Example exam Reasoning Techniques

Task 1.

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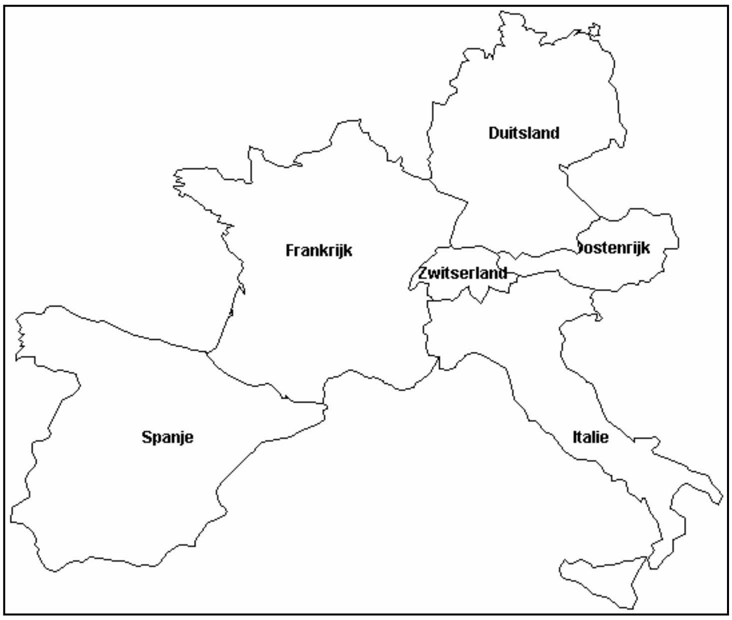
The map-3-colouring problem is a variant of the graph-3-colouring problem. The task is to colour all countries on a map in such a way that neighbouring countries have different colours. Use the following map:



a. Define the problem to colour this map with only 3 colours, i.e., red, blue and yellow, as a CSP problem <*V, D, R*>. State clearly the contents of the sets *V*, *D* and *R*.

b. Simulate the process of the standard backtrack procedure using the following (vertical) ordering for the countries: {Spanje, Oostenrijk, Italië, Frankrijk, Duitsland, Zwitserland} and (horizontal) ordering {red, blue, yellow} for the colours of each country. Give explicitly and in the right order which country each time gets which colour and state when an assignment fails or has success. How many assignments do you need to find a solution and how often did you have to backtrack?

c. Do the same for the application of the forward-check method, using the same horizontal and vertical orderings as in part b. State at each moment clearly the contents of the domains of the variables after every assignment.

Task 2.

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Given are the following facts:

- if pushable objects are blue, then non-pushable objects are green;
- all object are either blue or green, but not both;
- if there exists a non-pushable object, then all pushable objects are blue;
- object O1 is pushable;
- object O2 is non-pushable.

a. Bring this information in predicate form.
b. Next bring the predicate assertions in *conjunctive normal form* (CNF).
c. Give a resolution proof, using the *unit-preference* strategy, that there exists a green object.

Task 3.
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A Martian robot has to make a journey from her base camp to a crater at a distance of 20 km of the base camp. The robot needs not return to the base camp. The robot can travel exactly 10 km using 1 capsule of fuel. She can also take with her an additional capsule of fuel (without increasing the fuel consumption). We call the base camp *B*, the crater *K* and an in-between camp exactly halfway between the base camp and the crater *T*. There are three fuel capsules, *C*1, *C*2 and *C*3, available in *B*. The robot has at the start no fuel capsule loaded yet.

The robot has 4 possible actions:

- `goto(x,y)`, in which *x* is the starting place (*B*, *K*, or *T*) and *y* the target (*B*, *K*, or *T*). The robot has to have a fuel capsule loaded in her fuel tank to be able to do this action;
- `pickup(u,x)`, in which *u* is a fuel capsule on place *x*. The effect is that the robot carries *u* as cargo;
- `putdown(u,x)`, in which *u* is a fuel capsule being put down at place *x*. Of course *u* must be carried as cargo to be able to perform this action;
- `refuel(u,x)`, in which *u* is a fuel capsule on place *x* being placed in the fuel tank of the robot.
  [Assume that no fuel is consumed for the actions `pickup`, `putdown`, and `refuel`.]

We use the following predicates with obvious meanings:

- `Atrobot(x)`, in which *x* is one of the places *B*, *K*, or *T*;
- `At(r,x)`, in which *x* is one of the places *B*, *K*, or *T* and *r* is one of the fuel capsules; [a fuel capsule in the fuel tank of the robot is assumed not to be at place *x*, even if the robot is at *x*]
- `Carrying(u)` denotes that the robot carries fuel capsule *u* as cargo;
- `Fueled` denotes that the robot has a fuel capsule in her fuel tank (ready for ignition);
- `Cango(x,y)` indicates the maximum reach of the robot using one fuel capsule. It indicates that the robot can go from *x* to *y* (if a full fuel capsule is placed).

We want to formulate this problem in such a way that a STRIPS-like problem-solving agent can make a plan to direct the robot from the base camp to the crater.

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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Given is the following (simplified) chunk of domain knowledge:

> ***Dyspnoea*** *(shortness of breath) can be the result of tuberculosis, lung cancer, or bronchitis, but can also be the result of more of these causes simultaneously. A recent visit to Asia enhances the chance on tuberculosis. Smoking is a risk factor for both lung cancer and bronchitis. An X-ray photograph can be indicative of the presence of tuberculosis or lung cancer (but is unable to distinguish between the two). The presence of dyspnoea also cannot distinguish between tuberculosis and lung cancer.*

a. Design a Bayes belief network for this example.

Suppose that the following facts are given:

- *On average 50% of the population smokes.*
- *For a smoker it is the case that he/she has 10% chance on lung cancer; for a non-smoker this change is only 1%.*
- *For a smoker it is the case that he/she has 60% chance on bronchitis; for a non-smoker this chance still is 30%.*
- *1% of the group being investigated has been in Asia recently.*
- *People having been in Asia recently have 5% chance on tuberculosis; for people not having been in Asia recently this chance is 1%.*

b. Add this information as *conditional probability tables* (CPTs) to your network. [You don't have to give tables for information not given above!]

c. Answer the following questions:

- *What is the chance that a smoker who has been in Asia recently has lung cancer?*
- *And what is the chance for the same person on tuberculosis?*
- *And still for the same person, what is his/her chance on lung cancer or tuberculosis?*
- *What is the chance that an arbitrary person has bronchitis?*
- *If we know that an arbitrary person has lung cancer, what is his/her chance on having bronchitis as well?*