

# CS151 - Assignment 2

## Mancala

~~Due: Wednesday Sept. 22, 2:44pm~~

Due: Friday Sept. 24, 5pm

The purpose of this assignment is to program some of the search algorithms and game playing strategies that we have learned in class. In particular, you will implement two aspects of Mancala (and other two-player games): search with alpha-beta pruning, and a game board evaluator. Your goals are to implement alpha-beta pruning correctly, and to create the best AI player you can. We will hold a tournament between the submitted players. (However, your placement in the tournament will have no effect on your grade and involvement is optional).

For this assignment, you may work with one other person (i.e. in a pair) if you'd like. If you choose to do so, collaboration on the assignment must be truly collaborative; sitting together and programming together.

### 1 Introduction to Mancala



Mancala is a two-player game from Africa in which players moves stones around a board (shown above), trying to capture as many pieces as possible. In the board above, player 1 owns the bottom row of stones and player 2

owns the top row. There are also two special pits on the board, called Mancalas, in which each player accumulates his or her captured stones (player 1's Mancala is on the right and player 2's Mancala is on the left).

To take a turn, a player chooses one of the pits on his or her side of the board (not the Mancala) and removes all of the stones from that pit. The player then places one stone in each pit, moving counterclockwise around the board, starting with the pit immediately next to the chosen pit, including the player's Mancala but **NOT** the opponent's Mancala, until the player has run out of stones. If the player's last stone ends in his or her own Mancala, the player gets another turn. If the player's last stone ends in an empty pit on his or her own side, the player "captures" all of the stones in the pit directly across the board from where the last stone was placed (the opponent's stones are removed from the pit and placed in the player's Mancala) **as well as the last stone placed** (the one placed in the empty pit). The game ends when one player cannot move on his or her turn (i.e. there are no stones left on the player's side), at which time the other player captures all of the stones remaining on his or her side of the board.

For slightly more detailed instructions on how to play, visit:  
<http://en.wikipedia.org/wiki/Mancala>

## 2 Provided Code

On the course web page, I have included some initial code to get you started. This code includes support for the basic game as well as a simple AI player (it's REALLY simple). The starter code contains the following files:

- `MancalaBoard.py`: A file that contains a class that represents the Mancala gameboard (similar to `TTTBoard` from the first assignment). This class manages the gameboard, knows how to add moves, can return legal moves, can determine when a player has won, etc.
- `Player.py`: A player class that can be instantiated with several types ("constants" defined at the beginning of the class):
  - `HUMAN`: a human player (i.e. prompt the user for a move)
  - `RANDOM`: a player that makes random legal moves
  - `MINIMAX`: a player that uses the minimax algorithm and the `score` function to choose its next move, limited by a specified ply depth

- ABPRUNE: a player that uses alpha-beta pruned search and the `score` function to choose its next move, limited by a specified ply depth. This player is not yet supported (you will implement it).
- CUSTOM: the best player you can create. This player is not yet supported (you will implement it).

Notice that this file also contains a class `MancalaPlayer` which inherits from `Player` and which you will also fill out the details for.

- `MancalaGUI.py`: A simple GUI for playing the Mancala game. To invoke the game you call the `startGame(p1, p2)` function, passing it two player objects.
- `TicTacToe.py`: A file that contains a class representing a Tic Tac Toe gameboard, similar to what you implemented in the first assignment.

Download these files and make sure you can run them. To run a GUI game between two humans:

```
# load the GUI class and associated functions
>>> execfile('MancalaGUI.py')
>>> player1 = Player(1, Player.HUMAN)
>>> player2 = Player(2, Player.HUMAN)
>>> startGame(player1, player2)
```

Note that the `ply` parameter is not required for some of the players (e.g. `HUMAN` and `RANDOM`). The GUI will show up when you execute the `startGame` command. You should see a window appear (it may appear in the background). You can now play Mancala with a friend.

But what if you don't have a friend, you ask? Well, never fear! The computer will play against you (and you will likely win). To play against the computer you simply need to create a computer player to play against:

```
>>> startGame(Player(1, Player.HUMAN), Player(2, Player.RANDOM))
```

or

```
>>> startGame(Player(1, Player.HUMAN), Player(2, Player.MINIMAX, 5))
```

If Mancala isn't your game, you can also play a very basic version of Tic Tac Toe using the same player objects (but no GUI provided with Tic Tac Toe). Use the `hostGame` function in the `TTTBoard` class:

```
>>> execfile('TicTacToe.py')
>>> board = TTTBoard()
>>> board.hostGame(Player(1, Player.HUMAN), Player(2, Player.MINIMAX, 6))
```

Once you understand how to run the code, make sure you read through the provided code and understand what it does. Notice that the minimax algorithm we discussed in class has already been implemented.

### 3 A Better Board Scoring Function

The board scoring function in the basic player is too simple to be useful in Mancala—the agent never looks ahead to see the end of the game until it's too late to do anything about it. Your first task is to write an improved board `score` in the `MancalaPlayer` class, a subclass of `Player`. You may wish to consider the number of pieces your player currently has in its Mancala, the number of blank spaces on its side of the board, the total number of pieces on its side of the board, specific board configurations that often lead to large gains, or anything else you can think of.

You should experiment with a number of different heuristics, and you should systematically test these heuristics to determine which work best. Note that you can test these heuristics with the MINIMAX player, or you can wait until you've completed part 4 below (alpha-beta pruning). In addition to your code, you will submit a short (1-2 paragraphs) writeup about how you chose your final score function. What did you try along the way? What worked well and how did you determine what works well? This writeup will be a large part of your grade for this part!

### 4 Alpha-Beta Pruning

The next part of the assignment is to implement the alpha-beta pruning search algorithm described in the textbook and in class. Look in the code to see where to implement this function (in the `Player` class). I encourage you to refer to the pseudocode in the book, but make sure you understand what you are writing.

In your alpha-beta pruning algorithm, you do NOT have to take into account that players get extra turns when they land in their own Mancalas with their last stones. You can assume that a player simply gets one move

per turn and ignore the fact that this is not always true. Notice that my provided version of minimax also makes this simplifying assumption. This makes the scoring function slightly inaccurate, but easier to code.

You will likely want to test your alpha-beta pruning algorithm on something simpler than Mancala, which is why we have provided the Tic Tac Toe class. Using alpha-beta pruning, it's possible for an agent to play a perfect game of Tic Tac Toe (by setting ply=9) in a reasonable amount of time. The first move will take the agent awhile (20 seconds or so depending on the computer), but after that the agent will choose its moves quickly. Contrast this to minimax, where a ply greater than 5 takes an unreasonable amount of time.

Test your algorithm carefully by working through the utility values for various board configurations and making sure your algorithm is not only choosing the correct move, but pruning the tree appropriately. You will need to submit at least one example that illustrates that your algorithm correctly prunes the search tree. For example, consider the board:

```
X X _
_ O _
- - -
```

Your search will first try an O in the top right corner and should find that that move leads ultimately to a tie. Now consider this point in the search tree:

```
X X _
O O _
- - -
```

where O has tried a move in the left, center spot. On the next level (when X plays in the top right), the algorithm immediately sees that X will win, resulting in a score of 0 for O. Since X is the min player, X will choose this move unless there is a move with an even LOWER value (which there is not). Thus, the best O can do is a score of 0 if it moves in the middle left. It does not need to try the other positions for X because it knows that it is not going to choose to play here (because blocking X in the top row leads to a score of 50, which is better). Thus the algorithm will prune the rest of the search tree at this point after it has tried the top right corner for X.

To write this part up, you must first illustrate that your program behaves correctly in this case by adding print statements to your code (**that you must remove before submitting**), which might then produce the following output:

```
alpha is 50.0, score is 0.0. Aborted on move 2 in minValue on
XX2
005
678
```

You should then explain what is going on as above. You should choose a different example when testing your code. Come see me if you have questions about this part. Your explanation of what is going on is worth a significant part of your grade, so be sure that you understand the above explanation and that you can produce one of your own.

## 5 Creating a custom player

Create a custom player (using any technique you wish) that plays the best game of Mancala possible. This will be the player that you enter into the class tournament.

Past years of resourceful students have led me to be more specific about my specification and restrictions for your players:

- Your player must compile without errors.
- Your player must make its moves in 10 seconds or less (you don't need to get fancy with timers or anything, but if it runs significantly longer than that, it will be disqualified from the tournament).
- Choose a name for your player. Rename both the MancalaPlayer subclass and the Player.py file to exactly match your player's name. (This is so they can be easily identified in the tournament). For example, I might name my player "DavesPlayer". So, my file (which would be called "DavesPlayer.py") would contain a class called `Player` and a class called `DavesPlayer`.
- I will not specify a ply for your tournament player. It is your (your players) responsibility to use the ply that makes it return a move within 10 seconds. What I mean by this is, I'll instantiate your player in this way for the tournament:

```
DavesPlayer.DavesPlayer(1,DavesPlayer.Player.CUSTOM)
```

In other words, I will not initialize it with a ply and you should either have a default ply, or have the player determine on its own what ply it can get to in each move.

- Your player may NOT use a database.
- Your player may NOT connect remotely to another machine.
- Your code must compile in 5 seconds or less.
- Your player may NOT spawn any other processes or threads. The player must use a single thread.
- Any pre-computed moves can be hard coded, but not written to or loaded from a file or database.
- Let me know if you have any further questions!

## 6 Hints!

- For alpha-beta pruning, you likely will need to equivalent `minValue` and `maxValue` functions for your pruning approach, for example `minValueAB` and `maxValueAB`.
- Notice that `minValue`, `maxValue` and `minimaxMove` return both a score and a state. When you call a function that returns two values, make sure that you assign the result to two values, otherwise, you can get unexpected results. (technically, we only need the score in `minValue` and `maxValue`, however, it was included here for debugging purposes).
- If you want to start Tic Tac Toe from a particular state, comment out `self.reset()` in the `hostGame` method. Then, create a new board and two new players. Use `makeMove` to make the appropriate moves to change the board configuration. When the board state is where you'd like it to be, you can then call `hostGame` and since the `reset` call is commented out, it will start from that state.

## 7 When you're done

When you're all done, follow the directions on the course web page for submitting your work. Make sure that your code compiles, that your files are named as specified and that all your functions have the same name and number of parameters. If you get an error, try changing the name of the folder to include a version number and resubmit.

If you worked with a partner, put both people's last names on the submitted directory.

### What to submit

- YourPlayer.py: (i.e. the **appropriately renamed** "Player.py" file) This file should contain all the code you have written, including your score function, your alpha beta pruning algorithm and your custom player.
- ABcorrectness.txt: Your analysis of the correctness of your alpha-beta pruning algorithm, as described above.
- boardScore.txt: Your analysis of how you chose your board score function, as described above.

### Commenting and code style

Your code should be commented appropriately (though you don't need to go overboard). The most important things:

- Your name (or names) and the assignment number should be at the top of each file
- Each class and method should have a short "docstring"
- If anything is complicated, put a short note in there to help the graders out if there are any issues.

There are many possible ways to approach this problem, which makes code style and comments very important here so that the grader and I can understand what you did. For this reason, you will lose points for poorly commented or poorly organized code.



## Grading

Part	points
<b>Board scoring function</b>	
code style	5
good heuristics	20
write-up/discussion	15
<b>AB pruning</b>	
code style	5
correctness	20
example write-up	20
custom player	10
commenting	5
<b>total</b>	100

## Optional – Just for fun!

If you find yourself incredibly interested in this assignment and want to do a little extra, read on...

As described above, the current minimax implementation does not take into account the fact that a player gets another move if his or her last stone ends in the player's own Mancala. Write a new minimax function, called "minimaxFull" and a new alpha-beta pruning function, called "abPruneFull", that takes into account that a player gets another move on their turn if they land in their own Mancala with their last stone.