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Lab B
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Lab B Report

Lab B involves creating a board game called breakthrough and the goal of this game is to get to the other end of the board before your pieces have all been captured. We use a minimax function to look at all future moves and pick the move that maximizes utility based on the utility function used by individual players. The two utility functions provided are evasive, which tries to maximize the number of their own pieces, and conqueror, which tries to minimize the number of opponent pieces. The two other utility functions that we created are called forward_move and kill_and_survive, which are discussed later in the report

EVASIVE

Evasive, like discussed earlier, wants to maximize the number of its player, and assumes the opponent wants to minimize your number of players. Observing the play when both players play evasive strategy, we see that the players move or not what you would expect in a normal breakthrough game. The players don't try to take the opponents pieces, nor do they try to get to the goal state when it is possible to do so. That is obvious as the goal is to save its pieces and not necessarily to 'win' the game. AI players win when they are making moves to maximize their utility, but happen to reach a goal state. A few final states are given below:

```
X . . . X
X 0 . . 0
. . . . 0
. . . X .
X 0 . 0 .
-----
0 white pieces captured
0 black pieces captured
16 moves played total
```

```
0 . X . .
. . X X .
. 0 . . X
X . 0 0 .
. . 0 . .
-----
0 white pieces captured
0 black pieces captured
15 moves played total
```

```
0 . X . .
0 . . . 0
. . . . X
X X 0 X 0
. . . . .
-----
0 white pieces captured
0 black pieces captured
23 moves played total
```

An interesting fact about these states is that in this board size, no player captured the opponent's piece.

CONQUERER

Conqueror and its goal is to minimize the opponent's number of pieces in the board. This utility function also doesn't necessarily aim to 'win' and reach the goal state, however, makes a move that tries to minimize the opponent's move. When both players have the same utility functions, the assumptions made by the opponent about minimizing its goal is accurate. However, when two players have different utility functions, the players assume that the opponent wants to minimize their respective utility functions, but they are actually implementing very different

strategies. When evasive and conqueror and evasive play against each other, evasive was the weaker strategy in general and conqueror won in general in boards of different sizes. Evasive did not capture any piece from its opponent while conqueror almost always captured some piece in sizable boards. Some goal states are given below:

```
X . . . X
. X . . X
. 0 . 0 .
. 0 . . .
. . . 0 X
-----
1 white pieces captured
0 black pieces captured
12 moves played total
```

In this case, X, called black in our boards, was playing conqueror and O, white, was playing evasive. Conqueror strategy captured one piece from the opponent and also won the game.

```
. . 0 . .
. . 0 X 0
. . . . .
X . 0 X .
. . . . 0
-----
0 white pieces captured
2 black pieces captured
21 moves played total
```

Here, the white player used conqueror and black used evasive. Like in the case of the previous board, conqueror won and captured opponents pieces while evasive did not capture any piece.

```
X X 0 X . . . .
. . . . X . X .
X . X . . . . X
X 0 0 0 . X . .
. . X 0 . 0 0 X
. . 0 . . 0 . 0
0 . . . . . 0 .
0 . 0 0 . 0 . .
-----
0 white pieces captured
4 black pieces captured
55 moves played total
```

The pattern continues in a (8x8, 2) board where white used conqueror and blacked used evasive. We used minimax with a depth of 3 levels for all of these games. Conqueror captured 4 of the opponents pieces.

FORWARD MOVE

The utility function called forward_move aims to get its piece as high as possible on the board. In the case of white, or O, it wants to go as up as possible, and in case of black, or X, it wants to come as down as possible in the game. We tried running this function as the heuristic in boards of various sizes, and it generally beat evasive and conqueror. Some final states are given:

```

X X 0 X X X X
X . . . X . .
. X . X 0 . X .
. . . . . . X
. . . . X . . .
0 X 0 . . . . 0
. . . 0 . 0 0 .
0 0 0 0 0 0 0
-----
0 white pieces captured
1 black pieces captured
25 moves played total

```

Used a (8x8, 2) board with white playing forward_move and black playing evasive heuristic.

```

X . . . 0 X
. . . X . .
. X X . . .
0 . . . X .
. . 0 . 0 .
. 0 . . . 0
-----
0 white pieces captured
0 black pieces captured
17 moves played total

```

```

. 0 X X X
. . . . .
. . . . .
. . X 0 .
0 0 . . 0
-----
0 white pieces captured
1 black pieces captured
9 moves played total

```

```

. . . X 0 X . .
. X X X . . . X
X X . . . . X .
X . . . . . 0 X
0 . X X . . X .
. . . . . 0 X
0 0 0 . 0 . . 0
0 0 . . . . . 0
-----
4 white pieces captured
1 black pieces captured
55 moves played total

```

(6x6, 1), depth =3

(5x5, 1), depth =3

(8x8, 2), depth = 2

All these boards are forward_move vs evasive, with black playing evasive.

```

. 0 . . X
X . X . .
. 0 . . .
. . . X .
. . 0 0 .
-----
1 white pieces captured
1 black pieces captured
13 moves played total

```

(5x5, 1), depth =3

```

X . X . . 0
. X . . . X
. 0 X . . .
. . . . .
. X . . . .
0 . 0 . . 0
-----
1 white pieces captured
0 black pieces captured
17 moves played total

```

(6x6, 1), depth =3

```

0 . . X X . X .
X . X . . X X
. X . . X . X X
. . X . . X . .
. . . . .
0 0 . . . . 0 .
. . 0 0 0 . 0 .
. 0 0 . 0 0 0 0
-----
2 white pieces captured
3 black pieces captured
35 moves played total

```

(8x8, 2), depth = 2

All these boards are forward_move vs conqueror, with black playing conqueror.

KILL AND SURVIVE

Kill and survive utility is a combination of evasive and conqueror, combined with a strong incentive of reaching the goal state. It wants to maximize the number of its own pieces, minimize the number of opponents pieces, and has a very high utility for goal states. This heuristic was also generally able to win against both evasive and conqueror. Some of the screenshots are provided below:

```
X . X . X 0 X X
X . X . X . . .
. . X . . X X X
. X . X 0 . . 0
. 0 X 0 . X 0 .
. . . . . . . .
0 . 0 . . . . .
0 0 0 0 0 0 0 0
```

0 white pieces captured
0 black pieces captured
35 moves played total

(8x8, 2) depth = 2

```
. . X 0 X
X X . . X
. . . . .
. . . . .
0 . 0 0 0
```

0 white pieces captured
0 black pieces captured
7 moves played total

(5x5, 1), depth = 3

```
. X 0 . X X
X . . X . .
. . . X . .
. . . . .
. . . . .
. 0 0 0 0 0
```

0 white pieces captured
0 black pieces captured
9 moves played total

(6x6, 1), depth = 3

All these boards are kill_and_survive vs evasive, with black playing evasive.

```
. . 0 . X
0 X . . .
. . . . .
. X X . .
. . 0 . .
```

2 white pieces captured
1 black pieces captured
21 moves played total

(5x5, 1), depth = 3

```
X X X . 0 . . .
. . . . . X .
X 0 X 0 . . . X
. . . . . X X X
0 . 0 . . . . .
. 0 . X 0 . 0 0
0 . . . 0 . 0 0
0 . . . . . 0
```

1 white pieces captured
5 black pieces captured
63 moves played total

(8x8, 2), depth = 2

```
. X . X X 0
. X . . . X
X . . . . .
. . . . .
. . . . .
0 0 . 0 0 0
```

0 white pieces captured
0 black pieces captured
9 moves played total

(6x6, 1), depth = 3

All these boards are kill_and_survive vs conqueror, with black playing conqueror.

FACE OFF OF THE HEURISTICS:

Final experiment was to play the two heuristics we created against each other. We played forward_move against kill_and_survive in a standard 8x8 breakthrough board with 2 rows of pieces each and we used minimax with depth of 3. Playing it a few number of times, we see that forward_move tends to win kill_and_survive. It kind of makes sense as moving up should give you better chances of winning than just trying to maximize your number of players and minimize the opponents.

```
X 0 X X X X X X
. X X . . . . .
. . X 0 . . . X
X . . X X . . .
. . . . . . . .
. . . . X 0 . .
0 0 0 0 0 . 0 0
0 . . 0 0 0 0 0
```

0 white pieces captured
1 black pieces captured
25 moves played total

```
X X X X 0 X X X
. X . X . . . .
. X X . . 0 X X
. . . . . X .
. . . . . . .
. . . . X . 0
0 0 0 . 0 . 0 0
0 0 0 0 0 . 0 0
```

0 white pieces captured
1 black pieces captured
23 moves played total

As expected, kill_and_survive which is being played by the black player, captures pieces of the opponent while forward_move does not. However, forward_move is able to penetrate through the opponent pieces and win consistently.