15-110: Principles of Computing, Spring 2018

LOOK !

Problem Set 12 (PS12)

NO HAND-IN REQUIRED! FOR PRACTICE ONLY!

This assignment is not graded. These problems cover the final topics of artificial intelligence and the limits of computation. Use these problems to review these areas to prepare for the final exam.

1. ELIZA is a computer program that emulates a psychotherapist and was one of the first examples of natural language processing which is very important in the field of computing today (think: Siri, automated phone menus, etc.).

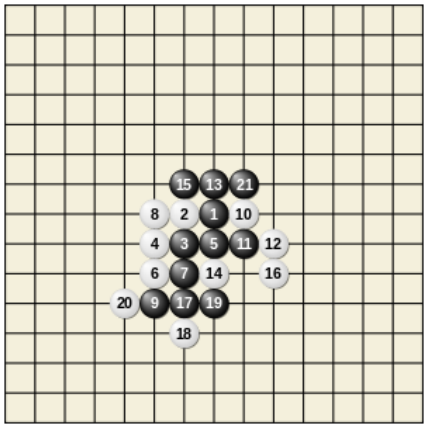
   Read the following paper, written in 1966 as the field of artificial intelligence was emerging:

   http://www.cse.buffalo.edu/~rapaport/572/S02/weizenbaum.eliza.1966.pdf

   (Focus on the introduction and the general description of the program, and on the implications in the Discussion section. You do not need to follow all of the detailed examples in the middle of the paper, although feel free to explore these if you wish. Note all of the data structures you know that are mentioned in the paper!)

   What is the function of a decomposition rule? What is the role of a keyword?

2. In the game of Gomuku, the play area consists of a 15 X 15 grid. Two players alternate turns, placing a piece (black or white) on the intersections of the grid lines as shown below:



Source: http://en.wikipedia.org/wiki/Gomoku

The object is to be the first player to get five adjacent pieces in a row, column or diagonal.

(a) Assume a game tree is built to analyze all possible moves in this game. Starting with a root node that represents an empty grid, how many nodes will be on the first level of the game tree below the root?

(b) How many nodes will be at the second level of the game tree below the root?

(c) At what level would the first leaf of the game tree occur? Why?

(d) Why would we use a heuristic to determine a player's move rather than a game tree?

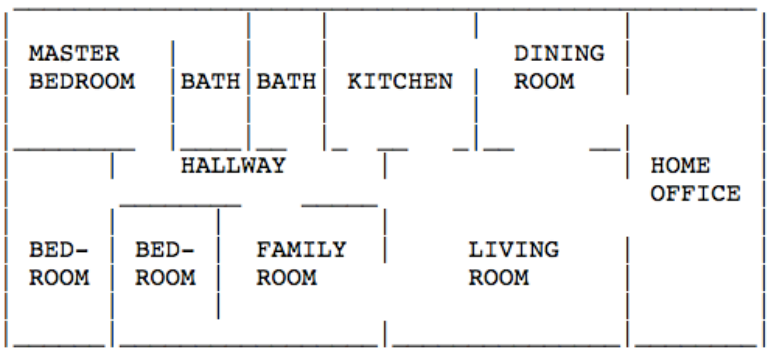
3. Beyonce's management team is scheduling a concert tour for next year, which will visit 15 cities including the first concert in her hometown of Los Angeles. She will perform one show in each city. She has a private jet that will fly her directly from any city to any other city on her tour. The cost of each flight depends on many factors including availability of staff, landing fees at airports, etc. Additionally, the flight from city A to city B may not cost the same as the flight from city B to city A. A computer can compute the total travel cost for 1000 potential concert tour schedules per second. At the end of the tour, she wants to fly directly back to Los Angeles.

   (a) How long will it take to determine the sequence of cities in a concert tour schedule that has the lowest total flight cost? Show your work.

   (b) If Beyonce adds a 16th city to her tour, how many times longer will it take the computer to compute the lowest total flight cost? Explain your answer.

4. The class P represents those problems that can be solved in polynomial time. The class NP represents those problems with a solution that can be verified in polynomial time. Consider the monkey puzzle problem, where we want to find a square arrangement of N cards that matches all monkeys for touching cards. Explain why this problem is in NP. (HINT: Determine the number of monkeys to be verified as a function of N.)

5. A one-story house is shown below. The owner does not want any multi-colored rooms. Put another way, the owner wants to paint each room with a single color, but the colors of all rooms do not have to be the same color (but they could be). Hallways are considered rooms, but closets are not rooms and are not shown in the diagram.



(a) Using only 3 colors of paint (tan, white and yellow), how many different ways can the owner paint the house? Explain your answer.

(b) Now, the owner adds another requirement that no two rooms that share a doorway can be painted the same color. Can this be done for the owner's house? Either give a valid color assignment for each room or explain why no such assignment is possible.

(c) Why is this general problem (i.e. painting any house with an arbitrary number of rooms using 3 paint colors so that no two connected rooms use the same color) considered *intractable* computationally?

6. The implication operator → is a boolean operation on boolean values A and B such that A → B is false only when A is true and B is false; otherwise, A → B is true. Consider the following logical formula: ¬(A ∧ B) ∧ (A → C) ∧ (C → B)

   (a) Is this formula satisfiable? Why or why not?

   (b) The formula above has 3 variables. If the formula had *n* variables, what is the only known algorithm (at this time) that can determine if the formula is satisfiable? What is the worst-case order of complexity of this algorithm?

7. Let A be the set of all programs such that each program in this set has no input and outputs a single integer as its answer after it does its computation. For example, the program that computes and prints out the sum of the integers from 1 to 100 is one of the programs in this set. Now, let X be a new program that analyzes any program from the set A. If the program it analyzes outputs an even integer, X outputs the word "EVEN"; otherwise it outputs "ODD". Finally, let Y be a new program that runs X to analyze itself (Y). If X outputs "EVEN", then Y outputs 1. If X outputs "ODD", then Y outputs 2.

   (a) Why is Y is one of the programs in set A?

   (b) Why are there contradictions if Y outputs 1 and if Y outputs 2?

   (c) What does all of this say about the existence of program X?