

**CSE 4082**  
**AI PROJECT 2**

**CONNECT FOUR AI**

Süleyman KELEŞ  
Ahmet Emre SAĞCAN

150118039  
150119042

# Design Document

We have 3 classes.

Board: The class for operations about board interactions.

## *Attributes*

- HEIGHT: Height of the game board.
- WIDTH: Width of the game board.
- board: State of the board

## *Methods*

- print\_board: Prints the board
- make\_children: Creates a children list for the current state of board.
- make\_move\_AI: Makes a move and changes it on the board (for AI).
- make\_move\_manual\_player: Same with above but for manual player.
- check\_board: Does all the checks for the current state of the board.
- is\_full: Checks whether the board is full or not.
- check\_win: Checks whether a winner is present.

Ai: The class for AI operations such as alpha-beta (negamax) and heuristics(the heuristics themselves are explained in the next part) .

## *Attributes*

- depthLimit: Depth limit for that AI.
- heuristic: Function pointer that switches to a heuristic function according to the given input.

## *Methods*

- ai\_move: Returns a move from function, calls negamax.
- alpha\_beta: Alpha-Beta Pruning happens in this function.
- choose\_heuristic: Sets the heuristic function pointer here.
- heuristic1: First heuristic function that can be used by negamax.  
(easy)
- heuristic2: Second heuristic function that can be used by negamax.  
(easy-medium)
- heuristic3: Third heuristic function that can be used by negamax.  
(medium)

## Heuristic Details

### *Heuristic 1*

This heuristic looks only for a win for itself. Checks the state to make diagonal, horizontal or vertical wins. If there exists one, increase the score by 1.

### *Heuristic 2*

Aside from the first heuristic, this heuristic also looks for the opponent's states. Meaning it checks for diagonal, horizontal, vertical wins for both players. If it can win with that move, it increases the score by 1. If the opponent can win, it decreases by 1. Using this way, negamax (its minimax parts actually) is implemented better.

### *Heuristic 3*

This heuristic also does diagonal, horizontal and vertical checks. But the big difference from those heuristics is, it does scoring gradually. It increases the score according to the side by side pieces count.

1. 2 pieces adjacent: +10
  2. 3 pieces adjacent: +100
  3. 4 pieces adjacent: +1000
- 
1. 2 pieces adjacent for opponent: -10
  2. 3 pieces adjacent for opponent: -100
  3. 4 pieces adjacent for opponent: -1000

## Videos and Outputs

1. *AI player using h1 vs AI player using h2 (using the maximum ply possible for each player).*
  - h1\_vs\_h2\_depth\_11\_11.mkv is the corresponding video.
  - Depth limit for both: 11

2. *AI player using h2 vs AI player using h3 (using the maximum ply possible for each player).*

- h2\_vs\_h3\_depth\_9\_9.mkv is the corresponding video.
- Depth limit of h2: 9
- Depth limit of h3: 9

3. *AI player using h1 vs AI player using h3 (using the maximum ply possible for each player).*

- h1\_vs\_h3\_depth\_9\_9.mkv is the corresponding video.
- Depth limit of h1: 9
- Depth limit of h3: 9

4. *Human Player vs the Best AI Player Configuration.*

- human\_vs\_ai\_h3\_depth\_9.mkv is the corresponding video.
- Depth limit of h3: 9

*Maximum Ply Numbers of Heuristics:*

- h1: 15
- h2: 15
- h3: 9

For h3 since it is much more complex than other heuristics it takes too long to finish with more than 9, it isn't measurable.

For h1 and h2 we used the depth limit as 11 for the first video but it can go up to 15. Since it takes too long to finish, videos would be large but the screenshots are below.

```

C:\Users\suley\Desktop\AI_project
λ py game.py
Welcome to the Game!
1. Human vs Human
2. Human vs AI
3. AI vs AI
Please select an option: 3

1. h1 is basic
2. h2 is medium
3. h3 is hard
Choose a heuristic for AI Player 1 :
Please select an option: 1

1. h1 is basic
2. h2 is medium
3. h3 is hard
Choose a heuristic for AI Player 2 :
Please select an option: 2

Choose a depth level for AI Player 1
depth level :15

Choose a depth level for AI Player 2
depth level :15
Starting a game of AI vs AI...
hello i am ai.
hello i am ai.
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .

```

image:1

```

Run time: AI player 1 1029.0319516658783
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
X . . . . .

Run time: AI player 2 898.103805065155
move 0
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
O . . . . .
X . . . . .

Run time: AI player 1 1055.3830709457397
. . . . .
. . . . .
. . . . .
. . . . .
X . . . . .
O . . . . .
X . . . . .

Run time: AI player 2 613.5946605205536
move 0
. . . . .
. . . . .
. . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .

```

image:2

```
Run time: AI player 1 628.0969817638397
. . . . .
. . . . .
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .
```

```
Run time: AI player 2 231.7334852218628
move 0
. . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .
```

```
Run time: AI player 1 332.5072772502899
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .
```

```
Run time: AI player 2 309.0849885940552
move 1
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X O . . . . .
```

image:3

```
Run time: AI player 1 421.65068531036377
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X . . . . .
O X . . . . .
X O . . . . .
```

```
Run time: AI player 2 332.646892786026
move 1
X . . . . .
O . . . . .
X . . . . .
O . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
```

```
Run time: AI player 1 345.74955582618713
X . . . . .
O . . . . .
X . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
```

```
Run time: AI player 2 93.94203543663025
move 1
X . . . . .
O . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
```

image:4

```

Run time: AI player 1 126.41673517227173
X . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .

Run time: AI player 2 126.3070318698883
move 1
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .

Run time: AI player 1 141.88704252243042
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O X . . . .

Run time: AI player 2 186.64907312393188
move 2
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O . . . . .
O X O . . . .
X O X . . . .

```

image:5

```

Run time: AI player 1 185.57700276374817
X O . . . . .
O X . . . . .
X O . . . . .
O X . . . . .
X O X . . . .
O X O . . . .
X O X . . . .

Run time: AI player 2 200.81428241729736
move 2
X O . . . . .
O X . . . . .
X O . . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X . . . .

Run time: AI player 1 132.26953291893005
X O . . . . .
O X . . . . .
X O X . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X . . . .

Run time: AI player 2 144.73439526557922
move 2
X O . . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X . . . .

```

image:6

```

Run time: AI player 1 68.55602717399597
X O X . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X . . . .

Run time: AI player 2 172.47196578979492
move 3
X O X . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X . . . .
O X O . . . .
X O X O . . .

Player2 wins!

```