Knowledge Representation and Semantic Technologies – 1/2/2022

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

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

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

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

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

(d) given the ABox $\mathcal{A} = \{F(a), r(a, b)\}$, use the tableau method to establish whether the knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$ entails the assertion $B(b)$.

Exercise 2 Given the following ASP program P:

```
r(X,Y) :- q(X,Y).
r(X,Y) :- q(X,Z), r(Z,Y).
s(X,Y) :- p(X), p(Y), r(X,Y).
t(X,Y) :- r(X,Y), not r(X,X).
v(X,Y) :- p(X), p(Y), not r(X,X).
v(X,Y) :- p(X), p(Y), not s(X,Y).
v(X,Y) :- q(X,Y), not t(X,Y).
p(a). p(c). p(d).
q(a,b). q(b,c). q(c,a). q(c,d).
```

(a) tell whether P is stratified;

(b) compute the answer sets of P.

Exercise 3

We want to formalize knowledge about persons and kinship relationships. In particular, we want to formalize the following statements:

1. every woman is a person;
2. every man is a person;
3. for every x, y, z, if x has child y and x is a woman, then y has mother x;
4. for every x, y, z, if x has child y and x is a man, then y has father x;
5. for every x, y, if x has mother y, then x does not have father y;
6. for every x, y, if x has father y, then x does not have mother y;
7. for every x, y, if x has mother y, then y does not have mother x;
8. for every x, y, if x has father y, then y does not have father x;
9. for every x, y, z, if x has mother y and y has mother z, then x has grandmother z.

(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, $DL\text{-}Lite_R$, $\mathcal{EL}$, 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`, `HasParent`, `HasMother`, `HasFather`, `Man`, `Woman`, `City`, `livesIn`, `Ann`, `Bob`, `Jane`, `Mary`, `Paul`, `Sandy`, `Rome`, `Milan`,

1. `Person`, `Man`, `Woman`, and `City` are classes;
2. `Man` and `Woman` are subclasses of `Person`;
3. `HasParent`, `HasMother`, `HasFather`, `livesIn`, are properties;
4. `IsMother` and `HasFather` are subproperties of `HasParent`;

5. `HasParent` has domain `Person` and range `Person`;
6. `HasMother` has domain `Person` and range `Woman`;
7. `HasFather` has domain `Person` and range `Man`;
8. `livesIn` has domain `Person` and range `City`;
9. Jane is a woman;
10. Jane has father Bob;
11. Paul is the son of Ann;
12. Mary and Bob are the children of Paul and Sandy;
13. Jane and Bob live in Milan.

(b) Write SPARQL queries corresponding to the following requests: (b1) return all the pairs of siblings (i.e., the pairs of persons who have the same parents); (b2) return all the grandparents of Jane and, optionally, the city where they live; (b3) return the men who live in the cities where at least a grandchild of Paul lives.

Exercise 5

Given the *RL* knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$, where $\mathcal{T}$ is the following TBox:

$$
\begin{array}{l}
C \sqcap D \sqsubseteq G \\
E \sqcap D \sqsubseteq H \\
s \sqsubseteq r \\
t \sqsubseteq r \\
r^{-} \sqsubseteq u \\
\exists u.\top \sqsubseteq F \\
\exists u.F \sqsubseteq D \\
\exists t^{-}.\top \sqsubseteq C \\
\exists s^{-}.\top \sqsubseteq E
\end{array}
$$

and $\mathcal{A}$ is the following ABox:

$$t(a_5, a_4), \quad s(a_5, a_3), \quad t(a_4, a_2), \quad s(a_4, a_1), \quad t(a_3, a_7), \quad s(a_2, a_6)$$

1. compute the materialization of the ABox $\mathcal{A}$ with respect to the TBox $\mathcal{T}$;
2. tell whether the concept assertion $G(a_7)$ is entailed by $\langle \mathcal{T}, \mathcal{A} \rangle$;
3. write a Datalog program corresponding to the above TBox.