M164-CS2 Knowledge Technologies
Homework II
Out on November 20, 2023.
Due on December 20, 2023 at 24:00.

1. "Translate" the following sentences into $\mathcal{ALCQO}$. If you think that the given sentence cannot be translated into $\mathcal{ALCQO}$, then you should give a translation into first-order logic (remember: $\mathcal{ALCQO}$, like all DLs we studied, is a subset of first-order logic).

   (a) John is handsome.

   (b) Peter is strong and rich.

   (c) Every person likes clever dogs.

   (d) No person likes John.

   (e) All athletes are happy.

   (f) Whoever likes a person, who likes them back, is happy.

   (g) Maria likes all men who like her.

   (h) Peter likes all women who are kind and smart.

   (i) Maria, John, and Peter are members of the Running Team.

   (j) Each member of the Running Team who is not a speed runner is a marathon runner.

   (k) Speedrunners don't like marathon running.

   (l) Any person who doesn't like running is not an athlete.

   (m) Donald doesn't like what Joe likes and he likes what Joe dislikes.

   (n) Joe likes marathon running and speed running.

   (o) There is a member of the Running Team who is a speed runner and not a marathon runner.

   (p) A biped is an animal that has exactly two legs.

   (q) A triangle is a polygon with exactly three angles and exactly three edges which are line segments.

   (r) A right-angled triangle is a triangle that has one right angle.

   IMPORTANT NOTE: You can take as one word only the following: "Running Team", "marathon running", "marathon runner", "speed running", "speed runner", "line segment", "right-angled triangle", "right angle".

2. Make an $\mathcal{ALCQ}$ KB (at least 3 TBox axioms, at least 3 ABox axioms) $\mathcal{K}$ following the constraints below:

   (a) At least one TBox axiom must contain at least 3 connectives and at least one quantifier.

   (b) At least one ABox axiom must contain at least one connective and at least one quantifier.

   (c) $\mathcal{K}$ must be such that new axioms can be inferred using reasoning techniques (involving at least one (TBox/ABox) axiom that its structure is described above).

   You need to use terms only from the following pools:

- **Atomic Concepts:** “red”, “blue”, “green”, “kind”, “nice”, “big”, “cold”, “young”, “round”, “rough”, “orange”, “smart”, “quiet”, “furry”.
- **Role Names:** “likes”, “loves”, “eats”, “chases”, “admires”.
- **Individual Names:** “Ioanna”, “Eleni”, “Manolis”, “Angelos”, “Panos”, “Anna”, ‘Petros”, “Lisa”.

We do not expect the resulting $\mathcal{K}$ to make any sense.

Then, write the $\mathcal{ALCQ}$ axioms, the inferred axioms $\mathcal{ALCQ}$, and the translation of $\mathcal{K}$ and of the inferred axioms to natural language.

3. Which of the following expressions are syntactically correct in $\mathcal{ALCQ}$ and which ones are incorrect?
   (a) $\texttt{Person} \sqcap \texttt{hasChild}$
   (b) $\exists\texttt{hasChild}. \equiv \texttt{Person}$
   (c) $\exists\texttt{hasChild}.(\geq \texttt{1})$
   (d) $\texttt{hasChild} \sqsubseteq \texttt{hasBaby}$
   (e) $\texttt{hasChild}(\texttt{ANNA})$
   (f) $\texttt{Person} \equiv \exists\texttt{hasChild}.\bot$
4. Consider the following English sentences:
   (a) Andy is a person.
   (b) Andy has only two distinct pets: Gini and Jack.
   (c) Gini and Jack are animals.
   (d) An animal lover is a person which has at least three pets that are animals.
   (e) Andy is an animal lover.
   (f) Andy is not an animal lover.

   Now answer the following questions:

   (a) Give an $\mathcal{ALCQ}$ knowledge base KB which formalizes the first four of the above sentences and two $\mathcal{ALCQ}$ formulas ϕ and ϕ' that formalize the fifth and sixth sentence.
   (b) Can you use tableau techniques to prove that $KB \models \phi$ and $KB \models \phi'$? For the case or cases where the entailment is not true, prove formally that this is the case.

   The description logic $\mathcal{ALCQ}$ has been covered in class. The tableau proof techniques for it have not been covered in class but are covered in the following paper we have in the readings: “Franz Baader. Description Logics. In Reasoning Web: Semantic Technologies for Information Systems, 5th International Summer School 2009, volume 5689 of Lecture Notes in Computer Science, pages 1-39. Springer-Verlag, 2009.” It is available from `https://iccl.inf.tu-dresden.de/web/LATPub427/en`.
5. Consider the following English sentences:
   (a) If someone is a parent the he/she is a person.
   (b) Every person is happy if all his children are successful.
   (c) All beautiful persons are successful.

(d) Every person is beautiful if one of his/her parents is beautiful, otherwise he/she is ugly.

(e) Aphrodite is a parent of Eros.

(f) Aphrodite is beautiful.

(g) Eros is successful.

(h) Every beautiful parent is happy.

(i) Every person is happy if he/she has no children.

Now answer the following questions:

(a) Write an OWL 2 ontology which encodes sentences (a)-(e) above.

(b) Now formalize the sentences (f)-(h) as OWL 2 axioms. Which ones of these axioms are entailed by the previous ontology? You do not need to give detailed proofs; only explain why the corresponding entailment relation holds or does not hold and how you can use Protege to show this.

6. Consider the following English sentences:

   (a) Konstantina, Stella and Roi are members of the club Psiloritis.

   (b) Every member of the club Psiloritis who is not a skier is a mountain climber.

   (c) Mountain climbers do not like rain.

   (d) If someone is a skier then he likes snow.

   (e) Konstantina doesn't like anything that Stella likes.

   (f) Stella likes rain and snow.

   Now answer the following questions:

   (a) Give an OWL 2 ontology which formalizes the above sentences.

   (b) Explain what properties and class memberships or non-memberships hold for Konstantina, Stella and Roi as a result of the above sentences and your formalization in OWL 2. Use Protege to verify your claims i.e., discuss what Protege will do with your ontology and how you have verified your claims.