Knowledge Representation and Semantic Technologies – 21/7/2017

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

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

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

(b) given the ABox $\mathcal{A} = \{C(a)\}$, tell whether the knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$ is satisfiable (consistent), and if so, show a model for $\langle \mathcal{T}, \mathcal{A} \rangle$;

(c) given the ABox $\mathcal{A}' = \{C(a), \forall R.F(a)\}$, tell whether the knowledge base $\langle \mathcal{T}, \mathcal{A}' \rangle$ is satisfiable (consistent), and if so, show a model for $\langle \mathcal{T}, \mathcal{A}' \rangle$;

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

Exercise 2 Given the following ASP program P:

```
r(x,y) :- p1(x), p2(y).
s(x,y) :- r(x,y), not p2(x), not p1(y).
t(x,y) :- s(x,y).
t(y,z) :- s(x,y), t(x,z).
v(x,y) :- r(x,y), not s(x,y).
w(x,y) :- r(x,y), not v(x,y).
p1(a). p1(b). p1(c). p2(b). p2(c). p2(d). p2(e).
```

(a) tell whether P is stratified;

(b) compute the answer sets of P.

Exercise 3

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

1. every student is a person;
2. every professor is a person;
3. student and professor are disjoint classes;
4. the property "is friend of" has domain person and range person;
5. the property "studies with" has domain student and range student;
6. the property "studies with" is a subproperty of the property "is friend of";
7. every professor that is the supervisor of at least one student is an active professor;
8. every professor that is also a student is a special professor;
9. every student studies with at least one student;
10. every student has a friend.

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following: $\mathcal{ALC}$, Datalog with constraints, ASP, OWL, $DL\text{-}Lite_R$, $\mathcal{EL}$, 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 `Person`, `Director`, `Actor`, `Writer`, `Movie`, `Country`, `Continent`, `Comedy`, `Drama`, `Man`, `Woman`, `filmedInYear`, `filmedInCountry`, `hasBoxOfficeGross`, `isDirectorOf`, `isWriterOf`, `actsIn`, `bornIn`, `Joe`, `Mary`, `Ann`, `Paul`, `Italy`, `France`, `Europe`, `ABC`, `XYZ`.

1. `Person`, `Director`, `Writer`, `Actor`, `Country`, `Continent`, `Movie`, `Comedy`, `Drama`, `Man`, and `Woman` are classes;
2. `Man` and `Woman` are subclasses of `Person`;

3. `Comedy` and `Drama` are subclasses of `Movie`;
4. `actsIn`, `bornIn`, `filmedInCountry`, `isDirectorOf` and `isWriterOf` are properties;
5. `isDirectorOf` has domain `Director` and range `Movie`;
6. `filmedInYear` has domain `Movie` and range `xsd:integer`;
7. `filmedInCountry` has domain `Movie` and range `Country`;
8. `bornIn` has domain `Person` and range `Country`;
9. `actsIn` has domain `Actor` and range `Movie`;
10. `isInContinent` has domain `Country` and range `Continent`;
11. Ann is the director and the writer of movie XYZ;
12. Joe and Paul act in movie ABC;
13. ABC was filmed in France in 2015;
14. Ann is a woman;
15. Italy and France are in Europe.

(b) Write SPARQL queries corresponding to the following requests: (b1) return all the directors of the movies filemd in Europe in 2016; (b2) return the dramas filmed in Italy and played by at least an Italian actor, and, optionally, the year when the movie was filmed.

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 `isWrittenBy` and state that it is the inverse of `isWriterOf`;
2. add a new class `WrittenByMultipleAuthors` and state that it corresponds to the class of movies written by at least two writers;
3. add the new class `allFemaleCast` and state that such a class corresponds to the class consisting of every movie whose writers, directors and actors are all women;
4. add a new class `LowBudgetMovie` and state that it corresponds to the class of movies played by at most 5 actors;
5. add the new class `EuropeanMovie` and state that such a class corresponds to the class consisting of every movie having at least a director who was born in Europe.

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:

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

Actions:

- `goInsideRoom` - The robot goes inside the room. This can be done if the robot is not inside the room, and has the effect that the robot will be inside the room.
- `goOutsideRoom` - The robot goes outside the room. This can be done if the robot is inside the room and the window is open, and has the effect that the robot will be outside the room.
- `goCloseToWindow` - The robot moves close to the window. This can be done if the robot is not close to the window and is inside the room, and has the effect that the robot will be close to the window.
- `closeWindow` - The robot closes the window. This can be done if the robot is close to the window and the window is open, and has the effect that the window will be closed.

Initial situation description: Initially the robot is outside the room, is not close to the window, and the window is open.

(b) Show, by applying regression, that the window is closed after the sequence of actions `goInsideRoom, goCloseToWindow, closeWindow, goOutsideRoom`, and that the sequence of actions is indeed executable.