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Assignment 5

Propositional Logic and Inference

Date Due: Thursday March 2 2023, 5:00pm **Total Marks: 12**

General Instructions

- **This assignment is individual work.** You may discuss questions and problems with anyone, but the work you hand in for this assignment must be your own work.
- If you intend to use resources not supplied by the instructor, please request permission prior to starting. **You should not use any resource that substantially evades the learning objectives for this assignment.** You must provide an attribution for any external resource (library, API, etc) you use. If there's any doubt, ask! No harm can come from asking, even if the answer is no.
- Each question indicates what the learning objective is, what to hand in, and how you'll be evaluated.
- **Do not submit folders, or zip files, even if you think it will help.**
- Assignments must be submitted to Canvas.

Question 1 (12 points):

Purpose: To formalize a problem description using propositional logic; to practice resolution inference

AIMA Chapter(s): 7.1-7.5

Overview

Dr. Light, the famous robot inventor, is in trouble. His notes are a mess and he can't remember where he left the **Rushjet** and the **Rushmarine**.[1] He knows these tools are in the hands of his robot masters (who have rebelled and are going berzerk), but he doesn't know exactly which ones.

More specifically, here is what Dr. Light knows for sure about the situation based on his jumbled notes.

- One of Snakeman, Needleman and Geminiman has the **Rushjet**.
- One of Snakeman and Shadowman has the **Rushmarine**
- There is only one Rushjet, i.e. if one robot master has it, the others don't
- Similarly, there is only one Rushmarine
- The same robot doesn't have both items
- If Geminiman has the Rushjet, then Shadowman does **not** have the Rushmarine
- If Shadowman has the Rushmarine, then Snakeman does **not** have the Rushjet
- If Snakeman has the Rushmarine, then Geminiman does **not** have the Rushjet
- Dr. Light doesn't trust Snakeman (this bullet point is a joke and you can ignore it for the purpose of the question)

Your task is to formally encode this problem using **propositional logic**, and then use the **resolution** algorithm to see if it's possible to determine the locations of the missing items after all.

[1] Both of these being useful tools that help his robot son Mega Man navigate through dangerous areas.

1 Atomic Sentences

First, define what you will use as your **atomic propositional sentences** for this problem. Give your sentences meaningful names (abbreviations are fine, just don't use something silly like A, B and C or X1, X2, etc....) and state what each of your sentences means with respect to the problem environment.

2 Build the Knowledge Base

Using your basic propositions, write a series of compound propositional sentences that encode the **knowledge** expressed by Dr. Light's notes. At this point, you can (and probably should) use the full set of propositional operators ($\vee, \wedge, \Rightarrow$ etc...) to write logical sentences that describe each rule as simply as possible. You want to be certain that your rules have captured all the dynamics of the real problem before moving on.

3 Convert to CNF and list the full KB

For each rule you devised for part 2 above, convert it to Conjunctive Normal Form (CNF). You may find that this process sometimes results in redundant (i.e. identical) clauses. You only need to keep one copy of each such clause for the final KB. List one clause per line, and number each line; you will find this very helpful for the last step of performing inference.

4 Perform Inference Queries

Use a **resolution inference query** to help Dr. Light answer the following questions with respect to your KB. You may have learned some other ways of doing logical proofs in other classes, but here you must **only** use the **resolution** algorithm for your query (see figure 7.13 from AIMA).

For the resolution proofs, show your work. Each line of the proof should clearly list which two clauses are being resolved, and the new clause that is created as a result.

Hint: If you ever end up with a clause that contains both P and $\neg P$, that clause is a **tautology**, and can be safely discarded (see AIMA, pg. 228).

The Rushjet

Can you determine who has **the Rushjet**? If yes, give a **resolution proof** that shows it. If no, explain which resolution queries you would NEED to perform and what their result(s) would need to be to prove this (but you do not need to actually perform these proofs).

The Rushmarine

Can you determine who has **the Rushmarine**? If yes, give a **resolution proof** that shows it. If no, explain which resolution queries you would NEED to perform and what their result(s) would need to be to prove this (but you do not need to actually perform these proofs).

What to Hand In

Hand in your problem formalization and inference proof in a single document called `a5q1.pdf` (or .doc, etc...).

Evaluation

- 1 mark for describing and naming atomic propositions
- 3 marks for encoding Dr. Light's knowledge correctly
- 2 marks for converting the rules to CNF and listing the finalized KB
- 3 marks for conclusion for the Rushjet
- 3 marks for conclusion for the Rushmarine