Ontology Engineering
Extra exercises on formalising natural language sentences

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This document contains extra practice in formalising natural language. The second page contains the FOL formalisation and the third page has the DL variant, where possible.

1 Natural language sentences

1. All lions are animals
2. Each professor teaches at least course
3. All humans eat some fruit and cheese
4. Animals are either herbivores or carnivores
5. The sister of one's mother is one's aunt
6. Something can't be both pap and pizza
7. If a person works for a company, then that person is an employee
8. Anything that manages something is a manager, and vice versa.
9. All flies have exactly two eyes as part
10. Anything has at most one life
11. The participation relation is defined by relating physical objects to processes
12. Having something as part is the inverse of being part of something
13. connection is symmetric (if one thing is connected to something else, that other thing is also connected to the one thing)
14. A vehicle can be either motorised or not, but not both
15. Several snails are slow
16. Each patient is registered at some hospital on a certain weekday
17. All students are at some time in their life not a student

2 Answers — FOL

Note: there may be more than one solution; only one is given. Also note that a problem of natural language is that it can be imprecise.

1. $\forall x(Lion(x) \rightarrow Animal(x))$
2. $\forall x(Professor(x) \rightarrow \exists y(teaches(x, y) \wedge Course(y)))$
3. $\forall x(Human(x) \rightarrow \exists y, z(eat(x, y) \wedge Fruit(y) \wedge eat(x, z) \wedge Cheese(z)))$ (note: twice the 'eat', with y and z, not "$fruit(y) \wedge cheese(y)$", for that refers to the objects that are *both*, which don't exist)
4. $\forall x(Animal(x) \rightarrow Herbivore(x) \vee Carnivore(x))$
5. $\forall x, y, z(hasmother(x, y) \wedge hassister(y, z) \rightarrow hasaunt(x, z))$ (or with $\leftrightarrow$ and/or with the composition operator $\circ$)
6. $\forall x(Pap(x) \rightarrow \neg Pizza(x))$
7. $\forall x \exists y((Person(x) \wedge worksfor(x, y) \wedge Company(y) \rightarrow Employee(x)))$
8. $\forall x, y(manages(x, y) \leftrightarrow Manager(x))$
9. $\forall x(Fly(x) \rightarrow \exists^{=2} y(haspart(x, y) \wedge Eye(y)))$ (note: this is shorthand notation...)
10. $\forall x, y, z(life(x, y) \wedge life(x, z) \rightarrow y = z)$
11. $\forall x, y(participation(x, y) \rightarrow PhysicalObject(x) \wedge Process(y))$
12. $\forall x, y(hasPart(x, y) \rightarrow partOf^{-}(x, y))$
13. $\forall x, y(connection(x, y) \rightarrow connection(y, x))$
14. Vehicles: combine the pattern for the 'or' from 4 with the disjoints of 6, for the vehicles.
15. $\exists x(Snail(x) \wedge slow(x))$ but not this is suboptimal (recall the apple & green; similar story here)
16. $\forall x(Patient(x) \rightarrow \exists y, z(registration(x, y, z) \wedge Hospital(y) \wedge Weekday(z)))$
17. Note: this requires either a temporal 'extension' or necessity (beyond the current scope). Let's take temporal, for which we introduce a notions of time, t, that quantifies over time points only (for simplicity, and linear time): $\forall x, t(Student(x, t) \rightarrow \exists t' \neq t(\neg Student(x, t')))$

3 Answers — DL

Note: there may be more than one solution; only one if given. Also note that these axioms are agnostic about particular fragments, and we don't consider datatypes.

1. $\mathsf{Lion} \sqsubseteq \mathsf{Animal}$
2. $\mathsf{Professor} \sqsubseteq \exists \mathsf{teaches.Course}$
3. $\mathsf{Human} \sqsubseteq \exists \mathsf{eat.Fruit} \sqcap \exists \mathsf{eat.Cheese}$
4. $\mathsf{Animal} \sqsubseteq \mathsf{Herbivore} \sqcup \mathsf{Carnivore}$
5. $\mathsf{hasMother} \circ \mathsf{hasSister} \sqsubseteq \mathsf{aunt}$ (or with $\equiv$, i.e., that the notion of 'aunt' is defined by it)
6. $\mathsf{Pap} \sqsubseteq \neg \mathsf{Pizza}$ (or with 'bottom': $\mathsf{Pap} \sqcap \mathsf{Pizza} \sqsubseteq \bot$)
7. $\mathsf{Person} \sqcap \exists \mathsf{worksFor.Company} \sqsubseteq \mathsf{Employee}$
8. $\forall \mathsf{manages}.\top \equiv \mathsf{Manager}$
9. $\mathsf{Fly} \sqsubseteq = 2\, \mathsf{hasPart.Eye}$
10. lazy option: $\mathsf{Func}(\mathsf{life})$, less lazy, as part of another axiom, $\leq 1\, \mathsf{life}$ or $\leq 1\, \mathsf{life}.\top$
11. lazy option: $\mathsf{Participation} \sqsubseteq \mathsf{PhysicalObject} \times \mathsf{Process}$, and in full: $\exists \mathsf{participation} \sqsubseteq \mathsf{PhysicalObject}$ and $\exists \mathsf{participation}^- \sqsubseteq \mathsf{Process}$
12. $\mathsf{hasPart} \sqsubseteq \mathsf{partOf}^-$
13. lazy option (in $\mathcal{SROIQ}$): $\mathsf{Sym}(\mathsf{connection})$
14. Vehicles: combine the 'or' from 4 with the disjoints of 6.
15. Not easily represented in DLs (rework it with some subtype of snails for which it always holds)
16. This can be represented in the $\mathcal{DLR}$ family of Description Logics, but not in most DLs and not in OWL either (which has only binaries—we'll return to this in the second part of the module)
17. This can be represented in several temporal description logics, using temporal operators, alike $\mathsf{Student} \sqsubseteq \diamond^* \neg \mathsf{Student}$ with the diamond-shape the temporal counterpart of $\exists$ and with $*$, this reads as 'sometime'. More about this can be found in the 'advanced topics'.