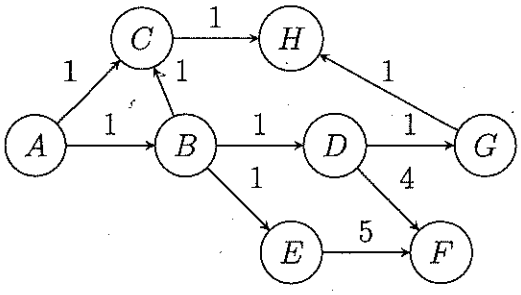
ECE 45234 - Spring 2018 Problem Set #1 Solutions Due: 2/12/18

The purpose of this problem set is to gain experience with state-space search methods. You can complete the exercises by either directly marking up this pdf, or by printing, completing, and scanning as a pdf. In the engineering design section you will be formulating and solving three problems using modules from the AIAMA text's website (included in the starter code): heuristic search and the 8-puzzle, a two-player game, and a constraint satisfaction problem. This will require writing three python programs.

You can complete the exercises by either directly marking up this pdf, or by printing, completing, and scanning as a pdf. You should complete the Engineering Design Problems by writing the python code as instructed. The resulting pdf and python files should be uploaded to Canvas via the assignment tab by the due date and time.

Exercises

1. Consider the following graph, with initial state A and goal F, and the heuristic function h.



node, n	h(n)
A	8
B	7
C	3
D	2
E	3
F	0
G	30
H	25

Fill in the order nodes are goal-tested and the contents of the frontier and explored list at each step using the following algorithms (see next page). For nodes in the frontier indicate the f value in parenthesis after the node label, e.g. A(8). Assume nodes are expanded and any ties are broken using alphabetical ordering of the node labels.

(a) (5 points) greedy best-first search

current node	frontier	explored
A	C(3) B(7)	
C	B(7) H(25)	A
B	D(2) E(3) H(25)	A, C
D	F(0) E(3) H(25) G(30)	A, C, B
F	E(3) H(25) G(30	A, C, B, D

(b) (5 points) A* search

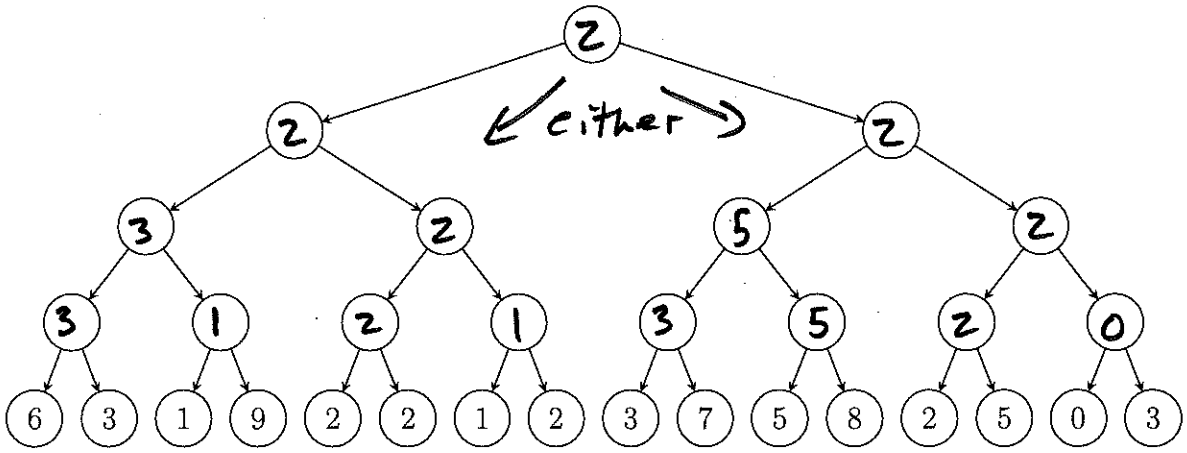
current node	frontier	explored
A	C(4) B(8)	
C	B(8) H(27)	A
B	D(4) E(5) H(27)	A, C
D	E(5) F(6) H(27) E(33)	A, C, B
E	F(6) H(27) G(33)	A, C, B, D
F	H(27) G(33	A, C, B, D, E

2. (5 points) Is the heuristic in the previous problem admissible? Explain why or why not.

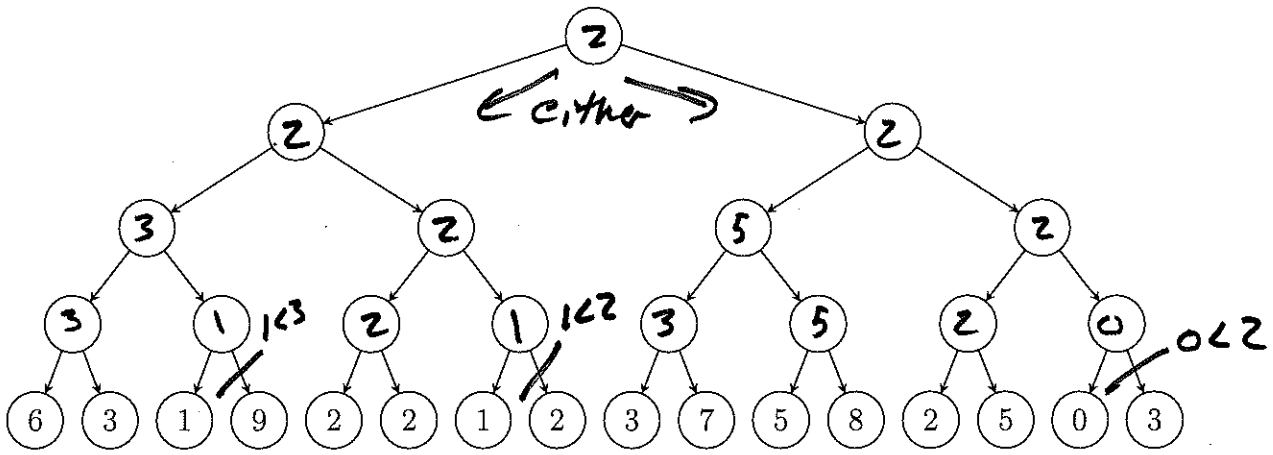
No. Example $h(B) = 7 > 6 = h^*(B)$

3. (10 points) Given the following game tree, where the terminal nodes contain their respective evaluation function, perform minimax search and indicate which move should be made. Then repeat the search using the $\alpha - \beta$ algorithm and indicate which branches would be pruned (if any) on the tree. Assume MAX goes first.

minimax



$\alpha - \beta$



3 places where it Prunes.

4. Consider the problem of assembling a mechanism consisting of 10 parts labeled A-J according to the following rules:

   - Part J must be the first part added to the assembly.
   - Part C must be added to the assembly before parts A,D,E,G.
   - Part E must be added to the assembly after part C.
   - Part A and Part B must be added sequentially (one directly after the other) in order

   (a) (3 points) Formalize the problem as a CSP.

There might be multiple way to do this, but I think this is the simplest.

Variables: A, B, ... J

Domain: order of assembly 1, 2 ... 10

Constraints: J = 1, unary.

C < A, C < D, C < E, C < G (binary)

B = A + 1 (binary)

Note: ~~*~~ constraint above is redundant.

   (b) (3 points) Is a solution possible?

Yes. example.

A = 3, B = 4, C = 2, D = 5, E = 6, F = 7

G = 8 H = 9 I = 10 J = 1

5. For the following CSP

- Variables and Domains:

$$X_1 = \{0, 1\}, X_2 = \{-1, 0, 1\}, X_3 = \{0, 1, 2, 3\}$$

- Constraints:

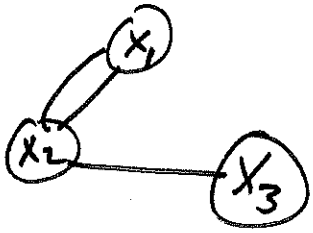
$$X_1 \neq X_2, X_2 = X_3, X_3 \neq 3, X_1 + X_2 = 0$$

(a) (2 points) Apply node consistency.

$X_1 = \{0, 1\}$ 3 removed from domain of X_3

$X_2 = \{-1, 0, 1\}$

$X_3 = \{0, 1, 2\}$



(b) (2 points) Then, apply arc consistency (AC-3).

(X_1, X_2) (X_2, X_1) (X_2, X_3) (X_3, X_2)

$X_1 = 0$ revise

$X_2 = -1$

$X_2 = 0$ revise

$X_3 = 1$ revise

$X_2 = -1$ revise

domain of X_2 empty

return fail

(c) (2 points) Using your result from part b, is a solution possible?

NO. The domain of X_2 becomes empty during AC-3.