CSCD84: Artificial Intelligence
Assignment 1: Search and CSPs
Due Friday 11:59PM, January 24, 2025

1 Written Component

1.1 Heuristic Search

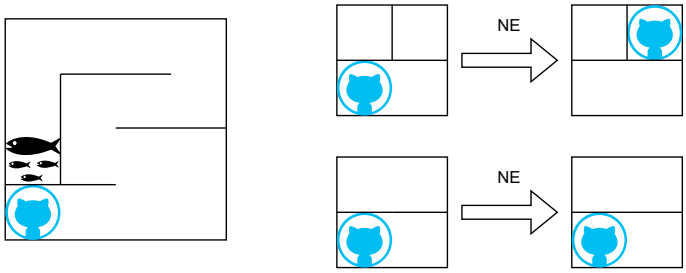

Figure 1: **(Left)** An search problem: A cat, Schrödinger, searching for fish to eat. **(Right)** Valid and invalid movements—Schrödinger can go through walls of shapes "L", "+", and "⊥".

Suppose a hungry cat, Schrödinger, is searching for fish for dinner (See Figure 1, left). However, Schrödinger is trapped in a 2D grid maze—Schrödinger can only move in eight directions $\mathcal{D} = \{N, S, E, W, NE, NW, SE, SW\}$ to navigate through the grid maze. Schrödinger moves from the current cell to the next cell based on direction $d \in \mathcal{D}$ when there is no obstacles at all. When Schrödinger takes direction $d \in \{N, S, E, W\}$ and there is a wall, Schrödinger stays at the current cell. It gets interesting when $d \in \{NE, NW, SE, SW\}$—Schrödinger, a quantum cat, can phase through the wall if Schrödinger is moving towards walls of shapes "L", "+", and "⊥" (see examples in Figure 1, right). Schrödinger's goal is to locate the fish and eat it with as little steps as possible (i.e. all costs are 1).
Please answer the following questions:

1. If the grid is $N \times M$, what is the size of the state space?
2. What is the maximum branching factor?
3. Suppose the i'th row, j'th-column cell is represented as a 2D-vector $[i, j]^\top$. Is a heuristic that uses Manhattan distance from positions of cat to fish admissible? Why or why not?
4. Suppose the i'th row, j'th-column cell is represented as a 2D-vector $[i, j]^\top$. Is a heuristic that uses Euclidean distance from positions of cat to fish admissible? Why or why not?
5. Provide a non-trivial admissible heuristic for this problem.
6. In lecture, we had briefly mentioned consistent heuristic. Formally, a heuristic h is consistent if for every node u, any of its (immediate) successor v satisfies $h(u) - h(v) \leq w(u, v)$, where w corresponds to the edge cost from u to v. Consequently consistent heuristic implies admissible heuristic, but not vice verse. Please provide an example where a heuristic is admissible but not consistent.

1.2 Constraint Satisfaction Problem

1			3
		2	
	1		4
	3		

Consider a 4×4 variant of Sudoku where i'th-row, j'th-column cell is v_{ij}, and taking on values 1 to 4.
Please answer the following questions based on the above example:

1. How many variables are there and what are their domains?
2. What types of constraints are there and how many of each type?
3. Draw the constraint graph.
4. Fill in the valid values for each cell.

5. According to the ordering heuristic, which variable(s) will the solver assign first? What value(s) will the variable(s) be assigned to?
6. Suppose our solver has decided to assign in the following order: $v_{12} = 2$ and $v_{21} = 4$. What does the solver do if it uses forward checking? Explain.

2 Programming Component

Our programming component for this assignment is related to search. UC Berkeley has provided a great educational codebase for this: `https://inst.eecs.berkeley.edu/~cs188/sp24/projects/proj1/`—it is a simplified Pacman game where it needs to eat one or more treats. The codebase consists of good documentation and test cases already—we will be using their unit tests for grading. Your task is to go through all eight questions.

3 Submission Instructions

For the written component, please submit `A1.pdf`. For the programming component, please submit only `search.py` and `searchAgents.py`.