TDT4136 Intro to AI - Final Exam Fall 2022 - Solution

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Overview

- There are multiple correct answers in many of the questions, the solutions presented here show only one possible answer.
- Some tasks are asking for partial solution to the problem. For the sake of completeness, solutions presented here solve the complete problems, which is not expected from students.
- For the sake of correctness, truth tables are computed automatically.

Task 1: Theoretical questions

1.1) Why might we want to use a factored state representation instead of an atomic state representation?

1.2) What is the benefit of having a model in a model-base agent?

1.3) Why is consistency a desired property of a heuristic?

1.4) What is the difference between incremental and local search?

1.5) Why do we have mutations in genetic algorithms?

1.6) How can we apply minimax to a 3-player game?

1.7) Why is Monte Carlo tree search less sensitive to evaluation function errors than alpha-beta search?

1.8) Explain why the ignore-delete-list heuristic is an admissible heuristic for planning

1.9) Entailment ($\models$) is not part of the logical representation language, nor a connective in any logic, Then, what is entailment? Entailment can be implemented by resolution/refutation or forward/backward chaining in propositional logic. Which inference rule is used in resolution refutation and which one is used in forward/backward chaining?

1.10) What is the main disadvantage of propositional logic? What are the four new elements introduced in the syntax of first order logic to address this issue?

Task 2: Intelligent Agents - Grocery Store Robot

Grocery store robots can navigate autonomously through the store to scan shelves and report on inventory. In other words, it reports the quantity of products currently available on the shelves. The robot is equipped with cameras, an ultrasonic sensor (measures distances to obstacles) and a collision sensor.

2.1) Specify:

- performance measure
- environment properties
- actuators and sensors

Explain your specification, including the answer for the following questions:

- Why this performance measure makes sense for this environment?
- With respect to each of the properties, why this environment can be characterized in this way?

2.2) What agent type will work best for this environment? Explain why. Make a visualization showing the main components for this type of agent. Briefly describe each component and interaction between them.

Task 3: Solving problems by searching: Wolf, goat and cabbage

A farmer went to the market and purchased a wolf, a goat, and a cabbage. On his way home, the farmer came to the bank of a river and rented a boat. But to cross the river by boat, the farmer could carry only himself and a single one of his purchases: the wolf, the goat, or the cabbage. If left unattended together, the wolf would eat the goat, or the goat would eat the cabbage. The farmer's challenge is to carry himself and his purchases to the far bank of the river, leaving each purchase intact.

3.1 Draw *part* of a state-space graph for this problem, with nodes that are 3 or less edges away from the start node. Explain what nodes and edges represent. Mark start and end nodes.

3.2) Apply iterative deepening search with depth limit of 3. Enumerate nodes in the order they are expanded.

3.3) Design an admissible heuristic for this problem. Describe the heuristic and explain why it is admissible.

Task 4: Constraint Satisfaction Problems - Four digit number

In this problem, you are trying to find a four-digit number satisfying the following conditions:

1. The number is odd
2. The number only contains the digits 1, 2, 3, 4 and 5
3. Each digit (except for the leftmost) is strictly larger that the digit to its left

4.1) Formulate this problem as a CSP: 4.1.1) Visualize this problem as a constraint graph. Explain what nodes and edges represent. 4.1.2) Apply unary constraints (condition 1) and show domains.

4.2) Solve this problem using backtracking with the following heuristics:

- Use **Minimum remaining values** for variable selection
- Use **Least constraining value** for value selection

Show each step with updated domains of the variables:

Task 5: Propositional logic - Boxes with gold

Three boxes are presented to you. One contains gold, the other two are empty. Each box has imprinted on it a clue as to its contents. The clues are:

- Box 1: *The gold is not here*
- Box 2: *The gold is not here*
- Box 3: *The gold is in Box 2*

Only one message is true, the other two are false. Which box has the gold? Solve the puzzle using propositional logic by completing the following steps:

5.1) Let B_i stand for the gold is in the i-th box, where $i \in [1:3]$. Formalize the following statements of the problem in propositional logic:

- One box contains gold, the other two are empty
- Only one message is true, the other two are false. Do the logical equivalent if needed.

5.2) Compute the truth table for expressions S_1 and *simplified* S_2, which we call S_3, and make an inference about which box has the gold.

5.3) Instead, if resolution refutation should be used for inference, how would you define the knowledge base KB and query α? And what should be achieved to prove the entailment $KB \models \alpha$?

Task 6: Planning - Monkey and bananas

A monkey in a laboratory wants to get some bananas which are hanging on the ceiling out of reach. However, a box that could enable the monkey to reach the bananas (if the monkey were to climb onto it) is available nearby. Consider the following:

- Initially, the monkey is at A, the bananas at B and the box at C.
- Both the monkey and the box have height Low, but if the monkey climbs onto the box he will have height $High$, which is the same as the bananas.
- The actions available to the monkey include:
  - Go from one place to another
  - $Push$ an object from one place to another
  - $ClimbUp$ onto on an object
  - $ClimbDown$ from an object *(NB! This one is no longer used in the exam. Left up for completeness purposes.)*
  - $Grab$ an object (only if the object and the monkey are in the same place and at the same height)
  - $Release$ an object *(NB! This one is no longer used in the exam. Left up for completeness purposes.)*

7 .1) Specify the problem using Planning Domain Definition Language (PDDL). Include initial and goal state descriptions as well as actions schemas.

7.2) Solve the problem using backwards search (regression). Show the first 3 steps in one of the branches, including actions and states after/before each action.