Assignment 1: Playing Connect 4

Deadline

Submission: 5pm, Friday 20 April, 2018 (week 6).

Marking

This assignment is worth 10% of your final mark. It is an individual assignment; no group work.

The assignment will be split into two parts: auto-marked and tournament. The auto-marked component of the assessment will be worth 80% of the marks (8% of your final mark), and the tournament will be worth 20% of the marks (2% of your final mark).

Your mark for the auto-marked part will be your mark from the automatic grading system, and your mark for the tournament part will be determined by your position in the tournament.

Late submissions policy

No late submissions are allowed.

Programming languages

Your implementation can be written in Python, Java, C, C++ or MATLAB. The assignment will be tested on the University machines, so your code must be compatible with the language version installed on those machines.

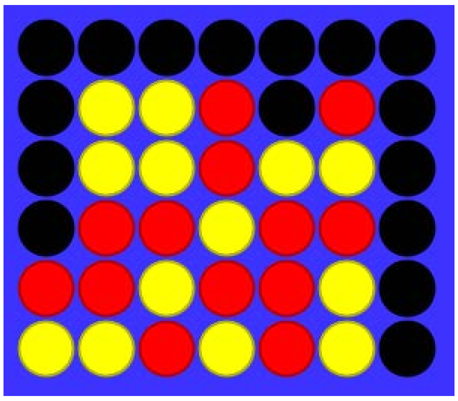
Submission

Your assignment must be completed individually using the submission tool PASTA (http://comp3308.it.usyd.edu.au). In order to connect to the website, you'll need to be connected to the university VPN. You can read this page to find out how to connect to the VPN. PASTA will allow you to make as many submissions as you wish, and each submission will provide you with feedback on each of the components of the assignment. Your last submission before the assignment deadline will be marked, and the mark displayed on PASTA will be the final mark for your assignment.

1. Connect 4

In this assignment, you will implement the minimax search algorithm with and without alpha-beta pruning in order to play a game of Connect 4.

The game of Connect 4 is played on a 6x7 vertical board (6 rows and 7 columns) with 21 red tokens and 21 yellow tokens. Players take turns in putting one of their tokens into the top of one of the columns, where it falls to the bottom-most available slot in that column, thus there are at most seven possible moves at any given point.



The first player to achieve a configuration where four of his/her tokens are lined up (horizontally, vertically or diagonally) wins.

2. Tasks

Write a program that, given an initial starting state of the board, and whose turn it is to play, will output the column to play in. Your program will accept inputs to determine whether it will use the regular minimax algorithm, or minimax with alpha-beta pruning. It will also need to accept input of a specified cut-off (maximum search depth).

See the section on "Input and Output" for how your program is expected to behave.

You will need to implement a version that follows strict rules for auto-marking, and you will also have the opportunity to implement your own algorithm to take part in a tournament-style competition.

The Auto-marked Version

Your auto-marked version of the program will need to follow a strict set of rules in order to be deterministic and automatically testable.

Search method

Your algorithm will perform a depth-first search (limited by a maximum depth) through the state space. When choosing the next (child) states, examine them in a left-to-right order, so the left-most column (column 0) is considered first, then the next column (column 1) and so on up to the right-most column (column 6).

Dealing with ties

When choosing the "maximum" or "minimum" node, if there is a tie for the next best node to choose, then choose the node that was examined first (i.e. the left-most one).

Utility and Evaluation Functions

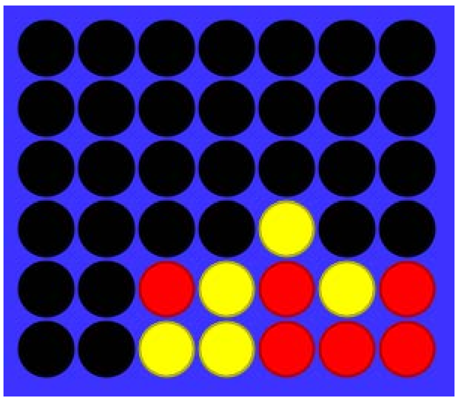
When implementing this version, you will need use the following (quite unintelligent) utility and evaluation functions:

```
UTILITY(state):
    if red is winner:
          return 10000
    if yellow is winner
          return -10000

EVALUATION(state):
    return SCORE(state, red player) – SCORE(state, yellow player)

SCORE(state, player):
    return number of tokens of player's colour +
          10 * NUM_IN_A_ROW(2, state, player) +
          100 * NUM_IN_A_ROW(3, state, player) +
          1000 * NUM_IN_A_ROW(4, state, player)

NUM_IN_A_ROW(count, state, player):
    returns the number of times that <state> contains a <count>-in-a-row
    for the given <player>
```



The evaluation function for this board would be calculated as follows (note that a 3-in-a-row does not count as any 2-in-a-rows):

$$SCORE(state, red) = 6 + (10 \times 4) + (100 \times 1)$$
$$= 146$$

$$SCORE(state, yellow) = 5 + (10 \times 3) + (100 \times 1)$$
$$= 135$$

$$EVALUATION(state) = 146 - 135$$
$$= 11$$

The Tournament Version

Your tournament version of the program does not need to be so strictly implemented. You will be free to implement your own algorithm for determining which column to play in. This may be as simple as making up your own version of the evaluation function, or as complicated as writing an entirely different search algorithm.

You must, however, follow the following restrictions:

1. Your algorithm will be timed out after 1 second. If your program does not offer an output before this timeout, your move will be forfeit, and play will return to the other player.
2. Your program must be entirely self-contained. It will not be able to interact with the filesystem or the network (no writing files or connecting to the internet).
3. You must still conform to the provided input and output rules, as provided in the "Input and Output" section.

3. Input and Output

As your program will be automatically tested, it is important that you adhere to these strict rules for program input and output.

Input

Your program should be called ConnectFour, and will be run from the command line with the following arguments:

1. A string of characters representing the current board state. This string will be in the following format:

```
row0,row1,row2,row3,row4,row5
```

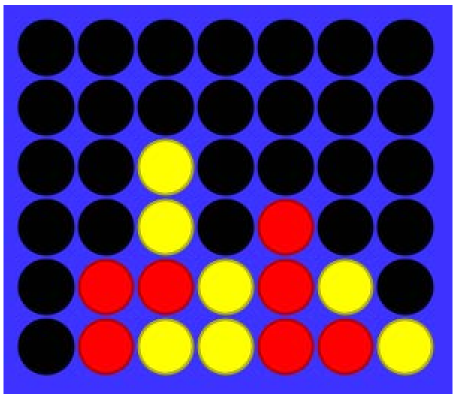
   And each row will contain 7 characters, representing the seven columns in the board. The characters will be only `r`, `y` and `.`, representing a red token, a yellow token and a blank space respectively.
   Note: row0 corresponds to the bottom row, and row5 corresponds to the top row.
2. Either "red" or "yellow" to indicate the player who is about to play a piece.

3. Either “M”, indicating that your program should use the regular minimax algorithm, or “A” indicating that your program should use minimax with alpha-beta pruning. **This argument will not be provided to your tournament code.**
4. A number representing the maximum depth that the algorithm should search to. **This argument will not be provided to your tournament code.**

For example, if the program is given the following arguments:

```
.ryyrry,.rryry.,..y.r..,..y....,.......,....... red A 4
```

Then this would be built into the game board below, indicating that it is red’s turn to play, and the algorithm should use alpha-beta pruning with a maximum search depth of 4.



Assumptions about the input

You can assume that all inputs will be sensible, in that the player will only be either “red” or “yellow”, the algorithm will only be either “M” or “A”, and the depth will be an integer > 0.

The state provided will be possible to make in a real game (no floating pieces), however it will not necessarily represent a balanced game (e.g. it might be full of red tokens).

How your program will be run

The following examples show how the program would be run for each of the submission languages, assuming we want to run the above example. For brevity, the game state has been abbreviated to “<state>”, however this would actually be written exactly as in the example above.

Python (version 2.7.9):

```
python ConnectFour.py <state> red A 4
```

Java (version 1.8):

```
javac ConnectFour.java
java ConnectFour <state> red A 4
```

C (gcc version 4.4.7):

```
gcc –lm -w -std=c99 –o ConnectFour ConnectFour.c *.c
./ConnectFour <state> red A 4
```

C++ (gcc version 4.4.7):

```
g++ –o ConnectFour ConnectFour.cpp
./ConnectFour <state> red A 4
```

MATLAB:

```
matlab -nodesktop -nosplash -nojvm -nodisplay -r
"try;ConnectFour('<state>','red','A','4');catch
me;disp(me.message);end;quit"
```

Output

For your automatically tested version of the program, you will output **two lines only**. The first line will contain the column that the algorithm will play in. This will be a single integer, where 0 represents the left-most column and 6 represents the right-most column.

The second line will be the number of nodes that were examined during the search, where a node is considered examined when you perform the terminal test on it.

As an example, running your code with the example from above:

```
.ryyrry,.rryry.,..y.r..,..y....,.......,....... red A 4
```

Should result in the following output:

```
1
297
```

This indicates that red should play in the second column, and that 297 nodes were examined.

For the tournament version of the code, your program is not required to print the second line. You still need to print the first line (as described above), however this is the only output your program should have.

4. Submission Details

This assignment is to be submitted electronically via the PASTA submission system.

Your submission files should be zipped together in a single .zip file and include a main program called ConnectFour. Valid extensions are .java, .py, .c, .cpp, .cc, and .m. If your program contains only a single file, then you can just submit the file without zipping it.

Upload your auto-marking submission on PASTA under **Assignment 1**, and your tournament version on PASTA under **Assignment 1 – Tournament**.