Principles of Knowledge Representation and Reasoning

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Exercise Sheet 6

Due: May 7th, 2018

Exercise 6.1 (Repetition: Epistemic Logic, 2+2+2)

We want to model and solve a simple logics puzzle.[1] Consider the following situation with two agents. Both have a number written on their forehead, which can only be seen by the other agent. It is also common knowledge between the agents that both numbers have to be consecutive integers between 0 and 9. Furthermore, let us assume that Agent 1 sees the number 4 on Agent 2's forehead. Now consider the following sequence of truthful announcements:

Agent 1: *"I don't know my number!"*
Agent 2: *"I don't know my number!"*
Agent 1: *"I don't know my number!"*
Agent 2: *"I don't know my number!"*
Agent 1: *"I know my number!"*

(a) Model the initial situation (prior to the announcements) as epistemic model $\mathcal{M}$. Identify the worlds that Agent 1 considers possible, given the problem description (but not the dialogue).

(b) Model the announcements from the dialogue as epistemic formulas $\alpha_1, \ldots, \alpha_5$.

(c) What is Agent 1's number? Will Agent 2 know his number in the end? Justify your answers!

Hint: For an example on how to model such problems, you can find another interesting logic puzzle (*three logicians walk into a bar*) at `http://docs.pacuit.org/papers/phco2.pdf`. It is sufficient to look at the example's introduction on Page 1 and at its epistemic modeling in appendix A.

Exercise 6.2 (Ontological Modeling and Upper-Level Ontologies, 2+1+3)

(a) As a first step you are asked to design your own ontology of kitchen items. So, go into your kitchen, relax, and categorize the things you see, i.e., pots, bowls, mugs, a stove, some furniture etc. You are absolutely free to come up with any structure you think makes sense. Model your ontology using Protégé and save your file in the OWL format.

(b) Next, import the Upper-Level Ontology DOLCE-Lite[2] into your Protégé project. To do so, click `Active Ontology > Ontology Imports > Direct Imports` then select `Import an ontology contained in a document located on the web` and enter the URL of where DOLCE-Lite lives: `http://www.loa.istc.cnr.it/ontologies/DOLCE-Lite.owl`. Now go back to the `Entities` tab and you will see your kitchen ontology along with the DOLCE-Lite ontology. Because the ontology from task a) presumably contains physical objects only, move your concepts under the DOLCE-Lite concept named `physical object` (`particular > spatio-temporal-particular > physical endurant > physical object`). As a result you see that your kitchen items inherit some properties, among others, for example, they have a spatial location. Use Protégé to determine the expressiveness of the description logic used. Is its satisfiability problem decidable? Finally, save your ontology as an OWL document.

[1] Different versions of this puzzle and their origins are discussed in the book *One Hundred Prisoners and a Light Bulb* by Hans van Ditmarsch and Barteld Kooi, Springer, 2015.

[2] Some explanations on the rationale of the choice of concepts and roles defined in the DOLCE-Lite ontology are provided in the annotations to each concept / role. Some more complete explanations can also be found here: `http://www.loa.istc.cnr.it/old/Papers/WonderWebD17V2.0.pdf`. Mainly, these explanations are philosophical in nature.

(c) Now you can use the ontology to represent the following facts I to IV as ABox assertions in your ontology (i.e., you have to create individuals, assign them to concepts, and interlink them using roles). Mind the hints added to each of the tasks I to IV, and consider the explanations provided by the authors of DOLCE-Lite in terms of Protégé annotations and in the document linked in the footnote.

I) The pot has a bump.
Hint: Concepts: feature/relevant-part, Roles: specific-constant-dependent/host-of

II) The stove is in the kitchen.
Hint: Concepts: physical-quality/spatial-location_q, space-region, Roles: inherent-in[3], q-location[4]

III) The mug is made of porcelain.
Hint: Concepts: amount-of-matter, Roles: generic-constituent

IV) Water is boiling in the pot for the whole day.
Hint: Concepts: amount-of-matter, temporal-location_q, time-interval, perdurant/state, Roles: inherent-in, q-location, participant/total-constant-participant

Again, save your ontology as an OWL document.

Send your OWL document(s) to `engesser@informatik.uni-freiburg.de`.

[3] In the document from footnote 1, `inherent-in` is called qt in Figure 3.
[4] In the document from footnote 1, `q-location` is called ql_t in Figure 3.