog with constraints, ASP, OWL, *DL-Lite*$_R$, $\mathcal{EL}$, *RL*, RDFS, motivating your choice;

(b) express the above knowledge in the formalism chosen at the previous point.

Exercise 4

(a) Write an RDF/RDFS model representing the following statements about URIs `Employee`, `Manager`, `Division`, `TopManager`, `Person`, `Man`, `Woman`, `City`, `livesIn`, `worksWith`, `isManagerOf`, `leadsDivision`, `locatedIn`, `Ann`, `Bob`, `Jane`, `Joe`, `Rome`, `Naples`, `ABC`, `XYZ`.

1. `Employee`, `Manager`, `TopManager`, `Division`, `Man`, `Woman` and `City` are classes;

2. `TopManager` is a subclass of `Manager` which is a subclass of `Employee`;
3. `worksWith`, `livesIn`, `isManagerOf`, `leadsDivision` and `locatedIn` are properties;
4. `isManagerOf` is a subproperty of `worksWith`;
5. `isManagerOf` has domain `Manager` and range `Employee`;
6. `worksWith` has domain `Employee` and range `Employee`;
7. `livesIn` has domain `Person` and range `City`;
8. `locatedIn` has domain `Division` and range `City`;
9. Jane is a manager;
10. Bob and Ann are employees;
11. Joe is manager of Bob;
12. Jane lives in Rome;
13. Mary leads division XYZ of the company;
14. division ABC is located in Naples.

(b) Write SPARQL queries corresponding to the following requests: (b1) "return every employee that works with an employee that lives in Naples, and, optionally, the manager of such an employee"; (b2) "return every top manager that leads a division that is located in the same city where she/he lives".

Exercise 5

(a) Write an OWL ontology that formalizes the domain described at point (a) of Exercise 4.

(b) Add to the above ontology the axioms formalizing the following statements:

1. `City` and `Division` are disjoint classes;
2. every manager manages at least three employees;
3. every division is located in exactly one city;
4. every employee works with at least one man and works with at least one woman.
5. every manager leads at most one division;
6. `RomanManager` is the class of managers who lead a division located in Rome.

Then, tell whether the resulting OWL ontology is redundant, i.e.: can some of the axioms constituting the ontology be deleted without changing the meaning of the ontology? if so, identify and list such axioms.

Exercise 6

Axiomatize the following scenario, appropriately with action precondition and effect axioms, and obtain successor state axioms.

Fluents:

- `windowOpen(s)` - The window is open in situation s.
- `robotCloseToWindow(s)` - The robot is close to the window in situation s.
- `objectInsideRoom(s)` - The object is inside the room in situation s.

Actions:

- `openWindow` - The robot opens the window. This can be done if the robot is close to the window, and has the effect that the window will be open.
- `closeWindow` - The robot closes the window. This can be done if the robot is close to the window, and has the effect that the window will be closed.
- `moveCloseToWindow` - The robot moves close to the window. This can always be done, and has the effect that the robot will be close to the window.
- `throwObject` - The robot throws the object outside the window. This requires that the oject is inside the room, the window is open and the robot is close to the window, and has the effect that the object will be outside the room.

Initial situation description: Initially the robot is not close to the window, the window is closed, and the object is inside the room.