Two hours – offline

EXAM PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

NANJING UNIVERSITY

SCHOOL OF ARTIFICIAL INTELLIGENCE

KNOWLEDGE REPRESENTATION AND PROCESSING

Date: Sunday, 21st June 2020

Time: 14:00 - 16:00

This is an offline examination.
The examination contains SHORT ESSAY QUESTIONS.
Be sure to answer ALL Questions.

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

1. This question is on knowledge representation and AI.

✧ Compare in short data-driven and knowledge-driven AI technologies. Is one replaceable by the other? Why?

(3 marks)

2. This question is on knowledge acquisition and modelling.

✧ What is closure axiom? What are they used for in an OWL ontology – explain this with an example. Your answer should include reference to OWL's semantics?

(3 marks)

✧ What is card sorting? When would you use it?

(3 marks)

✧ Consider the following ontology

```
ObjectProperty: hasColour
    Characteristics: functional
ObjectProperty: eats
Class: Grey
Class: White
DisjointClasses: Grey, White
Class: Animal
       SubClassOf: eats some Thing
Class: Seal
       SubClassOf: Animal
Class: Shark
       SubClassOf: Animal
Class: GreyShark
       EquivalentTo: Shark and (hasColour some Grey)
Class: WhiteShark
       EquivalentTo: Shark and (hasColour some White)
       SubClassOf: eats only Seal
Individual: Jaws
     Types: Shark,
     hasColour some (Grey or White)
```

For each of the Competency Questions below, consider whether the ontology is able to answer the question. If so, show how this can be done. If not, provide a brief discussion as to why not, and how you might extend or edit the ontology to address the problem.

- What kinds of animals are there?
- Are sharks dangerous?
- What colours can animals be?

(6 marks)

3. This question is on ontology, OWL and Description Logic.

✧ What is the relationship between ontology, W3C Web Ontology Language (OWL), and Description Logic?

(3 marks)

✧ State the trade-off between the expressive power of the language available for making statements and the computational complexity of various reasoning tasks for this language.

(3 marks)

4. This question is on syntax, semantics and OWL API.

✧ Write an axiom in Manchester Syntax that states that each and every instance of class A

- is an instance of B, and
  - has a p-successor that is an instance of A, or
  - has no r-successor that is an instance of B or C.

(3 marks)

✧ Sketch out a design for an application that checks whether, in a given ontology, only restrictions were used and, if so, on which properties. Identify the key features of the OWL API that you would use in doing so. Would reasoning play any role in such an application? Answer in 4-5 sentences.

(3 marks)

5. This question is on tableaux algorithm.

✧ Consider the ALC-concept

```
C = (not A) and (R some (R some A)) and (only R (not A))
```

Apply the ALC-tableaux algorithm to the concept C to determine whether C is satisfiable or not. In your answer, show how the completion rules →and, →or, →exists and →forall are applied step by step to the constraint system x:C. If C is satisfiable, construct an interpretation I satisfying C.

(5 marks)

✧ Use the ALC-Tableaux algorithm to determine whether

$$\varnothing \models \forall r.A \sqsubseteq \exists r.A$$

In words: determine whether the concept inclusion $\forall r.A \sqsubseteq \exists r.A$ follows from the empty TBox (without TBox).

(5 marks)

6. This question is on ontology-based query answering.

✧ Consider the TBox T containing

- $\texttt{City} \sqcap \texttt{Country} \sqsubseteq \bot$
- $\texttt{Country} \sqsubseteq \exists \texttt{capital\_of}^{--}.\texttt{City}$
- $\texttt{City} \sqsubseteq \forall \texttt{capital\_of}.\texttt{Country}$

Consider the ABox A containing

- City(Paris)
- City(Nanjing)
- Country(UK)
- capital_of(Paris, France)

Recall that the answers to Boolean queries given by database instances, and knowledge bases are "Yes", "No", "Don't know".

Given the answers given by

- the database instance I_A corresponding to A;
- the knowledge base (T, A),

to the following Boolean queries:

- City(Paris)
- Country(Paris)
- Coutnry(France)
- $(\forall \texttt{capital\_of}^{--}.\texttt{City})(\texttt{France})$
- $(\forall \texttt{capital\_of}^{--}.\texttt{City})(\texttt{UK})$
- $(\forall \texttt{capital\_of}^{--}.\texttt{Country})(\texttt{Nanjing})$

Give a brief explanation for each answer.

(6 marks)

✧ Explain why the answer to a query q returned by an ABox A is not always the same as the answer returned by the corresponding relational database instance. Use an example to illustrate your explanation and discuss the relevance of this difference.

(3 marks)

7. This question is on ontology engineering.

✧ Let $\mathtt{T} = \{\mathtt{A} \sqsubseteq \exists \mathtt{r}.\mathtt{B},\ \mathtt{A} \sqsubseteq \mathtt{B},\ \mathtt{B} \sqsubseteq \mathtt{E},\ \exists \mathtt{r}.\mathtt{E} \sqsubseteq \mathtt{F},\ \exists \mathtt{r}.\mathtt{B} \sqsubseteq \mathtt{F}\}$. Determine two sets of axioms in T that are in the pinpointing set **Pin**$(\mathtt{T},\ \mathtt{A} \sqsubseteq \mathtt{F})$.

(4 marks)

END OF EXAMINATION