CMSC 671 (Introduction to AI) – Fall 2017

Homework 5: Knowledge and Planning

Due: 11/20 at 11:59pm

Please submit all parts I–IV together as a **single PDF file** named *lastname*_hw5.pdf, with parts clearly marked and delineated. Files must start with your last name and have your full name in the file, at/near the top. This is an individual homework—no groupwork, please.

PART I. KNOWLEDGE-BASED AGENTS (15 POINTS)

(Adapted from R&N 2nd edition, Exercise 7.1.) Consider the game Minesweeper (shown right), in which an agent explores a grid. Each square contains either a mine (if the agent explores this square, it loses the game), nothing, or a number ≥1 that indicates how many mines are in the 8 adjacent squares. The agent's goal is to explore every unmined (safe) square and no mined squares.[1]

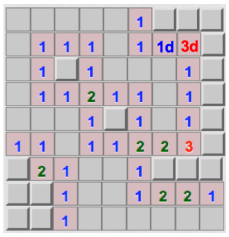

Figure 1. A partially finished game, including drone annotations.

Assignment: Answer the following about a Minesweeper agent.

1. Describe the Minesweeper world according to the properties of task environments listed in Chapter 2 (i.e., the seven characteristics described in Section 2.3.2). Your answer should include a brief (single sentence or phrase) justification for each of the seven answers.
2. How would your answer change in a world in which mines could relocate to a different unexplored square between your moves, according to certain rules? Your answer should include a brief (single sentence or phrase) justification for each property *that changes*.
3. Now consider a variation of this world that contains a **drone**. The squares surrounding the drone are marked with a **d** as well as a number (see illustration). If the agent explores the square containing a drone, it picks the agent up and drops it on a randomly selected square. Does that change the environment description? Your answer should include a brief (single sentence or phrase) justification for each property *that changes*.

PART II. LOGIC (20 POINTS)

Assignment: Answer the following questions using propositional logic.

4. You are given the following knowledge base (*Adapted from Mackworth & Poole 2nd edition*):

$B \wedge C \rightarrow A$	$E \wedge F \rightarrow A$	$D \rightarrow B$	$F \wedge H \rightarrow B$	$E \rightarrow C$
$H \rightarrow D$	E	$G \rightarrow F$	$C \rightarrow G$	

   a. Give a *model* of the knowledge base.
   b. Give an *interpretation* that is not a model of the knowledge base.
   c. Give two atoms that are logical *consequences* of the knowledge base.
   d. Give two atoms that are *not* logical consequences of the knowledge base.

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[1] If you are not familiar with the game, search for online versions and play until you are sure you understand how it works. Instructions: www.minesweeper.info/wiki/Strategy, online game (one of many): michaelbutler.github.io/minesweeper

5. Show all the possible resolutions for the following pairs of clauses:

   a. $A, \ \neg A \vee B$
   b. $A \vee B, \ \neg A \vee \neg B$
   c. $\neg X \vee Y, \ X \vee \neg Y \vee Y$

PART III. FOL & INFERENCE (35 POINTS)

Assignment: Construct the following knowledge base (list the sentences in it).

6. Represent the following knowledge base *in first-order logic*. Use the predicates:

   - `fast(y)`
   - `tasty(y)`
   - `has-cheese(y)`
   - `dieting(x)`
   - `likes(x,y)`
   - `eats(x,y)`
   - `hungry(x)`
   - `picky(x)`

where arguments `x` have the domain of all people, and arguments `y` have the domain of all food.

   a. Anyone who is hungry and not dieting will not be picky.
   b. Everyone who is picky only eats tasty food.
   c. A person eats food if and only if they like it and are hungry.
   d. A hungry person likes food that comes quickly.
   e. No-one who is dieting eats food with cheese.
   f. Every UMBC student likes tasty food.
   g. Val is a UMBC student.
   h. James ate chicken.
   i. Val is dieting and did not eat pizza.
   j. James is picky.

7. Convert the KB to conjunctive normal form (list the new set of sentences in the KB).

Assignment: Next, we wish to prove that: $\text{hungry}(\text{Val}) \rightarrow \text{eats}(\text{Val}, \text{chicken})$

8. Express the negation of this goal in conjunctive normal form.

9. Add the negated goal to the KB, and use forward chaining to prove that it is true. Show your proof as a series of sentences to be added to the KB. (Denote new sentences with letters starting after k.) You must clearly show which sentences are used to produce each new sentence.

Assignment: Answer the following questions *in English*.

10. For two of the sentences in the KB, give a 1-2 sentence explanation of how those sentences are a poor representation of the real world.