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CSCI 446
Fall 2018

HOMEWORK #3

Part 1: Translating English into Formal Logic

For the first part, you will translate the sentences below into first order logic. These came from the famous mathemetician (and more famous writer) Lewis Carroll. You might want to check out the puzzles at the Lewis Carrol Puzzles website to see how some of them are approached. Remember that you can use any of the logical equivalence rules (slide 31 in the Logical Agents lecture). In particular, you might find contraposition useful.

No kitten, that loves fish, is unteachable.
No kitten without a tail will play with a gorilla.
Kittens with whiskers always love fish.
No teachable kitten has green eyes.
No kittens have tails unless they have whiskers.

Solution:

R_1 $\forall x\ Loves(x, Fish) \Rightarrow Teachable(x)]$

R_2 $\forall x\ Tail(x) \Rightarrow \neg Play(x, Gorilla)]$

R_3 $\forall x\ Whiskers(x) \Rightarrow Loves(x, Fish)]$

R_4 $\forall x\ Teachable(x) \Rightarrow \neg GreenEyes(x)]$

R_5 $\forall x \neg Whiskers(x) \Rightarrow \neg Tail(x))]$

Part 2: Inference in First Order Logic
Let's say we also know:

> My kitten who has green eyes does not love fish.

Using three approaches, try to prove the following:

> My kitten is unteachable.

A. Forward Chaining. Use forward chaining to try to prove the previous assertion. Remember, that in order to use forward (or backward) chaining, the knowledge base must be in Horn form. So start by translating your KB into Horn clauses. Show your work in doing the translation, and then as you do the inference, show the logical progrssion so I can see how you did your reasoning.

Solution: KB:

R6: GreenEyes(K_1)
R7: ¬Loves(K_1, Fish)

R_8 Loves(K_1, Fish) => Teachable(K_1) (R_1; $\{x/K_1\}$)
R_9 Tail(K_1) => ¬Play(K_1, Gorilla) (R_2; $\{x/K_1\}$)
R_{10} Whiskers(K_1) => Loves(K_1, Fish) (R_3; $\{x/K_1\}$)
R_{11} Teachable(K_1) => ¬GreenEyes(K_1) (R_4; $\{x/K_1\}$)
R_{12} ¬Whiskers(K_1) => ¬Tail(K_1) (R_5; $\{x/K_1\}$)

R_{13}: ¬Loves(K_1, Fish) => ¬Whiskers(K_1) R_{10}; contraposition
R_{14}: GreenEyes(K_1) => ¬Teachable(K_1) R_{11}, contraposition
R_{15}: ¬Whiskers(K_1) R_7, R_{13}; modus ponens
R_{16}: ¬Teachable(K_1) R_6, R_{14}; modus ponens

B. Backward Chaining. Now use backward chaining to try to prove the previous assertion. You can use your KB from the previous part, but I do want to see all your steps in doing the backward chaining.

Solution: KB: $R6 - R_{12}$

Goal: $\neg Teachable(K_1)$

$GreenEyes(K_1) \Rightarrow \neg Teachable(K_1)$ R_{11}, contraposition

$GreenEyes(K_1)$ ✓ True according to R_6

$\Rightarrow$ $\boxed{\neg Teachable(K_1)}$

C. Resolution. Finally, use resolution to try to prove the assertion. Remember, that in order to use resolution, your KB must be in conjunctive normal form. So start by translating your KB into CNF. Show me all your work in this step. Then use resolution and show me all of your steps there, also.

Solution:

$R_8 \equiv \neg \text{Loves}(K_1, \text{Fish}) \vee \text{Teachable}(K_1)$

$R_9 \equiv \neg \text{Tail}(K_1) \vee \neg \text{Play}(K_1, \text{Gorilla})$

$R_{10} \equiv \neg \text{Whiskers}(K_1) \vee \text{Loves}(K_1, \text{Fish})$

$R_{11} \equiv \neg \text{Teachable}(K_1) \vee \neg \text{GreenEyes}(K_1)$

$R_{12} \equiv \text{Whiskers}(K_1) \vee \neg \text{Tail}(K_1)$

$KB \equiv (\text{GreenEyes}(K_1)) \wedge (\neg \text{Loves}(K_1, \text{Fish})) \wedge (\neg \text{Loves}(K_1, \text{Fish}) \vee \text{Teachable}(K_1)) \wedge \ldots$

$\ldots \wedge (\neg \text{Tail}(K_1) \vee \neg \text{Play}(K_1, \text{Gorilla})) \wedge (\neg \text{Whiskers}(K_1) \vee \text{Loves}(K_1, \text{Fish})) \wedge \ldots$

$\ldots \wedge (\neg \text{Teachable}(K_1) \vee \neg \text{GreenEyes}(K_1)) \wedge (\text{Whiskers}(K_1) \vee \neg \text{Tail}(K_1))$

$KB \equiv [\text{GreenEyes}(K_1) \wedge (\neg \text{Teachable}(K_1) \vee \neg \text{GreenEyes}(K_1))] \wedge \ldots$

$\ldots \wedge [\neg \text{Loves}(K_1, \text{Fish}) \wedge (\neg \text{Whiskers}(K_1) \vee \text{Loves}(K_1, \text{Fish}))] \wedge \ldots$

$\ldots \wedge (\neg \text{Loves}(K_1, \text{Fish}) \vee \text{Teachable}(K_1)) \wedge (\text{Whiskers}(K_1) \vee \neg \text{Tail}(K_1))$

$KB \equiv \text{GreenEyes}(K_1) \wedge \underline{\neg \text{Teachable}(K_1)} \wedge \neg \text{Loves}(K_1, \text{Fish}) \wedge \neg \text{Whiskers}(K_1) \wedge \ldots$

$KB \wedge \text{Teachable}(K_1) \Rightarrow \underline{\text{False}}$

$\boxed{\neg \text{Teachable}(K_1)}$