



Hw4 - Homework for cs404

Artificial Intelligence (Sabanci Üniversitesi)



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CS 404 – Artificial Intelligence
HW 4 – 2020 Spring
150pt

Objective: Learning about Propositional Logic

1) 20 pt - Decide whether each of the following sentences is valid, unsatisfiable, or satisfiable (not valid, but only satisfiable). Show how you come to that decision using truth table enumeration or logical equivalence rules.

- Smoke \Rightarrow Smoke 10pt

Smoke = A

This is valid since all the outcomes are True.

A		A \rightarrow A
1		1
0		1

Circle the correct answer: **Valid**, Satisfiable, Unsatisfiable

- Smoke \Rightarrow Fire 10pt

Smoke = A Fire = B

This is satisfiable since some outcomes are True

A	B		A \rightarrow B
1	1		1
1	0		0
0	1		1
0	0		1

Circle the correct answer: Valid, **Satisfiable**, Unsatisfiable

2) 40pt – Truth Table Enumeration for Inference

Assume we have the knowledge base **KB**: $\text{Rain} \wedge (\text{Rain} \Rightarrow \text{Wet}) \wedge (\text{Snow} \Rightarrow \text{Cold})$ and the given propositions are the only ones in the KB.

- a) **25 pts** – How many *possible worlds* (truth value assignments to the propositions) are *models of the KB*? Show your work by filling the truth table for the KB.

Cold	Rain	Snow	Wet	$(\text{Rain} \wedge ((\text{Rain} \rightarrow \text{Wet}) \wedge (\text{Snow} \rightarrow \text{Cold})))$
F	F	F	F	F
F	F	F	T	F
F	F	T	F	F
F	F	T	T	F
F	T	F	F	F
F	T	F	T	T
F	T	T	F	F
F	T	T	T	F
T	F	F	F	F
T	F	F	T	F
T	F	T	F	F
T	F	T	T	F
T	T	F	F	F
T	T	F	T	T
T	T	T	F	F
T	T	T	T	T

There are 3 True outcomes so 3 possible worlds.

- b) **15pts – Extend the above truth table** (use truth table enumeration method) to show whether the knowledge base entails $\alpha = \text{Wet}$.

State your answer here: Entails because, in all the places where KB evaluates true, Wet is true as well. That's why KB entails $\alpha = \text{Wet}$

3) 90pt – AIMA 3rd Ed. Q. 7.2

7.2 (Adapted from Barwise and Etchemendy (1993).) Given the following, can you prove that the unicorn is mythical? How about magical? Horned?

If the unicorn is mythical, then it is immortal, but if it is not mythical, then it is a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.

- a) 20pt – First state the English paragraph as a set of Propositional Logic sentences. Please use the given two-letter proposition names below. Be careful about what propositions to use (especially for the the statement “mortal mammal”), considering all of the paragraph.

1. $MY \Rightarrow IM$
2. $\neg MY \Rightarrow (\neg IM \wedge MM)$
3. $IM \vee MM \Rightarrow HO$
4. $HO \Rightarrow MA$

- b) 20pt – Convert the above KB into Conjunctive Normal Form. Show your work clearly.

1. $MY \Rightarrow IM$
2. $MY \vee (\neg IM \wedge MM)$. Then, $(MY \vee \neg IM) \wedge (MY \vee MM)$
3. $(\neg IM \wedge \neg MM) \vee HO$. Then, $(\neg IM \vee HO) \wedge (\neg MM \vee HO)$
4. $\neg HO \vee MA$

- c) 50pt – See if the KB entails each of the following conclusions: “unicorn is mythical”, “unicorn is magical”, “unicorn is horned”. Use the indicated method, if available.

For each of them, please indicate the inference method you are using and clearly indicate your conclusion at the beginning:

I. 10pts - “unicorn is mythical”:

Conclusion: Using resolution and modus ponens, we can show

that we can conclude?/not conclude? (infer/not infer?) that the unicorn is mythical.

Show your work or state your argument: In the part II I used simple resolution and modus ponens to show that unicorn is horned. If I use one more modus ponens: “If a unicorn is horned it is magical.” NOT mythical. So we cannot conclude.

II. 30pt - “unicorn is horned”:

Use either:

- **simple resolution:** that is apply resolution many times to see whether you can infer Horned, or

- **resolution refutation** (aka proof by contradiction): that is, add the negated form of whatever you want to check for entailment (e.g. \neg Horned), and see if you can reach a contradiction. This would show that the KB+negative is unsatisfiable, hence the conclusion can be inferred).

$\neg (MY \Rightarrow IM) = \neg IM \Rightarrow \neg MY$ (means that unicorn is not immortal and mythical)

1. $\neg IM \Rightarrow \neg MY$
2. $\neg IM \Rightarrow \neg IM \wedge MM$
3. $IM \vee (\neg IM \wedge MM)$
4. $(IM \vee \neg IM) \wedge (IM \vee MM)$
5. $IM \vee MM$ (if immortal or mammal it is horned)
6. HO (The conclusion is: Unicorns are horned)

III. 10pt - “unicorn is magical”:

Use Modus Ponens method and state your conclusion.

Here we proved that unicorns are horned for the question above:

1. $\neg IM \Rightarrow \neg MY$
2. $\neg IM \Rightarrow \neg IM \wedge MM$
3. $IM \vee (\neg IM \wedge MM)$
4. $(IM \vee \neg IM) \wedge (IM \vee MM)$
5. $IM \vee MM$ (if immortal or mammal it is horned)
6. HO

We have the following proposition:

$HO \Rightarrow MA$

By using Modus Ponens:

Unicorns are horned; therefore, they are magical.