

Exams

FAI2 - 16/06/2020

$\exists X. stays_home(X)$

$\exists X. (works_from_home(X))$

$\exists X. limits_contact(X)$

$\exists X. (\forall Y contact(X, Y) \rightarrow min_distance(X, Y, 2))$

$\exists X. (\forall Y. (live_together(X, Y) \wedge has_symptoms(Y)) \rightarrow not_leave(X))$

$\exists X. washes_hands(X)$

$\forall X. (stays_home(X) \wedge works_from_home(X) \wedge limits_contact(X) \wedge$

$(\forall Y contact(X, Y) \rightarrow min_distance(X, Y, 2)) \wedge$

$(\forall Y. (live_together(X, Y) \wedge has_symptoms(Y)) \rightarrow not_leave(X))$

$\wedge washes_hands(X)) \rightarrow safe(X)$

$\forall (X). (\neg safe(X) \rightarrow not_safe(X))$

$\forall (X). (not_safe(X) \rightarrow might_die(X))$

$\forall X, Y (not_safe(X) \wedge not_safe(Y) \wedge infected(X) \rightarrow might_transmit_virus(X, Y))$

$\exists X. (not_safe(X) \rightarrow died(X))$

stays_home(simmy).

Query

? – $\exists X. (might_transmit_virus(simmy, X))$

ALC

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FAI2 - 07/07/2020

First Order Logic

$\forall X. bus(x) \rightarrow (\exists Y. wheels(X, Y) \wedge Y > 3) \wedge powered(X, engine)$

$\forall X. car(X) \rightarrow wheels(X, 4) \wedge powered(X, engine)$

$\forall X. bike(X) \rightarrow wheels(X, 2) \wedge powered(X, human)$

$\forall X. ebike(X) \leftrightarrow bike(X) \wedge powered(X, engine)$

$\forall (Y). Drives(X, Y) \wedge car(Y) \rightarrow HasLicense(X, B) \wedge adult(X)$

$\forall (X). Drives(X, Y) \wedge bus(Y) \rightarrow HasLicense(X, C) \wedge adult(X)$

$\forall X. HasLicense(X, C) \rightarrow HasLicense(X, B)$

$\forall X. drives(X, Y) \wedge bike(Y) \rightarrow person(X)$

$\exists X, Y, T, Z. (drives(X, T) \wedge drives(Y, Z) \wedge X \neq Y \wedge T \neq Z)$

? – $\exists X. (drives(driver1, X) \wedge \neg drives(driver2, X))$

ALC

Bus $\sqsubseteq (\geq 4 hasComponent. wheel \sqcap poweredBy. engine)$

Car $\sqsubseteq (\geq 4 hasComponent. wheel \sqcap \leq 4 hasComponent. wheel \sqcap \exists poweredBy. engine)$

Bike $\sqsubseteq (\geq 2 hasComponent. wheel \sqcap \leq 2 hasComponent. wheel \sqcap \exists poweredBy. human)$

eBike $\sqsubseteq (\geq 2 hasComponent. wheel \sqcap \leq 2 hasComponent. wheel \sqcap \exists poweredBy. human \sqcap \exists poweredBy. engine)$

CarDriver $\sqsubseteq (Adult \sqcap \exists hasLicense. BLicense)$

CarDriver $\equiv Adult \sqcap \exists Drives. Car$

BusDriver $\equiv Adult \sqcap \exists Drives. Bus$

BikeDriver $\equiv Adult \sqcap \exists Drives. Bus$

BusDriver $\sqsubseteq (Adult \sqcap \exists hasLicense. CLicense)$

CLicense $\sqsubseteq BLicense$

BikeDriver $\sqsubseteq Person$

Vehicle $\equiv Bus \sqcup Car \sqcup Bike \sqcup eBike$

The There are different type of drivers is already encoded in the fact that *CarDriver* and *BusDriver* are two different entities.

hasLicense(driver1, X) \wedge hasLicense(driver2, Y) \wedge (X \sqsubseteq Y)

FAI2 - 10/6/2021

We can define a *contains(molecule, element, quantity, ion)* predicate that states that some element is contained in a molecule with given quantity and ionization (for neutral). For example, H_2O would be encoded as

contains(h2o, h, 2, 0) \wedge contains(h2o, o, 1, 0).

Then, we can encode possible reactions in our becher as implications:

becher_contains(h2) \wedge becher_contains(o) \rightarrow becher_contains(h2o)

Query

$\exists X, Y, I. contains(h2o, X, Y, I)$ and continue iterating to find them all, which is something we could do in Prolog with a `findall([X,Y,I], contains(h2o, X, Y, I), R).`

ALC

Molecule $\sqsubseteq \exists contains. Element$

Molecule $\sqsubseteq \exists hasFormula. Formula$

Formula $\sqsubseteq String$

Ion $\equiv (Atom \sqcap ((\exists hasIonization. PositiveIonization) \sqcup (\exists hasIonization. NegativeIonization)))$

Atom $\sqsubseteq isComposedOf. Element$

Ion $\sqsubseteq Atom$

Element \sqsubseteq *Molecule* An element can be considered as a single molecule?

ChemicalReaction $\sqsubseteq \geq 2$ *hasReactants. Molecule*

ChemicalReaction $\sqsubseteq \exists$ *hasProducts. Molecule*

Query

$q(x) \leftarrow \text{isComposedOf}(\text{querymolecule}, x)$

Exercise sheet

Exercise 1

Build a knowledge base in which the following knowledge is represented: Father, Mother, GrandMother, GrandFather, Aunt, Uncle, Niece, Nephew, Mother of at least 3 sons, Father of at most 2 Daughters.

First Order Logic

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parent(Fabrizio, Simone)
parent(Rossella, Simone)
woman(Rossella)
man(Fabrizio)

parent(X, Y) ∧ man(X) → father(X, Y)
parent(X, Y) ∧ woman(X) → mother(X, Y)
parent(X, Y) ∧ parent(Y, Z) ∧ woman(X) → grandmother(X, Z)
parent(X, Y) ∧ sister(Z, Y) → aunt(Z, X)
parent(X, Y) ∧ brother(Z, Y) → uncle(Z, X)
sibling(X, Y) ∧ man(X) → brother(X, Y)
sibling(X, Y) ∧ woman(X) → sister(X, Y)

(uncle(X, Z) ∨ aunt(X, Z)) ∧ woman(Z) → niece(Z, X)
(uncle(X, Z) ∨ aunt(X, Z)) ∧ man(Z) → nephew(Z, X)
mother(X, A) ∧ mother(X, B) ∧ mother(X, C) ∧ (A ≠ B ≠ C) ∧
man(A) ∧ man(B) ∧ man(C) → mother3(X)
father(X, A) ∧ father(X, B) ∧ (A ≠ B) ∧ woman(A) ∧ woman(B) → father2(X)
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ALC

$$\begin{aligned}
Father &\equiv Parent \sqcap Man \\
Son &\equiv (Man \sqcap \exists \text{hasParent}. Person) \\
Daughter &\equiv (Woman \sqcap \exists \text{hasParent}. Person) \\
Mother &\equiv Parent \sqcap Woman \\
GrandMother &\equiv (Mother \sqcap \exists \text{hasChild}. Parent) \\
GrandFather &\equiv (Father \sqcap \exists \text{hasChild}. Parent) \\
Aunt &\equiv (Woman \sqcap \exists \text{hasSibling}. Parent) \\
Uncle &\equiv (Man \sqcap \exists \text{hasSibling}. Parent) \\
Sibling &\equiv (Brother \sqcup Sister) \\
Niece &\equiv (Woman \sqcap \exists \text{Parent}. Sibling) \\
Nephew &\equiv (Man \sqcap \exists \text{Parent}. Sibling) \\
Mother_3 &\equiv (Woman \sqcap \geq 3 Son) \\
Father_2 &\equiv (Man \sqcap \leq 2 Daughter)
\end{aligned}$$

Exercise 2

Build a knowledge base in which the following knowledge is represented: All humans are mammals; all mammals are warm blooded. All dogs are mammals. Humans own animals. There are animals that are not warm blooded. All mammals are animals. A human cannot own another human.

First Order Logic

$$\begin{aligned}
\text{human}(X) &\rightarrow \text{mammal}(X) \\
\text{mammal}(X) &\rightarrow \text{warmblooded}(X) \\
\text{dog}(X) &\rightarrow \text{mammal}(X) \\
\text{own}(X, Y) &\rightarrow \text{human}(X), \text{animal}(Y) \\
\exists X. (\text{animal}(X) \wedge \neg \text{warmblooded}(X)) \\
\text{mammal}(X) &\rightarrow \text{animal}(X) \\
\text{own}(X, Y) &\rightarrow \text{human}(X) \wedge \neg \text{human}(Y)
\end{aligned}$$

ALC

$$\begin{aligned}
\text{Human} &\sqsubseteq \text{Mammal} \\
\text{Mammal} &\sqsubseteq \text{WarmBlooded} \\
\text{Dog} &\sqsubseteq \text{Mammal} \\
\text{AnimalOwner} &\equiv \text{Human} \sqcap \exists \text{owns}. \text{Animal} \\
\text{ColdBloodedAnimal} &\equiv \text{Animal} \sqcap \neg \text{WarmBlooded} \\
\text{Mammal} &\sqsubseteq \text{Animal} \\
(\text{Human} \sqcap \exists \text{owns}. \text{Human}) &\perp
\end{aligned}$$

Exercise 3

First Order Logic

$$\begin{aligned}
\text{student}(X) &\rightarrow \text{smart}(X) \\
\exists X. \text{student}(X) \\
\exists X. (\text{student}(X) \wedge \text{smart}(X)) \\
\forall X \exists Y. (\text{student}(X) \wedge \text{student}(Y) \wedge \text{loves}(X, Y))
\end{aligned}$$

$\forall X \exists Y. (student(X) \wedge student(Y) \wedge loves(X, Y) \wedge X \neq Y)$ $\exists X. (\forall Y. student(X) \wedge student(Y) \wedge loves(Y, X))$ $student(mark)$ $student(paul)$ $takes(mark, analysis) \leftrightarrow \neg takes(mark, geometry)$ $\neg takes(mark, analysis) \leftrightarrow takes(mark, geometry)$ $takes(paul, analysis) \wedge takes(paul, geometry)$ $\neg takes(mark, analysis)$ $\forall Y. (student(Y) \rightarrow \neg loves(Y, paul))$

ALC

 $Student \sqsubseteq Smart$ $SmartStudent \equiv Student \sqcap Smart$ $(Student \sqcap \exists loves. Student) \equiv Student$

Sentence 5 is not encodable in ALC (I think)

 $Student \sqcap \forall loves. Student$ $Mark \sqsubseteq Student$ $Paul \sqsubseteq Student$ $Mark \sqsubseteq ((\exists takes. GeometryExam \sqcap \neg \exists takes. AnalysisExam) \sqcup$ $(\exists takes. AnalysisExam \sqcap \neg \exists takes. GeometryExam))$ $Paul \sqsubseteq (\exists takes. GeometryExam \sqcap \exists takes. AnalysisExam)$ $Mark \sqsubseteq \neg \exists takes. AnalysisExam$ $(Student \sqcap \exists loves. Paul). \perp$

Other exercises

Not all students attend both the History and the Biology courses. The best mark in History is higher than the best mark in Biology. One only student did not pass the exam in History. One only student did not pass both the exam in History and the exam in Biology.

 $\exists X. (attends(X, history) \wedge \neg attends(X, biology))$ $\forall X, Y. (best_mark(history, X) \wedge best_mark(biology, Y) \rightarrow (X > Y))$ $\forall X, Y. (\neg pass(X, history) \wedge \neg pass(Y, history) \rightarrow X = Y)$ $\forall X, Y. (\neg pass(X, history) \wedge \neg pass(Y, history) \wedge \neg pass(Y, biology) \wedge \neg pass(X, biology) \rightarrow X = Y)$

Politicians always fool someone, and sometimes fool everyone, but they do not always fool everyone.

 $\forall X. politician(X) \exists Y. fools(X, Y)$

$\exists X. \text{politician}(X) \wedge (\forall Y. \text{fools}(X, Y))$ $\neg(\forall X. \text{politician}(X) \rightarrow (\forall Y. \text{fools}(X, Y)))$

Every person who does not like any vegetarian is intelligent. Nobody likes a vegetarian who is intelligent. There is a woman who likes every man who is not a vegetarian.

 $\forall X, Y. (\text{vegetarian}(Y) \rightarrow \text{not_like}(X, Y)) \rightarrow \text{intelligent}(X)$ $\neg \exists X, Y. (\text{likes}(X, Y) \wedge \text{vegetarian}(Y) \wedge \text{intelligent}(Y))$ $\exists X. \text{woman}(X) (\forall Y (\neg \text{vegetarian}(Y) \wedge \text{man}(Y)) \rightarrow \text{likes}(X, Y))$

1. (a) Tony, Mike and John are members of the Alpine Club
2. (b) Every member of the Alpine Club is a skier or a climber
3. (c) No climber likes rain
4. (d) Every skier likes snow
5. (e) Mike does not like everything that Tony likes
6. (f) Mike likes everything Tony does not like
7. (g) Tony likes both rain and snow

 $\text{member}(\text{alpine}, \text{tony})$ $\text{member}(\text{alpine}, \text{mike})$ $\forall x. \text{member}(\text{alpine}, x) \rightarrow (\neg \text{skier}(x) \wedge \neg \text{climber}(x))$ $\neg \exists x. (\text{climber}(x) \wedge \text{likes}(\text{rain}, x))$ $\forall x. \text{skier}(x) \rightarrow \text{likes}(\text{snow}, x)$ $\exists x. (\text{likes}(x, \text{tony}) \wedge \text{likes}(y, \text{mike}))$ $\text{likes}(\text{rain}, \text{tony}) \wedge \text{likes}(\text{snow}, \text{tony})$ $\text{bachelor} \doteq \neg \exists \text{married}. \top \sqcap \text{man}$

„bachelors are unmarried men“

 $\text{married} \doteq \text{married}^{-1}$

(being married to so. is reflexive)

 $\exists \text{married}. \top \sqsubseteq \text{happy}$

„all married people are happy“

 $\exists_{\geq 2} \text{love} \sqsubseteq \perp$

„you can love at most one person“

 $\exists \text{married.woman} \sqsubseteq \exists \text{love.woman}$

„someone married to a woman also loves a woman“