Homework 1

Please write the following on your homework:

- Name
- Collaborators (write none if no collaborators)
- Source, if you obtained the solution through research, e.g. through the web.

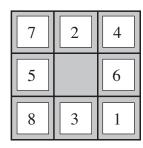
While you may collaborate, you *must write up the solution yourself*. While it is okay for the solution ideas to come from discussion, it is considered as plagiarism if the solution write-up is highly similar to your collaborator's write-up or to other sources.

You solution should be submitted to IVLE workbin. Scanned handwritten solutions are acceptable but must be legible.

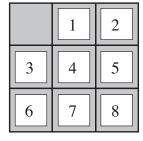
Late Policy: A late penalty of 20% per day will be imposed for the written assignment (no submission accepted after 5 late days) unless prior permission is obtained. Late submissions will not be accepted for the programming assignment.

1. Classical Planning

(a) Consider the 8 puzzle with the Slide schema.







Goal State

 $Action(Slide(t, s_1, s_2),$

PRECOND: $On(t, s_1) \wedge Tile(t) \wedge Blank(s_2) \wedge Adjacent(s_1, s_2)$ EFFECT: $On(t, s_2) \wedge Blank(s_1) \wedge \neg On(t, s_1) \wedge \neg Blank(s_2)$

Consider (i) ignoring $Blank(s_2)$ in the precondition as a heuristic and (ii) ignoring $Blank(s_2) \wedge Adjacent(s_1, s_2)$ in the precondition as a heuristic. Which of (i) or (ii) will result in fewer nodes being explored when used with the A^* algorithm?

Solution: Both (i) and (ii) results in relaxation of the problem, so are admissible heuristics. As (ii) is a further relaxation of (i), the heuristic (i) dominates heuristic (ii), hence (i) will result in fewer nodes being expanded when used with A^* .

Homework 1 2

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Init(At(C_1, SFO) \land At(C_2, JFK) \land At(P_1, SFO) \land At(P_2, JFK) \\ \land Cargo(C_1) \land Cargo(C_2) \land Plane(P_1) \land Plane(P_2) \\ \land Airport(JFK) \land Airport(SFO))
Goal(At(C_1, JFK) \land At(C_2, SFO))
Action(Load(c, p, a), \\ PRECOND: At(c, a) \land At(p, a) \land Cargo(c) \land Plane(p) \land Airport(a) \\ EFFECT: \neg At(c, a) \land In(c, p))
Action(Unload(c, p, a), \\ PRECOND: In(c, p) \land At(p, a) \land Cargo(c) \land Plane(p) \land Airport(a) \\ EFFECT: At(c, a) \land \neg In(c, p))
Action(Fly(p, from, to), \\ PRECOND: At(p, from) \land Plane(p) \land Airport(from) \land Airport(to) \\ EFFECT: \neg At(p, from) \land At(p, to))
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(b) Consider the Air Cargo problem. Describe how to modify the problem so that each plane can only carry one cargo.

Solution: Introduce a fluent Full(p). Add Full(p) to the add list of Load(c, p, c) and to the delete list of Unload(c, p, a).

(c) In the Air Cargo problem, write the successor state axiom for the fluent $At(P_1, SFO)$. **Solution:** $At(P_1, SFO)^{t+1} \Leftrightarrow Fly(P_1, JFK, SFO)^t \lor (At(P_1, SFO)^t \land \neg Fly(P_1, SFO, JFK)^t)$.

2. Decision Theory

(a) Bob is risk adverse but rational. His utilities for A, B, and C are U(A) = 0, U(B) = 100 and U(C) = 40. He is given a choice between C and a lottery [0.4, A; 0.6, B]. Which would he choose and why?

Solution: Bob is rational, hence would maximize his expected utility. He would choose the lottery which has expected utility of 60 instead of C which has utility of 40.

(b) Alice's utility function for money is $U(x)=x^2$. Argue that Alice is risk seeking. (Hint: U(x) is a strictly convex function. Jensen's inequality may be useful here.)

Solution: Jensen's inequality states that for a strictly convex function U(x), $pU(x_1) + (1-p)U(x_2) > U(px_1 + (1-p)x_2)$ for $p \in (0,1)$. Hence, Alice will always prefer a lottery $[p, x_1; (1-p), x_2]$ to the expected monetary value of $px_1, +(1-p)x_2$.

(c) Cathy prefers A to B but prefers lottery C = [0.2, A; 0.8, B] to lottery D = [0.3, A; 0.7, B]. Argue that there is no utility function that satisfies Cathy's preferences.

Solution: Cathy prefers A to B, so U(A) > U(B). Cathy also prefers C to D, so

$$\begin{aligned} 0.2U(A) + 0.8U(B) &> 0.3U(A) + 0.7U(B) \\ \Leftrightarrow & 0.1U(A) < 0.1U(B) \\ \Leftrightarrow & U(A) < U(B) \end{aligned}$$

giving a contradiction.