Semantics and reasoning

1 From the lecture

1. What is a counter-model? How can a counter-model be used to show that one set of triples is not entailed by another set of triples?
2. Explain briefly. What is the difference between entailment and inference?
3. How to we deal with literals in our "simplified semantics"?
4. How do we deal with blank nodes in our semantics?
5. What do we mean by monotonic reasoning?
6. What do we mean by a closed world assumption?
7. How can we interpret a SPARQL aggregation (count, sum etc.) query with an open world assumption?
8. What is soundness and completeness of a calculus?

Solution

1. A counter-model is an interpretation $\mathcal{I}$ that we can use if we want to show that a set of triples $\mathcal{T}$ is not entailed by another set of triples $\mathcal{A}$ ($\mathcal{A} \not\models \mathcal{T}$). The model must describe the interpretation $\mathcal{I}$. And to show that $\mathcal{A} \not\models \mathcal{T}$, we must:
   (a) prove that $\mathcal{I} \models \mathcal{A}$ using the semantics
   (b) prove that $\mathcal{I} \not\models \mathcal{T}$ using the semantics
2. Entailment is defined by semantics. A triple is entailed if it is valid in all possible interpretations. Inference is what is possible to derive using inference rules. A triple is inferred if we can apply the rules (e.g., RDFS inference rules) to derive it.
3. • We divide properties into two disjoint types of resources:
   (a) Object properties and

    (b) Datatype properties

  - We let Λ be the set of all literal values.
  - The interpretation must have:
    (a) For each object property URI r, a relation $r \subseteq \Delta^{\mathcal{I}} \times \Delta^{\mathcal{I}}$ (as before)
    (b) For each datatype property URI a, a relation $a \subseteq \Delta^{\mathcal{I}} \times \Lambda$

4. We define a blank node valuation β such that $\beta(b) \in \Delta^{\mathcal{I}} \cup \Lambda$ for every blank node ID b. And define the interpretation with the blank node valuation $\mathcal{I}, \beta$ as in the lecture slides.

5. Monotonic reasoning is reasoning such that if $\mathcal{B}$ is entailed by a set of triples $\mathcal{A}$, and we add another triple to $\mathcal{A}$, then $\mathcal{B}$ is still entailed.

6. Closed world assumption: We assume that we have complete information/knowledge of the domain. If something is not in the knowledge base, it doesn't exist.

7. It is problematic, we can only say that, with the information at hand... The information can change at any moment.

8. Soundness: if the calculus says that something is entailed, it is really entailed (no wrong answers). Completeness: If something is entailed, it can be found using the calculus.

2 Literals and blank nodes

Let Γ be the RDF graph below. You will need to interpret both blank nodes and literals using the semantics laid out in the lectures.

1. Create an interpretation $\mathcal{I}_1$ such that $\mathcal{I}_1 \models \Gamma$.

2. Create an interpretation $\mathcal{I}_2$ such that $\mathcal{I}_2 \not\models \Gamma$.

```
@prefix : <http://www.example.org#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

:Tweety rdf:type   :Bird .
:Nixon  rdf:type   :Republican .
:Nixon  rdf:type   :Quacker .
:Nixon  :listensTo :Tweety .
:Nixon  :likes     [ a :Bird ]  .
[]      :likes     :Nixon .
:Nixon  :hasNickname "Ric" .
:Tweety :hasNickname "Mr. Man" .
:Tweety :likes     :Tux .
```

Solution

New things to pay attention in this exercises are:

- Λ is the set of all literals. All literals are interpreted to themselves (i.e., there is no $\Lambda^{\mathcal{I}}$).
- We need to interpret blank nodes. For this we use a *blank node valuation* function β, which assigns values from $\Delta^{\mathcal{I}} \cup \Lambda$ to blank nodes: $\beta(b) \in \Delta^{\mathcal{I}} \cup \Lambda$ for all blank nodes b.

First, let's create an interpretation which satisfies Γ.

Since there are blank nodes in Γ the interpretation we give needs to interpret them, i.e., we need to find an interpretation $\mathcal{I}$ such that there exists a blank node valuation β where $\mathcal{I}, \beta \models \Gamma$.

We let b_1 identify the blank node in

```
:Nixon  :likes     [ a :Bird ]   .
```

and b_2 identify the blank node in

```
[]        :likes     :Nixon .
```

Construct the following interpretation $\mathcal{I}$:

- $\Delta^{\mathcal{I}} = \{Tweety, Nixon, aBird, Something, Tux\}$
- $\texttt{:Tweety}^{\mathcal{I}} = Tweety$
- $\texttt{:Nixon}^{\mathcal{I}} = Nixon$
- $\texttt{:Tux}^{\mathcal{I}} = Tux$
- $\texttt{:Bird}^{\mathcal{I}} = \{Tweety, aBird\}$
- $\texttt{:Republican}^{\mathcal{I}} = \{Nixon\}$
- $\texttt{:Quacker}^{\mathcal{I}} = \{Nixon\}$
- $\texttt{:listensTo}^{\mathcal{I}} = \{\langle Nixon, Tweety\rangle\}$
- $\texttt{:likes}^{\mathcal{I}} = \{\langle Nixon, aBird\rangle, \langle Something, Nixon\rangle, \langle Tweety, Tux\rangle\}$
- $\texttt{:hasNickname}^{\mathcal{I}} = \{\langle Nixon, \text{"Rix"}\rangle, \langle Tweety, \text{"Mr. Man"}\rangle\}$

Let

- $\beta(b_1) = aBird$, and

- $\beta(b_2) = \mathit{Something}$.

Then $\mathcal{I}, \beta \vDash \Gamma$, so we also have that $\mathcal{I} \vDash \Gamma$.

To construct a new interpretation such that $\mathcal{I} \not\vDash \Gamma$, let $\mathcal{I}$ be as above, but let `:Bird` $^{\mathcal{I}} = \emptyset$. Then there is nothing we can send the blank node b_1 to have $\mathcal{I}, \beta \vDash$ `:Nixon :likes [ a :Bird ] .` (and also nothing to send `:Tweety` to), so this interpretation does not satisfy Γ: $\mathcal{I} \not\vDash \Gamma$.