CS6364, Spring 2015
Dr. Mithun Balakrishna
Homework 2
Due February 22nd, 2014 11:59pm

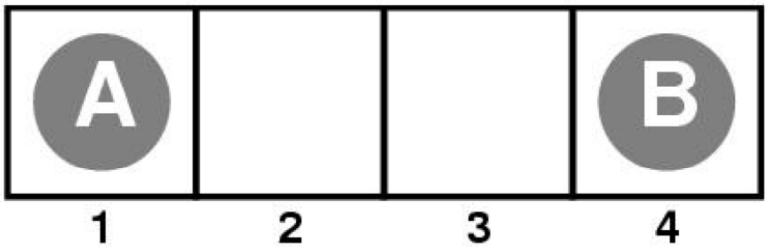
A. Submission Instructions:

- Submit your solutions via eLearning.
- Please submit a single zip file with the following files:
  - For programming questions:
    - Source code file(s) in C/C++, Java, or Python. For using any other programming language, please get prior approval from the TA.
    - A ReadMe file with instructions on how to compile/run the code.
  - For all other questions, a PDF/Doc/PS/Image file with the solutions.
- Late Submission Penalty:
  - up to 2 hours late — 10% deduction
  - 2 - 4 hours late — 20% deduction
  - 4 - 12 hours late — 35% deduction
  - 12 - 24 hours late — 50% deduction
  - 24 - 48 hours late — 75% deduction
  - more than 48 hours late — 100% deduction (zero credit)

B. Problems:

1. 4-square Game (25 points)

Figure 1:



This is the starting position of a simple game. Player *A* moves first. The two players take turns moving, and each player must move his token to an open adjacent space *in either direction*. If the opponent occupies an adjacent space, then a player may jump over the opponent to the next open space if any (for example, if *A* is on 3 and *B* is on 2, then *A* may move back to 1). The game ends when one player reaches the opposite end of the board. If player *A* reaches space 4 first, then the value of the game to *A* is +1; if player *B* reaches space 1 first, then the value of the game to *A* is -1.

Consider the two-player game described above (Figure 1).

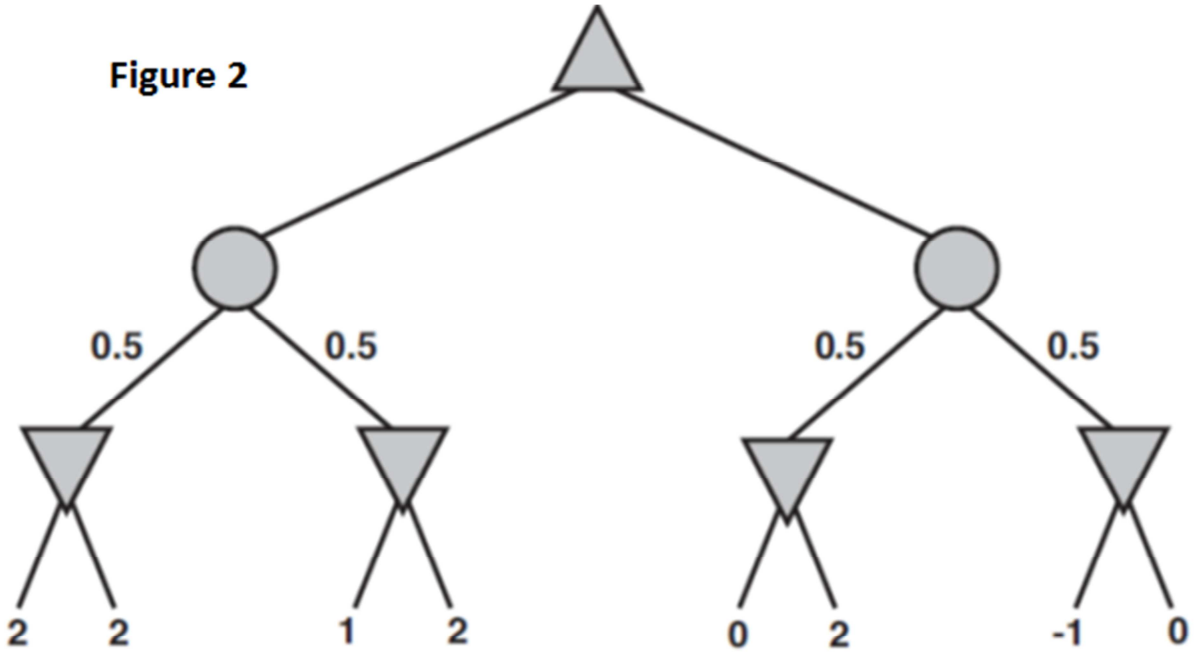
a) Draw the complete game tree, using the following conventions:
   - Write each state as (s_A, s_B) where s_A and s_B denote the token locations.
   - Put each terminal state in a square boxes and write its game value in a circle next to it.
   - Put *loop states* (states that already appear on the path to the root) in double square boxes. Since it is not clear how to assign values to loop states, annotate each with a "?" in a circle.

b) Now mark each node with its backed-up minimax value (also in a circle). Explain how you handle the "?" values and why.

c) Explain why the standard minimax algorithm would fail on this game tree and briefly sketch how you might fix it, drawing on your answer to (b). Does your modified algorithm give optimal decisions for all games with loops?

d) This 4-square game can be generalized to n squares for any $n > 2$. Prove that A wins if n is even and loss if n is odd.

2. Pruning (25 points):



This question considers pruning in a game with chance nodes. The figure above (Figure 2) shows the complete game tree for a trivial game. Assume that the leaf nodes are to be evaluated in left-to-right order, and that before a leaf node is evaluated, we know nothing about its value -- the range of possible values is $-\infty$ to ∞.

a) Mark the value of all internal nodes, and indicate the best move at the root with an arrow.
b) Given the values of the first six leaves, do we need to evaluate the seventh and eighth leaves? Given the values of the first seven leaves, do we need to evaluate the eighth leaf? Explain your answers.
c) Suppose the leaf node values are known to lie between -2 and 2 inclusive. After the first two leaves are evaluated, what is the value range for the left-hand chance node?
d) Circle all the leaves that need not be evaluated under the assumption in (c).

3. Prove each of the following assertions (25 points):

a. α is valid if and only if True $\models \alpha$
b. For any α, False $\models \alpha$
c. $\alpha \models \beta$ if and only if the sentence $(\alpha \rightarrow \beta)$ is valid
d. $\alpha \equiv \beta$ if and only if the sentence $(\alpha \leftrightarrow \beta)$ is valid
e. $\alpha \models \beta$ if and only if the sentence $(\alpha \wedge \neg\beta)$ is unsatisfiable

4. Convert the following set of sentences to clausal form (25 points):

a) $A \leftrightarrow (B \vee E)$
b) $E \rightarrow D$
c) $C \wedge F \rightarrow \neg B$
d) $E \rightarrow B$
e) $B \rightarrow F$
f) $B \rightarrow C$

Use resolution to prove the sentence $\neg A \wedge \neg B$ from the clauses.