Sample Exam Reasoning Techniques

Task 1.

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Consider the 4-Queens puzzle. Take as initial state the following configuration P_0:

		Q	
Q			Q
	Q		

and as goal a configuration without attacking Queens, such as the following configuration P_t:

		Q	
Q			
			Q
	Q		

In order to reach a goal the following actions are possible: choose a Queen and replace it at one of the four locations (including the square where it came from) within the same column. Columns are chosen from left to right, squares within a column from top to bottom.

(a) Show how depth-limited depth-first search with a depth-limit of 4 finds the solution from P_0 to P_t. At any level you only consider one Queen, i.e., Queen 1 at level 1, Queen 2 at level 2, etc. You don't need to show the complete solution tree (which is rather impossible), but you should explain how the tree looks like and explain how the solution is found. Give an educated guess for the number of actions to perform before a goal is reached.

(b) Now devise a heuristic function h based on how many Queen-attacks there are in a configuration. We only consider attacks between a Queen i and a Queen j with $i < j$. For example, in the start configuration there are 3 attacks (one between Queens 1 and 2, one between Queens 1 and 4, and one between Queens 3 and 4). Is this an admissible heuristic function? Explain. If not, adopt it in such a way that it becomes admissible.

(c) Use the admissible heuristic function from part (b) for an A* search with the number of steps as cost. Show how A* using this function finds the solution from P_0 to P_t. Give for all states considered the values for $f(n)$, $g(n)$, and $h(n)$. Also indicate in which order these states are considered. Hint: it is easiest to present the answer to this question in the form of a tree.

Task 2.

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Given is the following text:

> Every child loves Santa. Everyone who loves Santa loves any reindeer. Rudolph is a reindeer, and Rudolph has a red nose. Anything which has a red nose is weird or is a clown. No reindeer is a clown. Scrooge does not love anything which is weird.

(a) Bring this information in predicate form.
(b) Next bring the predicate assertions in *conjunctive normal form* (CNF).
(c) Give a resolution proof that Scrooge is not a child.

Task 3.
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Suppose you want a planning system to figure out how to move cargo between airports. Let's say that you are considering the airports ABQ, SFO, and BOS. You have three cargo objects (C1, C2, and C3) and two airplanes (P1 and P2), all initially located at ABQ. Your goal is for all of the cargo to end up in SFO and both of the planes to end up in BOS. Suppose every airport has exactly one loading site. All loading sites are free initially.

We use the following predicates with obvious meanings:

- `At(X,Y)`: object X is at location Y
- `In(X,Y)`: cargo X is in airplane Y
- `LoadInUse(X)`: the loading site at airport X is in use

There are 3 possible actions:

- `Load(X,Y,Z)`: load cargo X into plane Y at airport Z;
- `Unload(X,Y,Z)`: unload cargo X from plane Y at airport Z;
- `Fly(X,Y,Z)`: fly airplane X from airport Y to airport Z.
- `Reserve(X,Y)`: reserve the loading site for airplane X at airport Y.
- `Release(X,Y)`: release the loading site for airplane X at airport Y.

Note that before loading or unloading a plane, the loading site should be reserved for that plane and that after loading or unloading a plane, the loading site should be released for that plane before it can take off.

We want to formulate this problem in such a way that a STRIPS-like problem-solving agent can make a plan to reach the goal.

(a) Give a description of the starting situation and the goal situation.
(b) Describe the actions in STRIPS format (preconditions, effects).
(c) Design a partial-order plan (POP) to reach the goal situation from the start situation. Take into account *threats* of causal links (*clobbering*) and indicate in the POP how you have solved such threats.

Task 4.
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In a galaxy far, far away, 90% of the taxicabs are green and 10% are blue. An accident involving a taxicab occurs; we presume that the accident rate for green taxicabs is the same as that for blue taxicabs.

A court considers the accident, and a newspaper reporter who was at the scene says: "The cab involved was blue." This reporter is usually reliable; in fact, his statements are correct 80% of the time. That is, if the taxicab involved in the accident was in fact blue (or green), the probability that our witness would say "blue" (or "green") is 0.8.

(a) Draw a Bayes Belief Network modelling this.
(b) Give relevant conditional probability tables.
(c) What is the probability that the taxicab involved in the accident was blue, given the reporter's statement?