Knowledge Representation and Semantic Technologies – 5/7/2022

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

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

(a) tell whether the concept A is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where A is satisfiable, otherwise explain your answer;

(b) tell whether the concept $A \sqcap F \sqcap G$ is satisfiable with respect to $\mathcal{T}$, and if so, show a model for $\mathcal{T}$ where $A \sqcap F \sqcap G$ is satisfiable, otherwise explain your answer;

(c) given the ABox $\mathcal{A} = \{A(a), F(a), r(a,b)\}$, tell whether the knowledge base $\langle \mathcal{T}, \mathcal{A} \rangle$ entails the assertion $\neg E(b)$, explaining your answer;

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

Exercise 2 Given the following ASP program P:

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

(a) tell whether P is stratified;

(b) compute the answer sets of P;

(c) tell whether the fact `w(c,a)` is entailed by P.

Exercise 3

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

1. every student is a person;
2. every worker is a person;
3. student and worker are disjoint classes;
4. every person has a father who is a person;
5. every person has a mother who is a person;
6. every student is either a bachelor student or a master student.
7. every student who is both a bachelor student and a master student is a special student.

(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-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 the men who live in the cities where at least a grandchild of Paul lives; (b3) return all the descendants of Mary.

Exercise 5

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

$$
\begin{array}{l}
A \sqsubseteq B \\
A \sqcap C \sqcap D \sqsubseteq \bot \\
B \sqcap \exists r.C \sqsubseteq D \\
B \sqcap \exists r^{-}.C \sqsubseteq E \\
\exists s.\top \sqcap \exists s^{-}.\top \sqsubseteq F \\
E \sqcap F \sqcap \exists r.A \sqsubseteq A
\end{array}
$$

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

$$A(a), \quad C(b), \quad C(c), \quad r(a,b), \quad r(c,a), \quad s(c,d), \quad s(e,c)$$

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