Knowledge Representation and Semantic Technologies – 14/6/2017

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

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

(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 A is non-empty;

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

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

Exercise 2 Given the following ASP program P:

```
r(x,y) :- p1(y), p2(x).
s(x,y) :- q(x,y).
s(x,y) :- q(x,z), s(z,y).
t(x,y) :- r(x,y), not s(x,y).
t(x,y) :- s(x,y), not r(x,y).
v(x,y) :- t(x,y).
v(x,y) :- t(y,x).
w(x,y) :- v(x,y), not r(x,y).
p1(c). p1(d). p2(a). p2(b). p2(c).
q(a,b). q(b,c). q(c,d). q(d,e). q(e,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 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. busy person is a subclass of person;
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 is a friend of at least one professor;
8. every student studies with at least one student;
9. everyone who is both a student and a professor is a busy person.

(a) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following: $\mathcal{ALC}$, Datalog, 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 `Person`, `Director`, `Actor`, `Writer`, `Movie`, `Country`, `Comedy`, `Drama`, `Man`, `Woman`, `filmedIn`, `hasBoxOfficeGross`, `isDirectorOf`, `isWriterOf`, `actsIn`, `bornIn`, `Joe`, `Mary`, `Ann`, `Paul`, `Italy`, `France`, `ABC`, `XYZ`.

1. `Person`, `Director`, `Writer`, `Actor`, `Country`, `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`, `filmedIn`, `isDirectorOf` and `isWriterOf` are properties;
5. `isDirectorOf` has domain `Director` and range `Movie`;
6. `flmedIn` has domain `Movie` and range `Country`;
7. `bornIn` has domain `Person` and range `Country`;
8. `actsIn` has domain `Actor` and range `Movie`;
9. `hasBoxOfficeGross` has domain `Movie` and range `xsd:integer`;
10. Ann is the director and the writer of movie XYZ;
11. Joe and Paul act in movie ABC;
12. ABC was filmed in France;
13. Ann is a woman;
14. Paul is a man.

(b) Write SPARQL queries corresponding to the following requests: (b1) return all the pairs of movies having the same writer and such that at least one actor acts in both movies; (b2) return the directors of comedies filmed in Italy, and, optionally, the country where the director was born.

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 a new class `LowBudgetMovie` and state that it corresponds to the class of movies played by at most 5 actors;
4. add the new class `ItalianMovie` and state that such a class corresponds to the class consisting of every movie such that all its writer(s) and director(s) were born in Italy.

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:

- `boxClosed(s)` - The box is closed in situation s.
- `robotCloseToBox(s)` - The robot is close to the box in situation s.
- `objectInsideBox(s)` - The object is inside 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 (that is, not closed).
- `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 closed, 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, openBox, extractObject`, and that the sequence of actions is indeed executable.