Assignment#3

Knowledge Representation and Processing

May 11, 2021

Note: Assignment#3, due on 14:00 June 1, contributes to 10% of the total mark of the course.

Q1. A satisfiable class must always have a non-empty interpretation.

(A) True (B) False (C) Don't know

Q2. An unsatisfiable class may have a non-empty interpretation in some model.

(A) True (B) False (C) Don't know

Q3. An unsatisfiable class will be a subclass of any other class.

(A) True (B) False (C) Don't know

Q4. Given the following ontology definition.

- Class: PetOwner
- SubClassOf: Person that hasPet some Cat and hasPet only (Cat or Dog)
- Class: Cat
- SubClassOf: Animal
- Class: Dog
- SubClassOf: Animal
- Individual: Fred
- Types: PetOwner
- Facts: hasPet Tibbs
- Individual: Tibbs
- Types: not Dog
- *What additional information do we know about Tibbs?*

Q5. Given the following ontology definition.

- Class: PetOwner
- SubClassOf: Person that hasPet some Cat and hasPet some Dog
- Class: Cat
- SubClassOf: Animal
- Class: Dog
- SubClassOf: Animal
- Individual: Fred
- Types: PetOwner
- Facts: hasPet Tibbs hasPet Fido
- Individual: Tibbs
- Types: Cat
- Individual: Fido
- *Is Fido a Dog?*

Q6. Given the following ontology definition.

- Class: PetOwner
- SubClassOf: Person that hasPet some Cat
- *Is owning a Cat enough to recognize a Person as a PetOwner?*

Q7. Given the following ontology definition.

- Class: PetOwner
- SubClassOf: Person that hasPet some Cat and hasPet only Cat
- *How many Cats does a PetOwner have as Pets?*

Q8. What are Competency Questions? How would you use them during ontology development? Answer using around 150 words.

Q9. In Assignment#1, you produced a basic hierarchy of sushi ingredients. For this assignment, you are to repeat the exercise of producing an ontology (based on the one you produced for Assignment#1), but using the experience and information that you have gained along with the Competency Question you have been identifying. Your ontology should be sufficient to enable the set of Competency Questions for the ontology that you, as a class, will formulate. These Competency Questions are those that you would wish an intelligent, ontology driven restaurant sushi menu to be able to answer. These Competency Questions will form the basis for evaluating your ontology. There are several things you will do in developing your sushi ontology:

- Produce some competency questions that will guide the ontology's content, design and evaluation what should the ontology be "competent" to answer"?
- Produce a hierarchy of sushi ingredients such that each type of sushi can be described (This was supposed to be done in Assignment#1).
- For each class, identify adjectives (in the menu) that modify the ingredient and include them as *comments*.
- Design the axioms patterns that allow sushi and platters of sushi to be described according to the competency questions.
- Produce the sushi ontology, that covers both sushi and platters of sushi, that will allow a broad range of queries from the competency to be answered.

  Submit an OWL ontology sushi-XXX.owl, for XXX your student id.

Q10. If you had only existential restriction ($\exists$) or only universal restriction ($\forall$) in your ontology, which, from a modelling perspective, would be preferable, and why? (approx. 150 words)

Q11. Apply the $\mathcal{ALC}$-tableaux algorithm to the following concepts and determine which are satisfiable and which are not. If a concept is satisfiable, given an interpretation satisfying it.

- $A \sqcap \neg A$
- $\exists r.\exists r.(A \sqcap \neg A)$
- $\forall r.\forall r.(A \sqcap \neg A)$
- $\exists r.A \sqcap \forall s.\neg A$
- $\exists r.A \sqcap (\forall r.\neg A \sqcap \exists r.\neg A)$

Q12. Use the $\mathcal{ALC}$-tableaux algorithm to determine whether $\emptyset \models \forall r.A \sqsubseteq \exists r.A$.

Q13. Let $\mathcal{T}$ be a general $\mathcal{EL}$ TBox, C, D $\mathcal{EL}$ concepts and A, B concept names not occurring in $\mathcal{T}$ or C, D. *Show that:*

$\mathcal{T} \models C \sqsubseteq D$ *if and only if* $\mathcal{T} \cup \{A \sqsubseteq C, D \sqsubseteq B\} \models A \sqsubseteq B$.

Q14. Recall that a general $\mathcal{EL}$ TBox $\mathcal{T}$ is *in normal form* (*normalized*) if it only contains GCIs of the following form:

$$A \sqsubseteq B \qquad A_1 \sqcap A_2 \sqsubseteq B \qquad A \sqsubseteq \exists r.B \qquad \exists r.A \sqsubseteq B$$

where A, A_1, A_2, B are concept names or the top concept $\top$, and r is a role name. One can normalize a given $\mathcal{EL}$ TBox by exhaustively applying the following normalization rules (slightly different from those present in the lecture slides).

- $M \sqsubseteq N \longrightarrow M \sqsubseteq A, A \sqsubseteq N$
- $C \sqcap M \sqsubseteq B \longrightarrow M \sqsubseteq A, C \sqcap A \sqsubseteq B$
- $M \sqcap C \sqsubseteq B \longrightarrow M \sqsubseteq A, A \sqcap C \sqsubseteq B$
- $\exists r.M \sqsubseteq B \longrightarrow M \sqsubseteq A, \exists r.A \sqsubseteq B$
- $B \sqsubseteq \exists r.M \longrightarrow A \sqsubseteq M, B \sqsubseteq \exists r.A$
- $B \sqsubseteq D \sqcap E \longrightarrow B \sqsubseteq D, B \sqsubseteq E$
- $C \equiv D \longrightarrow C \sqsubseteq D, D \sqsubseteq C$

where C, D, E are arbitrary $\mathcal{EL}$ concepts, M, N are $\mathcal{EL}$ concepts that are neither concept names nor $\top$, B is a concept name, and A is a fresh concept name.
Show that: Any general $\mathcal{EL}$ TBox $\mathcal{T}$ can be transformed into a normalized one $\mathcal{T}'$ by a linear number of applications of the normalization rules.

Q15. Translate the following statements to concept inclusions in the description logic $\mathcal{SHOIQ}$. State which symbols are used as concept names, role names and nominals.

- Every student at Nanjing University is a human being.
- Nanjing University has at least 30,000 students.
- Every citizen of China is an Asia.
- East Asia consists of at least 5 countries.
- The domain of the relation "citizen of" consists of human beings.
- The range of the relation "citizen of" consists of countries.
- There are at least 1,000,000,000 Chinese citizens.

  Ensure that it follows from your translation that China is a country.