CPSC 481 - Artificial Intelligence

Project 2, Fall 2022 - due 21st October 2022

In this project you will solve a puzzle “Truthoraptor and Lieosaurus” using Propositional Logic.

There are two goals for this project

1. Exploring the concept of how reasoning can be done on knowledge given.
2. Learning the basics of propositional logic.

Teams

The project must be completed with a team of three to four students. You are free to make your own team.
Teams should be formed by next Wednesday, 12th October 2022.

In order to submit the project as a team, you must join a group for that project in canvas.

- Several groups have been pre-created by the instructor, and your team must join one of them for your submission. Projects cannot be submitted by groups that you create yourself.
- The first student to join the group would automatically become the leader.
- Groups on canvas are specific to each Project, so you need to join a group for each project separately.
- If there are no empty groups on canvas, contact the instructor via email.

Getting started

- The starter code is available under Assignments-> Projects-> Project 2. Download this from canvas.

Understanding the Project

In Krishna's Jurassic World, there exists two types of dinosaurs, Truthoraptor and Lieosaurus. A Truthoraptor always tells the truth: if Truthoraptor states a sentence, then that sentence is true. Conversely, a Lieosaurus will always lie: if a Lieosaurus states a sentence, then that sentence is false.

The objective of the puzzle is, given a set of sentences spoken by each of the dinosaurs, determine, for each dinosaur, whether that dinosaur is a Truthoraptor or a Lieosaurus.

For example, consider a simple puzzle with just a single dinosaur named A. A says "I am both a Truthoraptor and a Lieosaurus."

Logically, we might reason that if A were a Truthoraptor, then that sentence would have to be true. But we know that the sentence cannot possibly be true, because A cannot be both a Truthoraptor and a Lieosaurus – we know that each dinosaur is either a Truthoraptor or a Lieosaurus, but not both. So, we could conclude, A must be a Lieosaurus.

That puzzle was on the simpler side. With more dinosaurs and more sentences, the puzzles can get trickier! Your task in this problem is to determine how to represent these puzzles using propositional logic, such that an AI running a model-checking algorithm could solve these puzzles for us.

Take a look at **logic.py**. No need to understand everything in this file, but notice that this file defines several classes for different types of logical connectives. These classes can be composed within each other, so an expression like `And(Not(A), Or(B, C))` represents the logical sentence stating that symbol **A** is not true, and that symbol **B** or symbol **C** is true (where "or" here refers to inclusive, not exclusive, or).

Recall that **logic.py** also contains a function **model_check**. **model_check** takes a knowledge base and a query. The knowledge base is a single logical sentence: if multiple logical sentences are known, they can be joined together in an **And** expression. **model_check** recursively considers all possible models, and returns **True** if the knowledge base entails the query, and returns **False** otherwise.

Now, take a look at **puzzle.py**. At the top, we've defined six propositional symbols. **ATruthoraptor**, for example, represents the sentence that "A is a Truthoraptor," while **ALieosaurus** represents the sentence that "A is a Lieosaurus." We've similarly defined propositional symbols for characters B and C as well.

What follows are four different knowledge bases, **knowledge0, knowledge1, knowledge2** and **knowledge3**, which will contain the knowledge needed to deduce the solutions to the upcoming Puzzles 0, 1, 2, and 3, respectively. Notice that, for now, each of these knowledge bases is empty. That's where you come in!

The **main** function of this **puzzle.py** loops over all puzzles, and uses model checking to compute, given the knowledge for that puzzle, whether each character is a Truthoraptor or a Lieosaurus, printing out any conclusions that the model checking algorithm is able to make.

Requirements

Add knowledge to knowledge bases **knowledge0, knowledge1, knowledge2** and **knowledge3** to solve the following puzzles.

- Puzzle 0 is the puzzle from the Background. It contains a single dinosaur, A.
    - A says "I am both a Truthoraptor and a Lieosaurus."

- Puzzle 1 has two dinosaurs: A and B.
    - A says "We are both Lieosaurus."
    - B says nothing.

- Puzzle 2 has two dinosaurs: A and B.
    - A says "We are the same kind."
    - B says "We are of different kinds."

- Puzzle 3 has three dinosaurs: A, B, and C.
    - A says either "I am a Truthoraptor." or "I am a Lieosaurus.", but you don't know which.
    - B says "A said 'I am a Lieosaurus.'"
    - B then says "C is a Lieosaurus."

    - C says “A is a Truthoraptor.”

In each of the above puzzles, each dinosaur is either a Truthoraptor or a Lieosaurus. Every sentence spoken by a Truthoraptor is true, and every sentence spoken by a Lieosaurus is false.

Once you’ve completed the knowledge base for a problem, you should be able to run **python puzzle.py** to see the solution to the puzzle.

Some Hints

- For each knowledge base, you’ll likely want to encode two different types of information: (1) information about the structure of the problem itself (i.e., information given in the definition of a Truthoraptor and Lieosaurus puzzle), and (2) information about what the dinosaurs actually said.

- Consider what it means if a sentence is spoken by a dinosaur. Under what conditions is that sentence true? Under what conditions is that sentence false? How can you express that as a logical sentence?

- There are multiple possible knowledge bases for each puzzle that will compute the correct result. You should attempt to choose a knowledge base that offers the most direct translation of the information in the puzzle, rather than performing logical reasoning on your own. You should also consider what the most concise representation of the information in the puzzle would be.
    - For instance, for Puzzle 0, setting **knowledge0 = ALieosaurus** would result in correct output, since through our own reasoning we know A must be a Lieosaurus. But doing so would be against the spirit of this problem: the goal is to have your AI do the reasoning for you.

- You should not need to (nor should you) modify **logic.py** at all to complete this problem.

Rubrics

The project has a total of 50 points and 2 points for individual contributions, so a **total of 52 points**.

Puzzle 0 -> 5 points

Puzzle 1 -> 10 points

Puzzle 2 -> 15 points

Puzzle 3 -> 20 Points

The individual contribution of each team member will be confidentially evaluated by the other team members. You will be evaluated individually on the following criteria (2 points)

1. Discussion, Research and Problem Solving
2. Code Implementation
3. Checking in timely with other members
4. Willingness to help other team members

Submission

Only **ONE** submission is required per team. Do not submit your project via email. You must submit the projects through CANVAS.