**CS 440 Assignment 2**

R section 3 credits

Group members:

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1. **Overview**

In this assignment, we try to use backtracking searching and several algorithms to solve constraint satisfaction problems and games.

In the first part,

In the second part,

1. **Work distribution**

Chendi Lin: Flow Free problems, report

Zhuoyue Wang: Breakthrough game problems, report

**3. Part 1: CSP - Flow Free**

**3.1. Smaller inputs**

**3.2. Bigger inputs**

**3.3. Bonus**

**4. Part 2: Game of Breakthrough**

In this section, we try to implements a simple two-player zero-sum game called Breakthrough, and use minimax search and alpha-beta search to simulate two players’ actions. Besides these, we also create two evaluation functions, “Defensive” one and “Offensive” one to help agents find best-fit actions.

There are our evaluation functions:

Defensive Heuristic 1:

6\*(my remaining pieces) + random()

Offensive Heuristic 1:

6\*(30-opponent’s remaining pieces) +random()

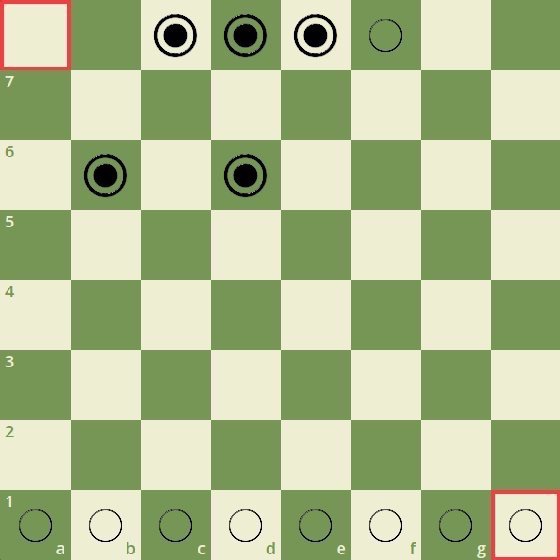
Defensive Heuristic 2:

6\*(my remaining pieces) - 2\*(opponent’s remaining piece)+random()

Offensive Heuristic 2:

2\*(my remaining pieces) - 6\*(opponent’s remaining pieces)+random()

In our Offensive and Defensive Heuristic 2, we start to consider the difference between opponent’s remaining pieces and my remaining pieces to avoid the unstable cases that both have many pieces or both have few pieces.

1. **Minimax (Offensive Heuristic 1) vs Alpha-beta (Offensive Heuristic 1)**

Winner:

White: Alpha-beta (Offensive Heuristic 1)

White:

Total steps: 25

Total expand game tree nodes: 13895961

Average expanded nodes per move: 555838.4

Average time to make a move: 13.8

Number of opponent captured: 11

Black:

Total steps: 25

Total expand game tree nodes: 349520

Average expanded nodes per move: 13980.8

Average time to make a move: 0.17

Number of opponent captured: 7

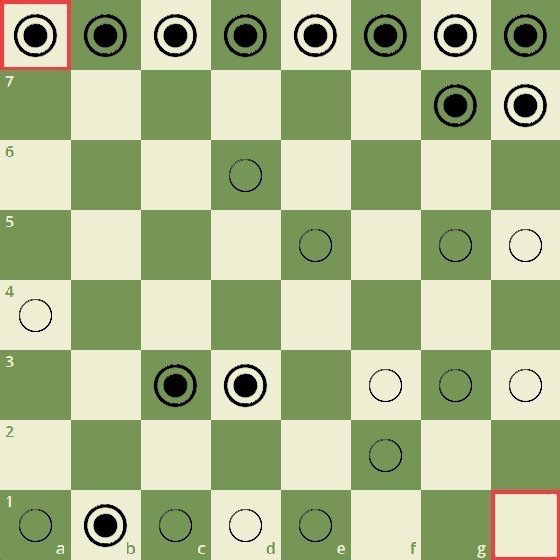
**2. Alpha-beta (Offensive Heuristic 2) vs Alpha-beta (Defensive Heuristic 1)**

Winner:

Black: Alpha-beta (Offensive Heuristic 2)

White:

Total steps: 25

Total expand game tree nodes: 6583669

Average expanded nodes per move: 263346.7

Average time to make a move: 13.3

Number of opponent captured: 3

Black:

Total steps: 26

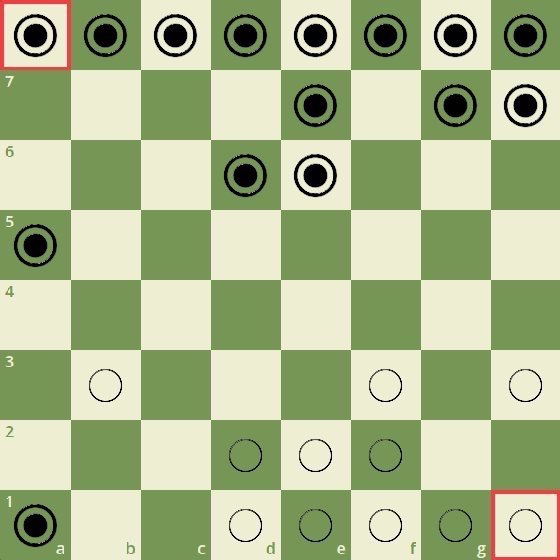
Total expand game tree nodes: 3563706

Average expanded nodes per move: 137065.6

Average time to make a move: 9.1

Number of opponent captured: 3

**3. Alpha-beta (Defensive Heuristic 2) vs Alpha-beta (Offensive Heuristic 1)**



Winner:

Black: Alpha-beta (Defensive Heuristic 2)

White:

Total steps: 14

Total expand game tree nodes:6854829

Average expanded nodes per move: 489630.6

Average time to make a move: 14.7

Number of opponent captured: 1

Black:

Total steps: 15

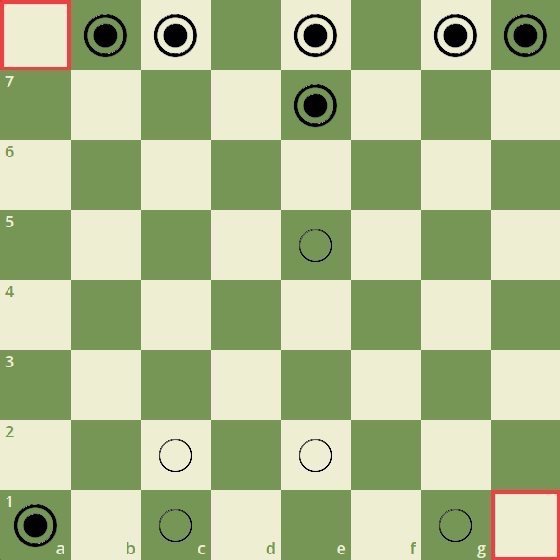
Total expand game tree nodes: 914810

Average expanded nodes per move: 60987.3

Average time to make a move: 4.0

Number of opponent captured: 5

**4. Alpha-beta (Offensive Heuristic 2) vs Alpha-beta (Offensive Heuristic 1)**

Winner:

Black: Alpha-beta (Offensive Heuristic 2)

White:

Total steps: 35

Total expand game tree nodes: 14955900

Average expanded nodes per move: 427311.4

Average time to make a move: 12.3

Number of opponent captured: 9

Black:

Total steps: 36

Total expand game tree nodes: 4410448

Average expanded nodes per move: 122512.4

Average time to make a move: 5.7

Number of opponent captured: 11

**5. Alpha-beta (Defensive Heuristic 2) vs Alpha-beta (Defensive Heuristic 1)**

Winner:

Black: Alpha-beta (Defensive Heuristic 2)

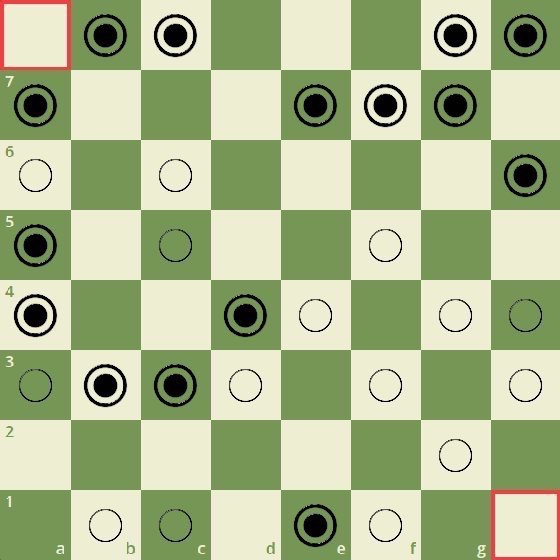
White:

Total steps: 30

Total expand game tree nodes: 12209874

Average expanded nodes per move: 406995.8

Average time to make a move: 19.4

Number of opponent captured: 1

Black:

Total steps:

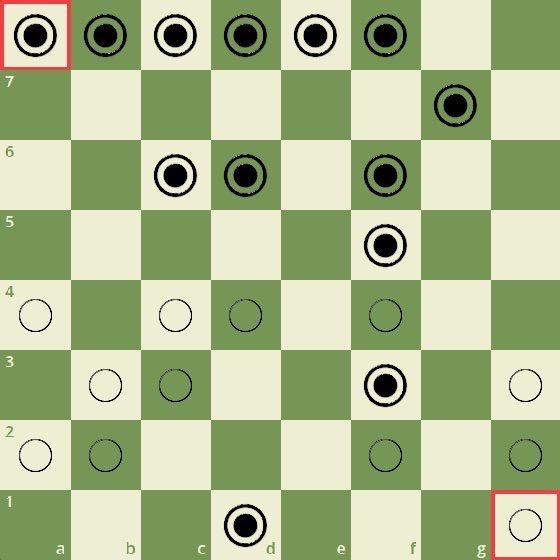
Total expand game tree nodes: 31

Average expanded nodes per move: 7444547

Average time to make a move: 240146.7

Number of opponent captured: 1

**6. Alpha-beta (Offensive Heuristic 2) vs Alpha-beta (Defensive Heuristic 2)**



Winner:

Black: Alpha-beta (Offensive Heuristic 2)

White:

Total steps: 25

Total expand game tree nodes: 13849007

Average expanded nodes per move: 553960.2

Average time to make a move: 22.9

Number of opponent captured: 4

Black:

Total steps: 26

Total expand game tree nodes: 23022326

Average expanded nodes per move: 885474.1

Average time to make a move: 32.2

Number of opponent captured: 4

According to the results, we can see that firstly using Alpha-beta search can defeat minimax search based on the same heuristic function. Secondly, our Heuristic 2 functions defeat all of Heuristic 1 functions, which means it is desirable to evaluate the decision based on both side’s current performance. Moreover, when we run the last game Alpha-beta (Offensive Heuristic 2) vs Alpha-beta (Defensive Heuristic 2) for several times, we find Offensive Heuristic 2 has 80% chance to win (4/5).