

Midterm

CSC 242

March 2009

Write your **NAME** legibly on your bluebook(s). Work all problems. You may use two double-sided pages of notes. Please hand your notes in with your bluebook. The best strategy is not to spend more than the indicated time on any question (minutes = points).

1. FOPC: 25 Min.

Here are two sentences in FOPC:

- (A) $\forall x \exists y (x \geq y)$
- (B) $\exists y \forall x (x \geq y)$

(a) (5 min) Translate both statements into (unambiguous, if you can) English, assuming that variables range over then natural numbers $0, 1, 2, \dots, \infty$, and that the infix predicate \geq means “greater than or equal to”.

(b) (1 min) Is (A) true under the above interpretation?

(c) (1 min) Is (B) true under the above interpretation?

(d) (1 min) Yes or No (proofs later!): Does (A) logically entail (B)?

(e) (1 min) Yes or No (proofs later!): Does (B) logically entail (A)?

(f) (8 min) Try to prove that (A) follows from (B), using resolution, even if you think (B) does not logically entail (A). Continue until you succeed by deriving the null clause or the proof breaks down and you cannot proceed. As you recall, you must negate the goal sentence, move negation inwards using quantifier equivalence rules, Skolemize to remove existential quantifiers, put sentences into conjunctive normal form, and finally resolve clauses until the null clause is derived.

(g) (8 min) Try to prove that (B) follows from (A), using exactly same instructions as part (f).

Ans: a) should be obvious, b-e YNYN respectively. If you keep the direction of entailment straight, tell you how the proofs of f and g should come out.

f) This \geq infix predicate really screwed most people up. negating it to get $<$ predicates, keeping it in infix, expanding it to the two ($>$, $=$) predicates... yuck! Simply rewrite it as $G(x, y)$, is all I had in mind. Also some made up complicating predicates like $Nat(x)$ for natural number... Several people started off trying to prove a statement of the form $A \Rightarrow B$, rather than just negating the conclusion and looking for the null clause.

negate (A), CNFify: $\neg \forall x \exists y (G(x, y))$, so $\exists x \neg \exists y (G(x, y))$, so $\exists x \forall y \neg (G(x, y))$, so Skolemizing get $\neg G(T, y)$.
(B) to CNF: $\exists y \forall x (G(x, y))$, so Skolemizing $G(x, S)$.

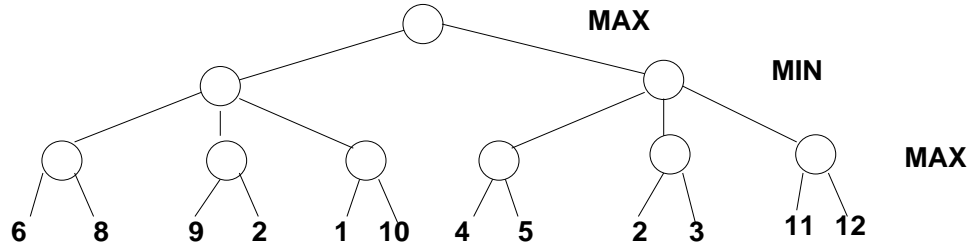
These unify and resolve nicely to null.

g) (A) to CNF: $\forall x \exists y (G(x, y))$, so $G(x, s(x))$ for Skolem function s .

not(B) to CNF: $\neg\exists y\forall x(G(x,y))$ is $\forall y\neg\forall x(G(x,y))$, so $\forall y\exists x(\neg G(x,y))$, so $\neg G(t(y),y)$, with Skolem function t . Trying to unify these two gives an infinite regress, so we're stuck.

2. Games: 15 Min.

What is the result of alpha-beta pruning on this game tree? That is, show the backed-up values of nodes, and which nodes or sub-trees are pruned by alpha-beta. (MAX and MIN levels shown – evaluate tree in usual left-right depth-first order.)

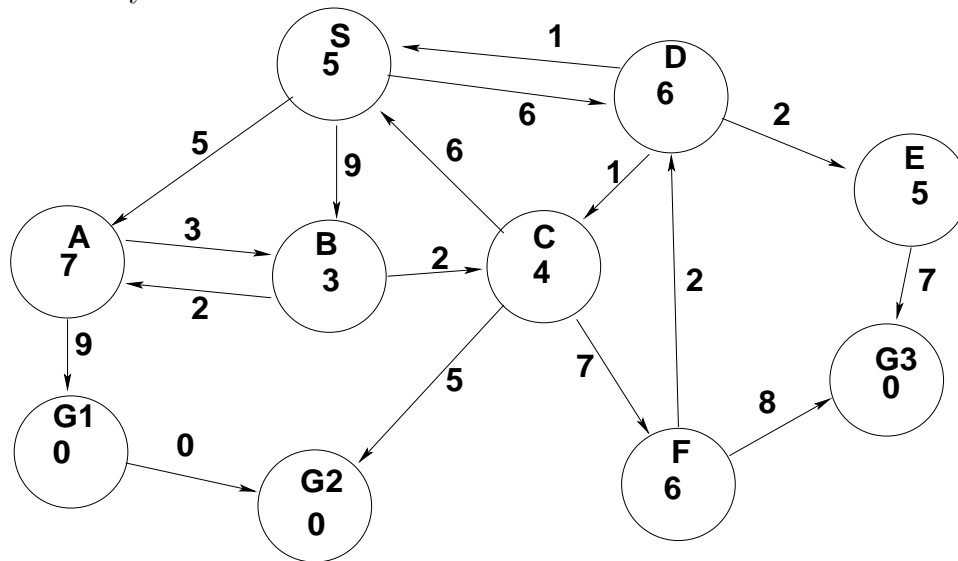


Ans: numbering terminal nodes from 1 thru 12, MIN won't let MAX take the 9 at node 3, so MAX doesn't need to look at the next node (no.4). MAX needs to look at both nodes 5 and 6 (if they were in the other order, 6 could have been pruned). Down the right branch: MAX can do better than 4 (node 5) by going down the left branch, so keeps searching, finds 5. At this point MAX knows MIN can force him to take that 5 if MAX goes down the right branch so the whole rest of the right branch is pruned.

Final backed up values levelwise: 8, 8 5, 8 9 10 5 X X.

3. Search: 15 Min.

Below is a search space with S the start note and G1, G2, G3 satisfying the goal test. Arcs are labeled with the cost of traversing them and the estimated cost to a goal is reported inside nodes. The space is a graph, so you can assume you have an OPEN list and a CLOSED list.



For each of the following search strategies, indicate which goal state is reached (if any) and list in order all the states popped off the open list. When all else is equal, nodes should be removed from OPEN in alphabetical order.

- (a) (5 min) Hill Climbing (Greedy)
 - (i) Goal Reached
 - (ii) States popped off OPEN in order:

- (b) (5 min) Iterative Deepening
 - (i) Goal Reached
 - (ii) States popped off OPEN in order:
- (c) (5 min) A*
 - (i) Goal Reached
 - (ii) States popped off OPEN in order:

Ans. This is a pretty snotty question (what I get for plagiarising it)...it should say whether tree or graph search is performed (is there a CLOSED list?). I'm assuming there is, as did the whole class, so we don't revisit nodes (oops...except as necessary – read on).

- (a) only use estimated costs: S B C G2. Many people visited A: S A B C G2, I dunno why.
- (b) explicitly pushing S every time gives S S A B D S A G1. Leaving off S's is OK.
- (c) S A B D C G2

Second infelicity with this problem: Note that you'll find a long path to C first (SABC) which, unless your algorithm is careful (sort of like the CB effect), will lose the actual best-cost path to G2 through C (SDCG2) costing 13 – path through A will win at cost 14. Crappy test question with these weights.

4. NLU: 15 Min. – 3 Min each

- (a) What do augmented grammars, such as the Definite Clause Grammar (DCG), buy us? (hint: Examples may be a good place to start an explanation.) Are these benefits “for free” or do they cost us something?
- (b) What problem are chart parsers supposed to fix? (Same hint).
- (c) Complete the sentence:

Chart parsers are examples of *dynamic programming*, which is a general technique simply described as _____.

- (d) What is quasi-logical form good for?
- (e) Your buddy says: “Chapter 22, man? Grammar useless: meaning!” You take him to claim that syntax is more or less irrelevant, at least in real-life, in non-literary NLU, and that what counts is semantics. State and defend your stance on the place of syntax and semantics in NLU.

Ans:

- (a) Passive constructions, chomsky transformations in general, elegant ways to deal with number and gender agreement. Problem is no longer CFG, so parsing time goes up.
- (b) In either TD or BU parsing, you can do a lot of work, useless or repeated, with certain 'surprising' sentences. English is such that many local decisions on structure are correct, so why throw them away? So Ch.Parser keeps partial results.
- (c) ... the idea of keeping useful partial results in an easily-accessible data structure for reuse.
- (d) easy to make good arguments both ways.

5. Induction: 5 min

There's a line of people with a woman at the front and a man at the end. Prove by induction that there's at least one man standing *directly* behind a woman in the line.

Ans: the only slightly tricky part is in the induction step, which needs some sort of case analysis; made easier if you pull one of these math. dept. tricks and say “without loss of generality” you can always add the next person at (say) the head of the line.

People still need to work on induction.