Knowledge Representation and Semantic Technologies – 15/6/2015

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

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

(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 $\mathcal{A} = \{D(a)\}$, 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) :- p1(x), p2(y).
r(x,y) :- r(x,z), r(z,y).
s(x,y) :- p2(x), p1(y).
t(x,y) :- r(x,y), not s(x,y).
v(x,y) :- s(x,y), not r(x,y).
w(x) :- t(x,y), not v(x,y).
p1(a). p1(b). p2(a). p2(c). p2(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. every project is either a research project or an industrial project;
4. every employee has at least a manager;
5. every employee works in at least an industrial project;
6. the property 'has manager" has domain employee and range manager.

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following: $\mathcal{ALC}$, Datalog, ASP, OWL, DL-Lite, 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 `Person`, `Director`, `Actor`, `Country`, `Movie`, `ComedyMovie`, `Male`, `Female`, `filmedIn`, `isDirectorOf`, `actsIn`, `bornIn`, `Joe`, `Mary`, `Ann`, `Paul`, `France`, `ABC`, `XYZ`.

 1. `Person`, `Director`, `Actor`, `Country`, `Movie`, `ComedyMovie`, `Male`, and `Female` are classes;
 2. `Male` and `Female` 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. Ann is the director of movie XYZ;
 9. Joe and Paul act in movie ABC;
 10. ABC was filmed in France;
 11. Ann is female.

12. Paul is male.

(b) Write SPARQL queries corresponding to the following requests: (b1) "return the directors of movies with at least one male actor"; (b2) "return every female director and, optionally, the country she 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 a new property `directed` and state that it is the inverse of `isDirectorOf`;
2. add the new class `DramaDirector` and state that `DramaDirector` corresponds to the class of directors who directed at least four comedy movies;
3. every actor is born in exactly one country;
4. every movie is filmed in at least one country;
5. `Male` and `Female` are disjoint classes.
6. `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:

- `boxOpen(s)` - The box is open in situation s.
- `closeToBox(s)` - The robot is close to the box in situation s.
- `objectOutsideBox(s)` - The object is outside the box in situation s.

Actions:

- `moveCloseToBox` - The robot moves close to the box. This can be done if the robot is not close to the box, and has the effect that the robot will be close to the box.
- `openBox` - The robot opens the box. This can be done if the robot is close to the box and the box is closed, and has the effect that the box will be open.
- `extractObject` - The robot extracts the object inside the box. This requires that the box is open and the robot is close to the box, and has the effect that the object will be outside the box.

Initial situation description: Initially the robot is not close to the box, the box is open, and the object is inside the box.

(b) Show, by applying regression, that the object will be outside the box after the sequence of actions `moveCloseToBox, extractObject`, and that the sequence of actions is indeed executable.