Two hours – online

EXAM PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

NANJING UNIVERSITY

SCHOOL OF ARTIFICIAL INTELLIGENCE

KNOWLEDGE REPRESENTATION AND PROCESSING

Date: Tuesday, 4 AUGUST 2020

Time: 14:00 - 16:00

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

This is a CLOSED book examination

NEVERTHELESS, the use of online dictionary is kindly PERMITTED

1. This question is on knowledge representation and AI.

✧ In 1993, Gruber originally defined the notion of an ontology as an "explicit specification of a conceptualization". In 1997, Borst defined an ontology as a "formal specification of a shared conceptualization". This definition additionally required that the conceptualization should express a shared view between several parties, a consensus rather than an individual view. Also, such conceptualization should be expressed in a (formal) machine readable format. In 1998, Studer et al. merged these two definitions stating that: " a formal, explicit specification of a shared conceptualization."

Do you think the last definition has been a good definition for ontology? Why and why not? Illustrate with an example as to why formal semantics is important for knowledge representation?

(5 marks)

2. This question is on ALC extensions and FOL.

✧ Consider the following sentences:

- Every university has at least 3 members.
- If something is a member of a university, then it is a school, a department or a faculty.
- NJU is a university whose members are not faculties.
- All members of NJU are schools or departments.

(1) Translate these sentences into SHOIQ inclusions (only the first sentence requires qualified number restrictions). State which concept names, role names and nominals are used.
(2) Translate the LAST THREE inclusions into FOL.

(7 marks)

3. This question is on DL syntax and semantics.

✧ Consider the interpretation I defined by

$\Delta^I=\{1, 2, 3, 4\}$;
$P^I=\{1, 2, 3\}$;
$Q^I=\{3\}$;
$r^I=\{(1,3), (2,3), (2,4)\}$.

Determine the following sets (“false” denotes the empty set):

- $(P \sqcap \exists r.Q)^I$
- $(\forall r.Q)^I$
- $(\exists r.Q \sqcap \forall r.Q)^I$
- $(\neg P \sqcap \neg\exists r.Q)^I$
- $(\exists r.\forall r.\text{false})^I$

(5 marks)

4. This question is on OWL.

✧ Why is OWL specified as a textual language, not a graphical one?

(5 marks)

5. This question is on tableaux algorithm.

✧ Consider the ALC-concept C:

$$\neg A \sqcap \exists r.(A \sqcup B) \sqcap \forall r.\neg B$$

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)

✧ Consider the following ALC-TBox T:

$$\text{Professor} \sqsubseteq \exists \text{works\_for}.\text{School}$$
$$\text{Professor} \sqsubseteq \exists \text{supervises}.\text{ResearchGroup}$$
$$\text{Professor} \sqsubseteq \forall \text{supervises}.\text{ResearchStudent}$$
$$\text{School} \sqsubseteq \exists \text{affialited\_with}.\text{University}$$

(1) Define a model I of T in which Professor is satisfiable.

(2) Add ResearchGroup $\sqcap$ ResearchStudent $\sqsubseteq \perp$ to T. Is the resulting TBox consistent? Why?

(5 marks)

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

✧ Consider the TBox T containing

- $Cat \sqcap Dog \sqcap Bird \sqsubseteq \bot$
- $Cat \sqsubseteq Mammal$
- $Dog \sqsubseteq Mammal$
- $\exists breatheWith.Lung \sqsubseteq Mammal$
- $Mammal \sqsubseteq \forall breatheWith.Lung$
- $True \sqsubseteq \exists breatheWith.Lung$

Consider the ABox A containing

- Cat(mimi)
- ¬Dog(gigi)
- Bird(lala)
- breatheWith(dudu, krp)

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

Given the answers given by

- the knowledge base (T, A),

to the following Boolean queries:

- Cat(gigi)
- Dog(mimi)
- Mammal(gigi)
- Mammal(dudu)
- Lung(krp)
- ∀breatheWith.Lung(dudu)
- ∀breatheWith.Lung(lala)
- ¬Dog(lala)

Give a brief explanation for each answer.

(8 marks)

✧ Let T be an EL-TBox containing:

$$A \sqsubseteq \exists r.B, \quad B \sqsubseteq \exists r.B$$

and A be an EL-ABox containing:

$$r(a,b), \quad A(b)$$

Compute the interpretation $I_{T,A}$ so that for all EL-concepts C and $d \in \{a, b\}$:

$$T, A \vDash C(d) \quad \Leftrightarrow \quad I_{T,A} \vDash C(d)$$

(5 marks)

7. This question is on ontology engineering.

✧ Elaborate on and differentiate (perhaps with illustrative examples) the notions of syntactic difference, structural difference, and semantic difference in the context of OWL ontologies (elaborate on: 详细解释, differentiate: 区分， notion: 概念).

(5 marks)

8. This is a BONUS question on proof with semantics.

✧ Consider the following EL-TBox T:

$$A \sqcap C \sqsubseteq D, \quad B \sqsubseteq \exists r.A$$

For any EL-concept inclusion α with (i) $sig(\alpha) \subseteq sig(T)$ and (ii) $A \notin sig(\alpha)$, show (on the semantics level) that $\alpha = B \sqsubseteq \exists r.true$ is the strongest logical consequence (strongest logical entailment) of T.
(Hint: α is the logical consequence of T means: $T \vDash B \sqsubseteq \exists r.true$, while α is the STRONGEST logical consequence of T means: there is no another α with (i) $sig(\alpha) \subseteq sig(T)$ and (ii) $A \notin sig(\alpha)$ such that $T \vDash \alpha \vDash B \sqsubseteq \exists r.true$).

*Definition: by sig(X) we denote the set of all the concept and role names in X, where X can be an axiom (concept inclusion), or a TBox. For example, $sig(A \sqcap C \sqsubseteq D) = \{A, C, D\}$, $sig(T) = \{A, B, C, D, r\}$.

(5 marks)

EXAMPLE: we provide students with the following example that does a similar proof on the semantic level.

The problem is to show $A \sqsubseteq B, B \sqsubseteq C \vDash A \sqsubseteq C$. From the semantics viewpoint, this means that every model of $A \sqsubseteq B, B \sqsubseteq C$ is also a model of $A \sqsubseteq C$. We assume that there is a model I of $A \sqsubseteq B, B \sqsubseteq C$ such that I is not a model of $A \sqsubseteq C$. This means there is an element d in the domain, i.e., $d \in \Delta^I$ such that $d \in (\neg A \sqcup B)^I$ and $d \in (\neg B \sqcup C)^I$, but $d \notin (\neg A \sqcup C)^I$ (equivalently means $d \in A^I$ and $d \notin C^I$). Therefore, $d \in B^I$ and $d \in (\neg B)^I$, CONTRADICTION.

END OF EXAMINATION