

Final Exam
Saturday December 13
120 minutes == 120 points
Open book and notes

1. [20 points] You are given these action schemas to move and pickup an object:

Action ($Go(x, y)$,

PRECOND: $At(Robot, x)$

EFFECT: $\neg At(Robot, x) \wedge At(Robot, y)$

Action ($Pickyp(o, x)$,

PRECOND: $At(Robot, x) \wedge At(o, x) \wedge EmptyHand(Robot)$

EFFECT: $\neg At(o, x) \wedge \neg EmptyHand(Robot) \wedge Holding(Robot, o)$

1. Create a new action schema by combining the two given action schemas into one, i.e. the robot goes to a location and picks up an object.
2. Create another action schema that combines the two action schemas but in the opposite order, i.e. the robot picks up an object at its own location and goes to a new location.
3. Describe in general how action schemas can be created by combining existing schemas. Explain when this is a good idea and when not.

2. [20 points]

Suppose you have a (magic) ATM card that gives you money any time you use it on an ATM machine. You need money to get food, after which you have food but no money. You have an ATM card. Your goal is to have food.

1. Write two action schemas: one to get money and one to get food using the specifications given above.
2. Assuming you have an ATM card, show the corresponding planning graph to achieve the goal to have food. Mark the mutexes.
3. At what level can you achieve the goal?
4. If instead your goal is to have food and money, at what level can you achieve it?

3. [20 points]

1. Suppose you want to use A* with a heuristic function $h(n)$ which may under or overestimate the true cost of reaching the goal from state n . You know, however, that any overestimate is limited to no more than

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10% of the true cost. Is there anything you can do to guarantee that the algorithm will always find the optimal solution (if a solution exist)? If yes, explain how. If not, explain why not. Be precise.

2. What kind of search does Greedy Best-First Search emulate when used with $h(n) = -2 \times g(n)$, where $g(n)$ is the path cost from start to n ? Explain your reasoning and support it with a simple example.

4. [20 points]

For each of the following English sentences, decide if the logic sentence is a correct translation or not. If not explain why not and correct it:

1. There is only one house in Minneapolis that is pink.

$$\exists x \text{ house}(x) \wedge \text{in}(x, \text{Minneapolis}) \wedge \text{pink}(x) \wedge \forall y [\text{house}(y) \wedge \text{in}(y, \text{Minneapolis}) \Rightarrow (x = y)]$$

2. Every apartment is cheaper than every house.

$$\forall x \text{ apartment}(x) \Rightarrow [\exists y \text{ house}(y) \wedge \text{cheaper}(x, y)]$$

3. Some farms cost less than some houses.

$$\exists x \text{ farm}(x) \wedge [\exists y \text{ house}(y) \Rightarrow \text{cheaper}(x, y)]$$

4. All houses have at least one bathroom.

$$\forall x [\text{house}(x) \wedge \exists y \text{ bathroom}(y)] \Rightarrow \text{in}(x, y)$$

5. [20 points]

Prove by resolution that the following set of clauses (in predicate calculus) is unsatisfiable. Assume that upper case arguments are constant, lower case arguments are variable:

1. $G(B)$
2. $\neg G(x) \vee H(x)$
3. $\neg H(z) \vee I(z)$
4. $\neg H(w) \vee J(w, D)$
5. $\neg I(B) \vee J(C, B)$
6. $\neg I(q) \vee \neg J(q, y)$

6. [20 points]

Answer these questions briefly but precisely.

1. Why does iterative deepening require less space than breadth-first search?
2. Is it possible for alpha-beta and minimax to choose different moves when used on the same problem?
3. Is it true that resolution refutation always terminates either by finding a contradiction or by failing to find a contradiction?
4. Can semantic networks be used to represent non-binary relations? How?