# Reversi(Black-White Chess)

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CS 5114 Theory of Algorithm

Project 2 Report, 04/24/2020

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## 1. Aim

Greedy Algorithm is a useful way to solve complex problems which is relatively effective, although sometimes Greedy Algorithm's solution is not the most optimal one.

This project is going to apply Greedy Algorithm to solve the problem of Reversi(Black-White Chess). The Greedy Computer AI will play in White and you will play in Black, Black plays first and the one who has more pieces at the end of the game than the opponent will win the game.

## 2. Introduction

This game uses exactly the same rules with the all-known Reversi.

1. The **input parameters:** n defines the size of the map m*m(m=8 in default. Of course, you can change the size of the map by change m to any **even number** of m>= 6, e.g. 6,8,10). Other inputs like the initial number of pieces are fixed: Reversi has 2 black pieces and 2 white pieces initially. Opponent player is also another player. In this project, there are 2 opponent players: Brute and Terrain Occupier. In order to win the game, the AIs have to get at least m*m/2 white pieces usually or reverse all the black pieces to white.
2. **Objective function** is the Computer AI player(White) who will play against you in order to win the game. There are 3 Computer AI players in this project, 1 brute force AI and 2 Greedy AIs. The next paragraphs will call them Brute, Greedy-1 and Greedy-2.
3. **Expected output** is the number of Computer AI player's pieces(White) when the game is over.
4. As you can freely change the map size, it is in **large size** obviously. Although the code is able to accept any size of even n under integer max limit, it is better not to try m>14.

## 3. Method

There are 3 Computer AI players in total. Notice that AI always plays in white and human player(you) plays in black. Each AI will tend to not only win the game, but also try to make white pieces as many as possible. However, they strategies are different from each other:

**Greedy1**: Predictor. At each White's turn, Greedy1 tends to iterate through all the points possible to drop, and evaluate all traversal points to find the best point(the drop which makes the more points the computer can drop, and the fewer points the player can drop is the best), which means that Greedy1 is gradually locking down the opponent's choices.

Pseudo Code:

(G: available points to drop; estep: suggest best point of Greedy1)

```
Greedy1(G,estep,avg):
    Avg=10000
```

```
For each u∈G:
    if u.avg<avg
        Avg=u.avg
        Estep=u
    End if
End for
Return estep
```

**Greedy2**: Terrain Occupier. This AI will evaluate the map and tend to occupy favorable terrains when it is possible.

Greedy2's Priority from Greatest to Least is as below(Fig 1):

(1) Red Stars: 4 corner points

(2) Red Lines: 4 sides except points next to corner points.

(3) Yellow Lines: inner circle lines, start at the 3rd line from each side.

(4) Blue Lines: 4 second lines from side except corner.

(5) Gray Cross: the rest.

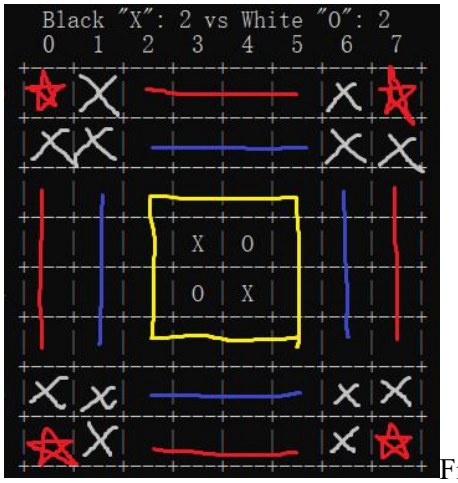

Fig 1

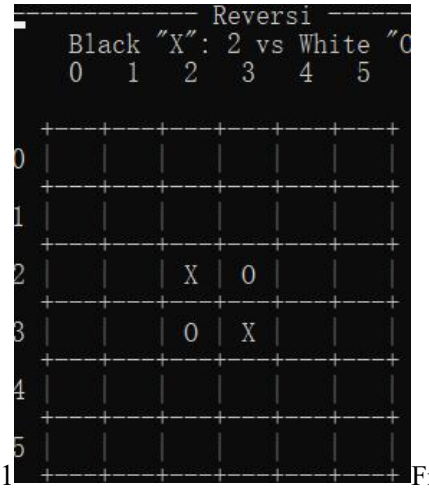

Fig 2

Pseudo Code:

```
Greedy2(G,estep):
    For each u∈G:
        If u∈corners
            Estep=u
            Break
        Else if u∈sides
            Estep=u
        Else if u∈innerLines
            Estep=u
        Else if u∈secondLines
            Estep=u
        End if
    End for
    Return estep
```

**Brute**: This AI thinks very easy. It just try to reverse as many Black pieces to White as possible in each round.

**6*6 Map: AI vs Terrain Occupier**

In the next games, AIs will meet the opponent which has the strategy same as Greedy2: Terrain Occupier.

The smallest possible map is when m=6 and the size of map is then 6*6(Fig 2).

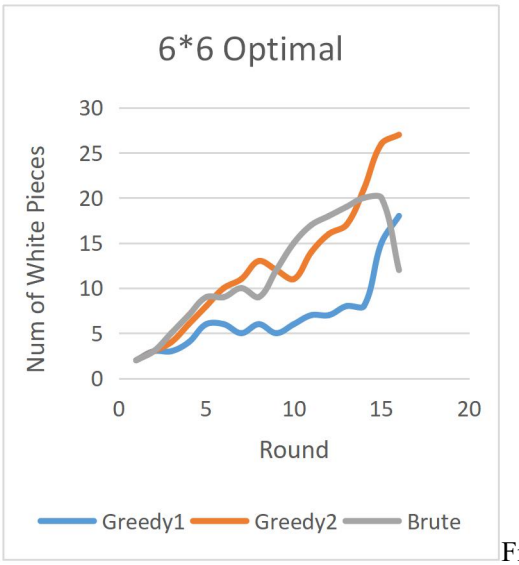


Fig3

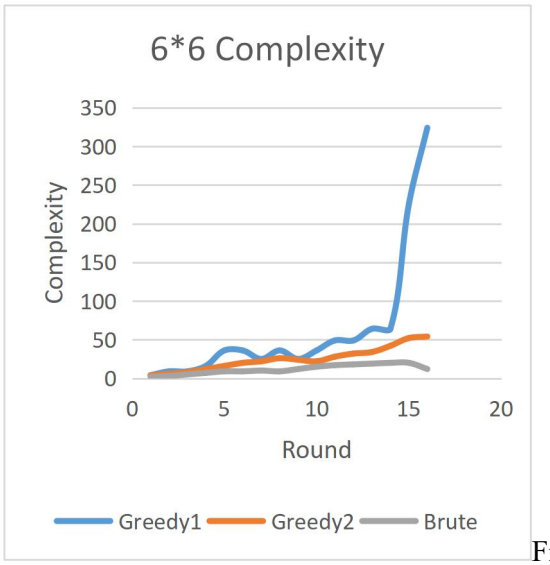


Fig4

Round in graphs means each turn of the game. Black and White both drop once means a unit round.

Fig 3 and Fig 4 show us how 3 AIs act during the game. At the end of a game, the numbers of white pieces that Greedy1, Greedy2 and Brute left are 18, 27 and 12. 6*6 map must have over 18 pieces to win so that Greedy2 wins the game, Greedy 1 meets draw and Brute loses. In Fig 3, Greedy2 always plays well, and its late advantage is obvious(It tells us that occupying favorable terrain is really important). Greedy1 is weak in the initial stage, but it shows some late advantage when the game is nearly ending, as gradually locking down opponent's choices shows much more effect in late stage than in the initial. Brute shows offensive attacks after beginning, but it finally falls when the game is going to end. It can be because Greedy2 is just occupying good terrain(corners and sides), and Greedy1's prediction also takes some care of terrain so that it makes these 2 AI have some benefits in the last of the game. Brute does not take care of terrain at all, it just focus on numbers of pieces so that it acts offensive at first, but after the opponent occupied many significant corners and sides, Brute then becomes very offensive.

Complexity of Greedy1, Greedy2 and Brute are n^2, 2n and n respectively(n is the number of white pieces at a round). Brute just counts the most effective Reverse step to go so that it is just n. Greedy2 needs to read the terrain of each points at every round so that its work is doubled, and its runtime is 2n. Greedy1 is the most complex one as predictor has to find out all the possible steps that its opponent is able to choose after it drops, so that Greedy1 has to calculate out all the opponent's possible drops after its choice. Greedy1's choice(n) multiplies opponent's possibility(n)=n^2.

**8*8 Map: AI vs Terrain Occupier**

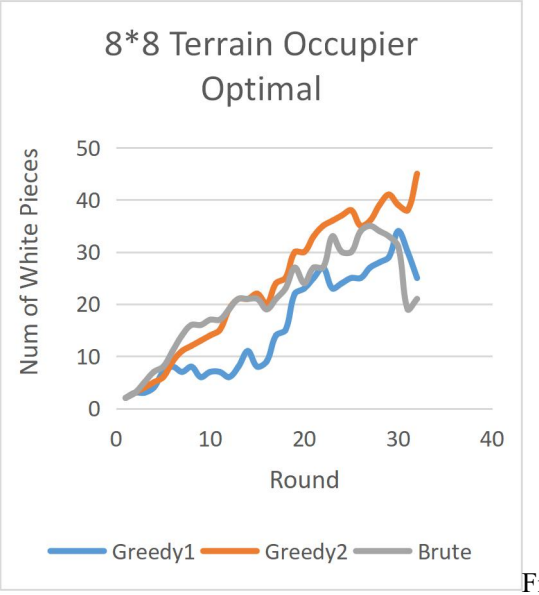

Fig 5

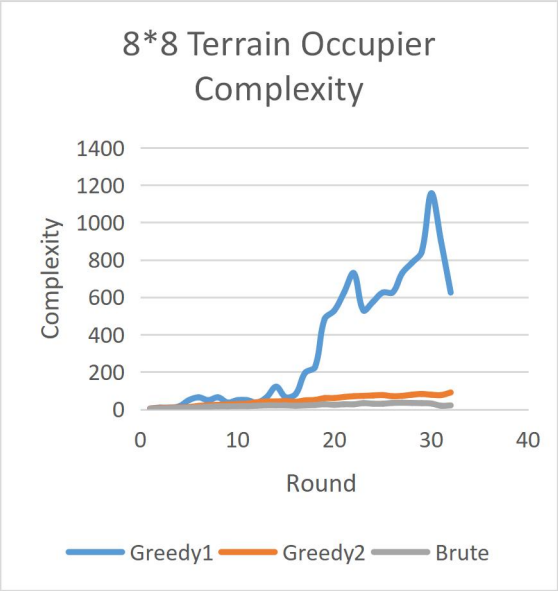

Fig 6

8*8 map shows similar properties as the previous stuffs. White Pieces at last are 25,45,21 for Greedy1, Greedy2 and Brute. 8*8 map requires 32 pieces to win and only Greedy2 wins at this time. Greedy 2 still acts the best, Greedy1 is still weak at first but breaks out at last. Brute is still very offensive at first but it becomes very weak at the very last. Complexity of Greedy2 is doubled than before, Brute does not have obvious change and that of Greedy1 is almost 4 times than before. Greedy2 seems to be the best AI as its complexity is not very high but its technique is very brilliant. Greedy1 is the next most valuable one. Although it has some technique, such technique is not very strong and its complexity is too high. Brute is the least valuable then. Although it seems very strong in initial, it does not have a good score at the end of the game.

## 4. Development

**8*8 Map: AI vs Brute**

Now Brute becomes the opponent of AIs. Let's see how Greedy1 and Greedy2 change when playing with the new opponent.

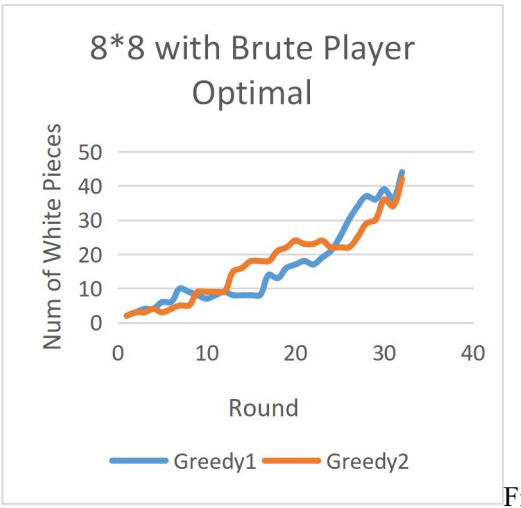

Fig 7

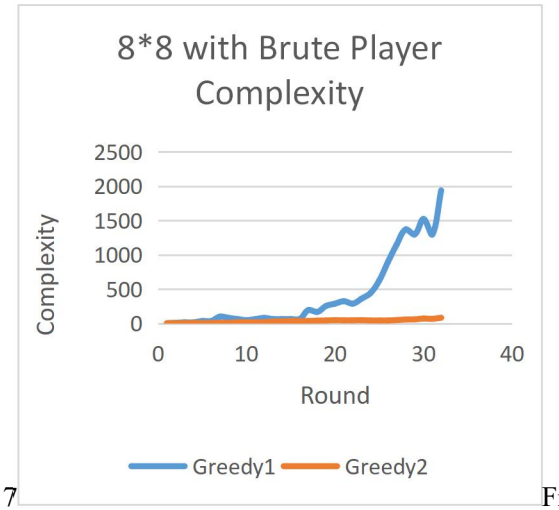

Fig 8

Greedy1 get 44 and Greedy2 get 42 pieces at the end of the game. Both AIs win.

Although Opponent Brute does not play well in the whole games, it is a very strong attacker at the initial stage. Now Greedy1 shows its advantages. Predicting and locking down opponent's choices is good at defense. It acts very stable throughout the whole game. In contrast, Greedy2's Terrain Occupier is very weak at the beginning, until the game move to the middle stage, maybe Greedy2 takes some sides so that it begins to counterattack from that time. There's a high risk that Greedy2 can be completely reversed all pieces to black. Base on the rule of Reversi, if that happens, Greedy2 loses directly. When meets strong attacker enemies, Greedy1 plays better than Greedy2. Of course, Predictor still consumes a large amount of complexity, which is much more than Greedy2.

## 5. Conclusion

Greedy1: Predictor and Greedy2: Terrain Occupier are effective under different situations. Greedy1 is good at defense and Greedy2 is good at stably growing and break out at last. So that in order to win the game, when meets offensive attacker opponent, Greedy1's strategy makes AI have a high possibility to insist at the beginning and wait for counterattack. Greedy2's strategy is good when the opponent is not very offensive. After takes some sides or corners, Greedy2's victory will then be ensured. Brute is good at attacking the opponents who have strong late advantages but are not very good at the beginning of the game.