

# Midterm with Answers and FFQ (tm)

CSC 242

6 March 2003

*Write your **NAME** legibly on the bluebook. Work all problems. Best strategy is not to spend more than the indicated time on any question (minutes = points). Open book, open notes.*

## 1. Search: 5 Min.

Remember that *uniform-cost search* expands the node with the lowest path cost, and that (greedy) *best-first search* tries to expand the node closest to the goal. Please show each of the following statements is true:

1. Breadth-first search is a special case of uniform-cost search.
2. Breadth-first, depth-first, and uniform-cost searches are special cases of best-first search.
3. Uniform-cost search is a special case of A\* search.

*Answer:*

1. True if path cost is always 1, or in fact any constant.
2. You get these behaviors by bizarre definitions of “best”, namely betting that the node coming off the queue, stack, or priority queue is “nearer” to the goal than any others.
3. A\* with  $h(n) = 0$  (thus  $f(n) = g(n)$ ) is uniform-cost; Contrariwise, A\* with  $g(n) = 0$  (thus  $f(n) = h(n)$ ) is greedy.

## 2. Fearful Symmetry: 8 Min.

*Quarto!* is a game played on a  $4 \times 4$  board. There are sixteen pieces, each one different. In each move a piece is placed on the board and then never moved or removed. The pieces have four characteristics, each of which can take on two values (tall-short, white-black, solid-hollow, round-square). So there’s a tall white solid round piece, a tall white solid square piece, etc.... The object is to produce a line (vertical, horizontal, or diagonal) of four pieces sharing any characteristic. Please fill in the blanks:

PROFESSOR: How many essentially different first moves are there?

ALPHA: That’s easy! [blank].

BETA: No, you’ve forgotten board symmetries. It’s [blank].

GAMMA: No, you both forgot piece characteristic symmetries, so the true answer is [blank].

*Answer:*

Alpha says 16x16 (pieces times squares)

Beta says 3 x 16 (pieces times different squares (corner, center, non-corner-non-center))

*FFQ: Lots of people thought there were four different squares, seemingly forgetting mirror symmetry.*

Gamma says 3 (only the different squares). It makes no difference which piece goes first, any more than whether X or O goes first in TTT. Can re-map its characteristics consistently to make it any other piece; it's the relations between characteristics that count, not what they actually are.

### 3. Resolution Proof: 15 Min.

Either (I like Animals and I also like Trees ) or (I like Trees and I like Cats too).

If I like Cats, then I also like Dogs.

If I like Dogs, that implies I like all Animals.

If I like Animals and Trees then I have to be an Environmentalist.

Am I in fact an Environmentalist?

**A.** Put these five statements into propositional calculus (the last one means we're going to try to prove I'm an environmentalist).

**B.** Put the resulting sentences into CNF, ready for a resolution proof.

**C.** Do the resolution proof. Be neat and be sure your reader knows what clauses yielded what resolvents.

*Answer*

A.

*FFQ: Propositional Calc. has no variables, functions, or quantifiers. Almost everyone had at least a meaningless  $Dogs(x)$  or  $LikeDogs(I)$  or  $somesuch$ . I didn't deduct lots of points if everything else was OK but I was actually trying to keep things simple and save writing.*

V is or,  $\wedge$  is and,  $\sim$  is not.

1.  $(A \wedge T) \vee (T \wedge C)$

2.  $C \rightarrow D$

3.  $D \rightarrow A$

4.  $(A \wedge T) \rightarrow E$

5.  $\sim E$

B.

1  $\rightarrow$  (a)  $A \vee T$ , (b)  $T$ , (c)  $T \vee C$ , (d)  $A \vee C$

2  $\rightarrow$   $\sim C \vee D$

3  $\rightarrow$   $\sim D \vee A$

4  $\rightarrow$   $\sim A \vee \sim T \vee E$

5  $\rightarrow$   $\sim E$

C.

6. (4,5)  $\rightarrow$   $\sim A \vee \sim T$

7. (1b, 6)  $\rightarrow$   $\sim A$

8. (7,3)  $\rightarrow$   $\sim D$

9. (8,2)  $\rightarrow$   $\sim C$

10. (9, 1d)  $\rightarrow$   $A$

11. (10, 7)  $\rightarrow$  nil

And a note.... student found much nicer proof by resolving 1a and 4, and the result against 5, for a two-step proof. Well done!

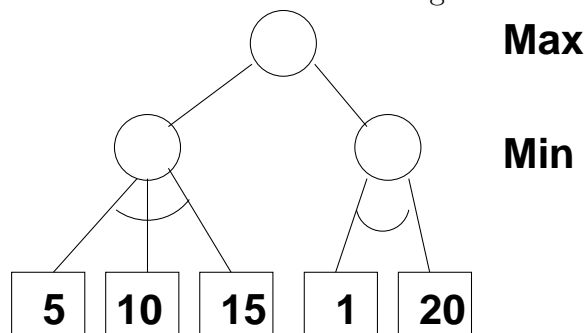
#### 4. Game Tree Pruning: 12 Min

Here is a snapshot of a game tree that would be generated by (left-to-right) depth first search to one ply. The numbers are the evaluations (for Max) of the resulting positions. The arcs across Min's branches are to remind you that Max must consider the AND of Min's choices but the OR of his own.

A. Now say this tree is actually being generated by the search with  $\alpha - \beta$  pruning. Do any nodes get pruned and if so which? What is the final backed up value for Max?

B. Draw the tree that results if the nodes are generated in an order that yields the minimum amount of pruning. Show which nodes are pruned, if any. What is the final backed up value for Max?

C. Is there an order for node generation that achieves more pruning?



Answer:

Max's BUW is always the same: 5.

In given tree the 20 node isn't looked at since Max will never go down this branch having seen the 1.

If right hand nodes are generated in the other order, 20 first and then 1, then no pruning happens.

Best you can do is to prune that one node... if nodes on Min's level are generated in the other order, then the (now) right-hand branch of 5, 10, and 15 in any order will all be visited by Max since they're all bigger than 1. Of course he first visits the entire left-hand branch too.

#### 5. Unification: 8 Min.

For each pair of sentences, give the most general unifier if it exists

A.  $P(A, B, B), P(x, y, z)$

B.  $P(x, A, g(x)), P(f(y), y, z)$

C.  $Knows(Father(y), y), Knows(x, x)$

D.  $Hits(Amy, Beth), Loves(x, x)$  Answer:

A.  $x/A, y/B, z/B$

B.  $y/Z, x/f(A), z/g(f(A))$  C. fails on an infinite regress it seems.

D. no match, Hits can't match Loves

Aside: Several people got C right but for the wrong reason, namely by claiming that unification knows that you can't be your own father. First, you CAN, as the links you've seen prove. Second, even if we restrict selves somehow to "biological father", the computer can't possibly know this: "father" is just a symbol, a string.

## 6. Simple Probabilistic Inference: 12 Mins.

You've got a touch of the plague and wonder if it's fatal. Medline.com informs you there's a test that indicates "fatal" with probability .9 if you actually are going to die. You also read it indicates "nonfatal" with probability .6 if in fact you have a non-fatal strain. Last, luckily the fatal strain is only found in one tenth of the cases.

A. What is the probability that the test will give a false alarm (way "fatal" when your plague is not fatal)?

B. Your test comes back with "fatal". What are the odds you'll survive?

*Answer*

Let F be "test says fatal" and D be "you die".

A) asks for  $P(F | \neg D)$

B) asks for the odds corresponding to  $P(\neg D | F)$ .

I thought this was a pleasingly simple and symmetrical sort of question but it caused a lot of heartburn so I graded it pretty easy. A couple of people got it exactly right.

A: Easiest is to note that  $P(F | \neg D) = 1 - P(\neg F | \neg D)$ . The latter cond. prob. is given in the problem statement so answer is  $1 - .6 = .4$ . Or it can be derived otherhow given what we know.

B: I went ahead and worked out the entire joint distribution and marginals, though that was not necessary: Just to share, it is

	D	~D	
F	.09	.36	P(F) = .45
~F	.01	.54	P(~F) = .55
P(D) = .1		P(~D) = .9	

Anyway we want to know  $P(\neg D | F) = P(\neg D, F)/P(F) = .36/.45 = .8$  This probability translates to odds of 4:1 for survival.

## 7. Planning: 15 Mins.

Your ceiling light is controlled by two switches. As usual, changing either switch changes the state of the light. The light only works if there's a bulb in the socket, but you've no way to add a bulb. Initially the light is off and there's a bulb in the socket.

A. Formalize this situation in situational calculus. (Looks like FOPC; don't plan, just formalize.)

B. Formalize this situation in STRIPS rules. (Looks like STRIPS rules; don't plan, just formalize.)

C. Briefly describe a partial order plan for turning on the light. (Maybe a diagram)

*Answer*

A. Have unary predicates Switch(x) and On(s) and Bulbin(s), initial state S0, switches x and situations s. Reified action predicate MoveSwitch and new-situation function Do.

S0 = Bulbin, ~On

Rules:

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(On(s) ^ Bulbin(s) ^ Switch(x)) -> (~On, Do(MoveSwitch(x,s)))
(~On(s) ^ Bulbin(s) ^ Switch(x)) -> (On, Do(MoveSwitch(x,s))) ;; two action rules
(Bulbin(s)) -> (Bulbin, Do(Moveswitch(x,s))) ;; frame axiom
}
```

B.

Precondition	Action	Add	Delete
Bulbin, On	Move Switch 1	Off	On
Bulbin, On	Move Switch 2	Off	On
Bulbin, Off	Move Switch 1	On	Off
Bulbin, Off	Move Switch 2	On	Off

C.

Key point is you start with “precondition” light off, end with “precondition” light on, and in the middle there are two choices, moving either switch 1 or switch2. SitCalc or STRIPS would pick one of these, but POP does not.

*FFQ: this was the most FFdQ by a long chalk. I liked it because it emphasizes formalizing things, which is an upcoming issue in the UCPOP problem. Also implicitly it shows if you understand how the planners work without having to try to hand-stimulate them (as we say). Only about 3 people used situations, I can't recall anyone using the words “add” and “delete”.*