Knowledge Representation and Semantic Technologies – 17/2/2015

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

$$\begin{array}{rcl} A & \sqsubseteq & \exists R.B \\ \forall R.C & \sqsubseteq & D \\ D & \sqsubseteq & \forall R.E \\ B & \sqsubseteq & C \\ D & \sqsubseteq & \neg E \end{array}$$

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

(b) tell whether the concept A is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where the interpretation of B is non-empty;

(c) given the ABox $\mathcal{A} = \{D(a), R(a,b), D(b)\}$, tell whether the knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$ is satisfiable (consistent), explaining your answer.

Exercise 2 Given the following ASP program P:

```
r(x,y) :- p(x,y), p(y,x).
s(x,y) :- q(x,y).
s(x,y) :- s(z,y), q(x,z).
t(x,y) :- p(x,y), not r(x,y).
u(x,y) :- t(x,y), not s(x,y).
v(x,y) :- s(x,y), not t(x,y).
p(a,b). p(b,a). p(b,c). p(c,d). q(a,b). q(b,c). q(c,d).
```

(a) tell whether P is stratified;

(b) compute the answer sets of P.

Exercise 3 We want to formalize knowledge about the domain of employees. In particular, we want to formalize the following statements:

1. every employee is a person;
2. every manager is an employee;
3. property "has manager" has domain employee and range manager;
4. every employee has at least a manager;
5. property "knows" has domain person and range person;
6. property "has manager" is a subproperty of property "knows".

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following: $\mathcal{ALC}$, Datalog, ASP, OWL, DL-Lite, RDFS;

(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 `Person`, `Director`, `Actor`, `Country`, `Movie`, `filmedIn`, `isDirectorOf`, `actsIn`, `bornIn`, `Jane`, `Joe`, `Mary`, `Paul`, `Italy`, `ABC`, `XYZ`.

1. `Person`, `Director`, `Actor`, `Country` and `Movie` are classes;
2. `Director` and `Actor` are subclasses of `Person`;
3. `actsIn`, `bornIn`, `filmedIn` and `isDirectorOf` are properties;
4. `isDirectorOf` has domain `Director` and range `Movie`;
5. `flmedIn` has domain `Movie` and range `Country`;
6. `bornIn` has domain `Person` and range `Country`;
7. `actsIn` has domain `Actor` and range `Movie`;
8. Jane is the director of movie XYZ;
9. Paul and Mary act in movie ABC;
10. ABC was filmed in Italy;

11. Joe is a director.

(b) Write SPARQL queries corresponding to the following requests: (b1) "return all directors that have directed at least a movie filmed in Italy"; (b2) "return every actor that was born in the same country in which the director of movie ABC was born in".

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. add the new classes `EuropeanDirector` and `EuropeanMovie` and state that `EuropeanMovie` corresponds to the class of movies directed by European directors;
2. add a new property `isDirectedBy` and state that it is the inverse of `isDirectorOf`;
3. every movie is filmed in at least one country;
4. `Country` and `Movie` are disjoint classes;
5. `bornIn` and `actsIn` are disjoint properties;

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 (that is, the models) of the ontology? if so, identify and list such axioms.

Exercise 6

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

Fluents:

- `doorOpen(s)` - The door is open in situation s.
- `windowOpen(s)` - The window is open in situation s.
- `outsideRoom(s)` - The robot is outside the room in situation s.

Actions:

- `openWindow` - The robot opens the window. This can be done if the robot is inside (that is, not outside) the room and the window is closed (that is, not open), and has the effect that the window will be open.
- `closeDoor` - The robot closes the door. This can be done if the robot is outside the room and the door is open, and has the effect that the door will be closed (that is, not open).
- `exit` - The robot goes out of the room. This requires that the door is open and the robot is inside the room, and has the effect that the robot will be outside the room.

Initial situation description: Initially the robot is inside the room, the window is closed and the door is open.

(b) Show, by applying regression, that the window will be open after the sequence of actions `openWindow, exit, closeDoor`, and that the sequence of actions is indeed executable.