

Final Project Report

Game: 4-in-a-line

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1. Approach

a. Start the program

- The program will ask the user for giving the **time limit** and the **depth** for the minimax algorithm with alpha-beta pruning.
- The user can decide **who go first**, Computer (AI) or Opponent (Human).
- When start to play, the program will show the information as below:

```
-- Game Start --
*****
| -Maximum time: 25 |
| -Game Depth: 3   |
| -First Hannd: Human |
*****
```

2. Evaluation Function

The evaluation function consider all the cases include:

a. How many pieces in line

- Line of two: _XX_, XX_, _XX, _X_X_, X_X_, _X_X, ...
- Line of three: _XXX_, XXX_, _XXX, _X_XX_, XX_X_, _X_XX, ...
- Line of four: Winning case.

b. How many block (red part)

- Block one:
 - Meet the limit of the board: _XXX|
 - Meet the opponent: _XXO
- Block two: O_XXX|, O_XXXO, OXX_X|, ...

c. Location of empty space (yellow part)

- No empty space: XXX, _XXX, _XXX_, ...
- Empty space at position [1]: X₁XX, _X₁XXX, ...
- Empty space at position [2]: XX₂X, _XX₂XX, ...
- Empty space at position [3]: XXX₃X, _XXX₃X, ...

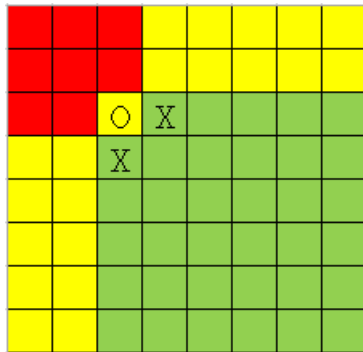
d. Decide the value

Decide the value for each cases depend on the situation list above. Keep changing the value for each cases to see which value works better in the games.

3. Strategy

a. Random function:

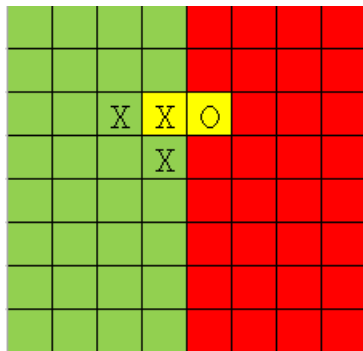
- Apply random move for the first two steps
 - If Opponent (O) goes first: block the region where has more space.



Use the left figure as example:

If the opponent goes first, the green region has more possibility for "O" to win than the red region, so AI should randomly place the piece on its right or below

- If Computer (X) goes first: place the second piece to the region with more space

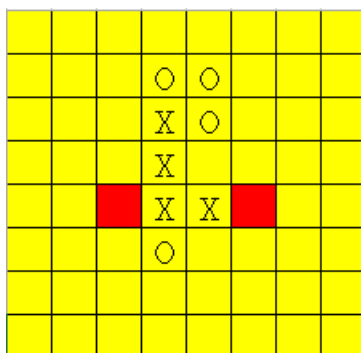


Use the left figure as an example:

If the computer AI goes first, then for the second move, randomly place the piece at the position where has more space to win.

b. Killer move and pre-killer move

- Killer move:
If any state has one move to win, that position will have the highest priority compare to other moves.
- Pre-Killer move:
If the opponent (O) doesn't have the killer move, than check the board to see if there is a move to make the next round a killer move.



The example for pre-killer move show as left:

If the opponent doesn't have killer move then the red region will be the pre-killer move for "X" to win the game.

c. Attack and Defense function:

- If the opponent doesn't have the pre-killer move, then the AI **should** do the attacking move.
- If there is a pre-killer move for the opponent, the AI **must** need to do the defense move.

4. Problems

Finish the project with no big problems and errors, the minimax algorithm with alpha-beta pruning is very straightforward. Very easy to finish the frame work and run the program but spent more time on testing the evaluation function and correct the moves for the AI.

How I improve the program:

- Correct the step during the game, find out in what situation the AI gives the wrong move or the move doesn't make any sense.
- Let AI vs. AI is the faster way to find out the problem and the inappropriate move.

5. Game Process (several steps example, not continue steps)

```
---Initial Board---
1 2 3 4 5 6 7 8
a - - - - - - -
b - - - - - - -
c - - - - - - -
d - - - - - - -
e - - - - - - -
f - - - - - - -
g - - - - - - -
h - - - - - - -

----- AI -----
1 2 3 4 5 6 7 8
a - - - - - - -
b - - - - - - -
c - - - 0 - - - -
d - - - X 0 - - -
e - - X X - - - -
f - - - - - - -
g - - - - - - -
h - - - - - - -
AI move: e3

----- OPPONENT -----
1 2 3 4 5 6 7 8
a - - - - - - -
b - - - - - - -
c - - - 0 - - - -
d - - - X 0 - - -
e - 0 X X - - - -
f - - - - - - -
g - - - - - - -
h - - - - - - -
Human move: e2

----- AI -----
1 2 3 4 5 6 7 8
a - - - - - - -
b - - - - - - -
c - - 0 0 - - - -
d X 0 X X 0 - - -
e - 0 X X 0 X - -
f X X X X 0 - - -
g - - 0 0 - - - -
h - - - - - - -
AI move: f0

AI win
```

6. Self-test

AI First

Game	# of games	win	lose	draw
AI vs. AI	10	4	3	3
AI vs. Human	10	7	3	0

Human First

Game	# of games	win	lose	draw
AI vs. Human	10	5	4	1