

Othelo.py

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یکی از مشکلاتی که وجود داشت ضعیف بودن AI و بردن آن به راحتی بود که با افزایش depth و جایگزین کردن تابع evaluation توانستم تا حد خوبی آن را بهبود ببخشم. البته افزایش depth زیادی موجب افزایش طول تصمیم گیری AI میشد و نتایج زیر برای depth = 7 ثبت شده است.

تابع evalutation اول به صورت زیر بود :

```
def evaluate(board):
    w_count, b_count = board.count_score()
    return w_count - b_count
```

که فقط اختلاف مهره های 2 بازیکن را حساب می کرد. که بعد به صورت زیر شد:

```
def heuristic_evaluation(board):
    w_count, b_count = board.count_score()
    mobility_factor = len([(r, c) for r in range(8) for c in range(8) if
    board.is_valid_move(r, c)])
```

```

corner_control_factor = 25 * (board.board[0][0] == 'B') + 25 *
(board.board[0][7] == 'B') + \
25 * (board.board[7][0] == 'B') + 25 * (board.board[7][7]
== 'B')

return w_count - b_count + mobility_factor + corner_control_factor

```

که با در نظر گرفتن عواملی مانند mobility و corner control factor ارزیابی پیچیده تری را ارائه می دهد.

نحوه کارکرد الگوریتم :minmax

Recursion.1

این الگوریتم حرکت های ممکن و نتایج آنها را به صورت بازگشتنی بررسی می کند.

- با انجام یک حرکت برای بازیکن فعلی و سپس در نظر گرفتن تمام حرکات ممکن برای حریف، بازی را شبیه سازی می کند.

2.Evaluation function

در گره های پایانی جستجو (زمانی که بازی به پایان می رسد یا به عمق مشخصی می رسد)، یک تابع ارزیابی برای ارزیابی مطلوبیت وضعیت تخته استفاده می شود.

- این تابع ارزیابی که کد آن را در صفحه قبل میبینید عواملی مانند mobility و corner control factor را در نظر میگیرد.

maximizing and minimizing.3

این الگوریتم بین دو نوع گره متناوب است: گره های حداکثر و گره های حداقل.

- گره های حداکثر نشان دهنده نوبت بازیکن فعلی است، جایی که هدف به حداکثر رساندن ارزش ارزیابی است.

- گره های حداقل نشان دهنده چرخش حریف است، جایی که هدف به حداقل رساندن ارزیابی است

backtracking.4

همانطور که الگوریتم به کاوش عمیقتر در درخت بازی می پردازد، برای به روزرسانی مقادیر ارزیابی گره های والد به عقب برمی گردد.

- در یک گره Max، الگوریتم حرکتی را انتخاب می کند که منجر به حداقل ارزش ارزیابی در بین گره های فرزند خود می شود.

- در یک گره Min، الگوریتم حرکتی را انتخاب می کند که منجر به حداقل ارزش ارزیابی در بین گره های فرزند خود می شود.

alpha-beta pruning.5

برای بهبود کارایی، الگوریتم Minimax اغلب از هرس آلفا-بتا استفاده می کند.

- مقادیر آلفا و بتا در طول جستجو حفظ می شوند تا شاخه هایی که نمی توانند بر تصمیم نهایی تأثیر بگذارند حذف شوند.

- اگر ارزیابی یک شاخه خارج از محدوده آلفا-بتا باشد، می توان آن را هرس کرد و تعداد گره های کاوش شده را کاهش داد.

تابع get_best_move از الگوریتم Minimax برای یافتن حرکت بهینه هوش مصنوعی با کاوش در حرکات احتمالی آینده و انتخاب حرکتی که نتیجه مورد انتظار را به حداقل می رساند، استفاده می کند. پaramتر عمق کنترل می کند که الگوریتم چقدر عمق درخت بازی را بررسی می کند و بین زمان محاسبه و کیفیت تصمیم تعادل برقرار می کند. افزایش عمق به هوش مصنوعی اجازه می دهد تا تصمیمات آگاهانه تری بگیرد اما هزینه محاسباتی بالاتری را به همراه دارد.

در بخش های زیر مراحل کامل بازی (مساوی و برد) نشان داده شده است هرچند مرحله انتهایی دو بازی زیر را میتوانید در دو عکس پایین مشاهده کنید:

	0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	W	B
1	B	W	W	W	W	W	W	B
2	B	W	B	W	W	B	W	B
3	B	W	W	B	W	W	W	W
4	B	B	W	B	B	W	W	W
5	B	B	W	B	W	B	W	B
6	W	B	W	W	B	B	B	B
7	B	B	B	B	B	B	B	B

Game over. Final score - W: 32, B: 32
It's a tie!

	0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	W	B
1	B	B	B	B	B	B	B	B
2	B	B	B	W	W	W	B	W
3	B	B	W	B	B	B	W	W
4	B	W	B	B	B	W	B	W
5	B	W	B	W	W	B	W	W
6	B	W	W	W	W	W	W	
7	B	W		W	W	W	W	B

Game over. Final score - W: 32, B: 30
You win!

مراحل کامل بازی(منجر به تساوی) :

The terminal window shows a game of Chinese Checkers in progress. The board is an 8x8 grid with columns labeled 0-7 and rows labeled 0-7. The pieces are represented by letters: W (White) and B (Black). The AI has just made a move at (2, 4), which is highlighted in the board diagram.

```
Enter your move (row and column, separated by space): 3 2
          0 1 2 3 4 5 6 7
 0| | | | | | | |
 1| | | | | | | |
 2| | | | | | | |
 3| | | W | W | | |
 4| | | W | B | | |
 5| | | | | | | |
 6| | | | | | | |
 7| | | | | | | |
 +-----+-----+-----+-----+-----+-----+-----+-----+
AT is thinking...
AT plays: 2, 4
          0 1 2 3 4 5 6 7
 0| | | | | | | |
 1| | | | | | | |
 2| | | | | B | | |
 3| | | W | W | B | |
 4| | | W | B | | |
 5| | | | | | | |
 6| | | | | | | |
 7| | | | | | | |
 +-----+-----+-----+-----+-----+-----+-----+-----+
Enter your move (row and column, separated by space): 1 2
          0 1 2 3 4 5 6 7
 0| | | | | | | |
 1| | | W | | | W | |
 2| | | W | | W | | |
 3| | | W | B | B | |
 4| | | W | B | B | |
 5| | | W | | | | |
 6| | | | | | | |
 7| | | | | | | |
 +-----+-----+-----+-----+-----+-----+-----+-----+
AI is thinking...
AI plays: 1, 1
```

Ln 133, Col 52 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 1 0

0 1 2 3 4 5 6 7

0
1 W W W W
2 B W
3 W B B
4 W B B
5 W
6
7

AI is thinking...

AI plays: 0, 0

0 1 2 3 4 5 6 7

0 B
1 W B W W
2 B W
3 W B B
4 W B B
5 W
6
7

Enter your move (row and column, separated by space):

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 5 4

0 1 2 3 4 5 6 7

0 B
1 W B W W
2 B W
3 W B W
4 W W W
5 W W
6
7

AI is thinking...

AI plays: 5, 3

0 1 2 3 4 5 6 7

0 B
1 W B W W
2 B W
3 W B W
4 W B W
5 W B W
6
7

Enter your move (row and column, separated by space):

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 6 2

	B						
0	W	B	W			W	
1			B		W		
2				B		W	
3					W	B	W
4						W	B
5						W	W
6						W	
7							

AI is thinking...

AI plays: 2, 1

	B						
0	W	B	W			W	
1			B			W	
2				B		W	
3					B	W	
4						W	B
5						W	W
6						W	
7							

Enter your move (row and column, separated by space):

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 2 3

	B						
0	W	B	W			W	
1		B	B	W	W		
2			B	B	W	W	
3	W	B	B	W	W		
4				W	W	W	
5					W	W	
6						W	
7							

AI is thinking...

AI plays: 0, 2

	B						
0	W	B	B			W	
1	W	B	B			W	
2		B	B	W	W		
3	W	B	B	W	W		
4				W	W	W	
5					W	W	
6						W	
7							

Enter your move (row and column, separated by space):

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 0 4

	0	1	2	3	4	5	6	7
0	B		B		W			
1	W	B	B		W	W		
2	W	W	W	B	W			
3	W	W	B	W	W			
4		W	W	W	W			
5		W	W	W	W			
6		W						
7								

AI is thinking...

AI plays: 4, 1

	0	1	2	3	4	5	6	7
0	B		B		W			
1	W	B	B		W	W		
2	W	B	W	B	W			
3	W	B	B	W	W			
4		B	W	W	W			
5		W	W	W	W			
6		W						
7								

Enter your move (row and column, separated by space):

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 4 0

	0	1	2	3	4	5	6	7
0	B		B		W			
1	W	B	B		W	W		
2	W	B	W	B	W			
3	W	W	B	W	W			
4	W	W	W	W	W			
5		W	W	W	W			
6		W						
7								

AI is thinking...

AI plays: 2, 5

	0	1	2	3	4	5	6	7
0	B		B		W			
1	W	B	B		W	W		
2	W	B	W	B	B	B		
3	W	W	B	W	W			
4	W	W	W	W	W			
5		W	W	W	W			
6		W						
7								

Enter your move (row and column, separated by space):

Enter your move (row and column, separated by space): 0 1

	0	1	2	3	4	5	6	7
0	B	W	B		W			
1	W	W	B		W	W		
2	W	W	W	B	W	W	W	
3	W	W	W	W	B	W	W	
4	W	W	W	W	W	B		
5			W	W	W			
6			W					
7								

AI is thinking...

AI plays: 1, 6

	0	1	2	3	4	5	6	7
0	B	W	B		W			
1	W	W	B		W	W	B	
2	W	W	W	B	W	B	W	
3	W	W	W	W	B	W	W	
4	W	W	W	W	W	B		
5			W	W	W			
6			W					
7								

Enter your move (row and column, separated by space): |

Enter your move (row and column, separated by space): 0 6

	0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	W	B
1	W	M	M	W	W	W	W	W
2	W	M	M	W	W	B	W	
3	W	W	M	W	W	W	W	
4	W	W	W	W	W	W		
5			W	W	W			
6			W					
7								

AI is thinking...

AI plays: 5, 5

	0	1	2	3	4	5	6	7
0	B	W	W	N	W	W	W	B
1	W	B	W	W	W	W	W	W
2	W	W	B	W	W	B	W	
3	W	W	W	B	W	B	W	
4	W	W	W	W	B	B		
5			W	W	W	B	W	
6			W					
7								

Enter your move (row and column, separated by space): |

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 4 6

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| W | B | W | W | W | W | W |
+-----+
2| W | W | B | W | W | B | W |
+-----+
3| W | W | W | B | W | W | W |
+-----+
4| W | W | W | W | W | W | W |
+-----+
5|   | W | W | W | B | W |
+-----+
6|   | W |   |   |   |   |
+-----+
7|   |   |   |   |   |   |
+-----+
```

AI is thinking...

AI plays: 5, 0

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| B | B | W | W | W | W | W |
+-----+
2| B | W | B | W | W | B | W |
+-----+
3| B | W | W | B | W | W | W |
+-----+
4| B | W | W | W | W | W | W |
+-----+
5| B |   | W | W | B | W |
+-----+
6|   | W |   |   |   |   |
+-----+
7|   |   |   |   |   |   |
+-----+
```

Enter your move (row and column, separated by space): 1

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 6 5

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| B | B | W | W | W | W | W |
+-----+
2| B | M | B | W | W | B | W |
+-----+
3| B | W | W | B | W | W | W |
+-----+
4| B | W | W | W | W | W | W |
+-----+
5| B |   | W | W | W | W | W |
+-----+
6|   | W |   |   | W |   |
+-----+
7|   |   |   |   |   |   |
+-----+
```

AI is thinking...

AI plays: 5, 1

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| B | B | W | W | W | W | W |
+-----+
2| B | B | B | W | W | B | W |
+-----+
3| B | B | W | B | W | W | W |
+-----+
4| B | B | B | W | W | W | W |
+-----+
5| B | B | W | W | W | W | W |
+-----+
6|   | W |   |   | W |   |
+-----+
7|   |   |   |   |   |   |
+-----+
```

Enter your move (row and column, separated by space): 6 1

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 6 4

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | W | W | W |
+---+---+---+---+---+---+---+
5| B | W | B | W | W | W | W |
+---+---+---+---+---+---+---+
6| W | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
7| | | | | | | | |
+---+---+---+---+---+---+---+
```

AI is thinking...

AI plays: 6, 6

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | W | W | W |
+---+---+---+---+---+---+---+
5| B | W | B | W | B | W | W |
+---+---+---+---+---+---+---+
6| W | W | W | W | W | B | |
+---+---+---+---+---+---+---+
7| | | | | | | |
+---+---+---+---+---+---+---+
```

Enter your move (row and column, separated by space):

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 7 6

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | M | W | W | W | W | W |
+---+---+---+---+---+---+---+
2| B | M | B | W | W | B | W |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | W | B | W | M | B | W |
+---+---+---+---+---+---+---+
6| W | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
7| | | | | | | |
+---+---+---+---+---+---+---+
```

AI is thinking...

AI plays: 2, 7

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | B |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
6| W | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
7| | | | | | | |
+---+---+---+---+---+---+---+
```

Enter your move (row and column, separated by space):

```
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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 6 0
 0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | W | B |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
6| W | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
7| B |   |   |   |   | W |   |
+---+---+---+---+---+---+---+
AI is thinking...
AI plays: 7, 7
 0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | W | B |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
6| W | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
7| B |   |   |   |   | W | B |
+---+---+---+---+---+---+---+
Enter your move (row and column, separated by space):
```

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 4 7

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
6| W | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
7| B | | | B | | | W | B |
+---+---+---+---+---+---+---+
```

AI is thinking...

AI plays: 7, 3

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | B | B | B | W | B | W |
+---+---+---+---+---+---+---+
6| W | W | B | B | W | W | B |
+---+---+---+---+---+---+---+
7| B | | | B | W | | W | B |
+---+---+---+---+---+---+---+
```

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 7 4

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | M | W | W | W | W | B |
+---+---+---+---+---+---+---+
2| B | M | B | W | W | B | W |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | B | B | B | W | B | W |
+---+---+---+---+---+---+---+
6| W | W | B | B | W | W | B |
+---+---+---+---+---+---+---+
7| B | | | B | W | | W | B |
+---+---+---+---+---+---+---+
```

AI is thinking...

AI plays: 7, 1

```
0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
2| B | W | B | W | W | B | W |
+---+---+---+---+---+---+---+
3| B | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
5| B | B | B | B | W | B | W |
+---+---+---+---+---+---+---+
6| W | B | B | B | W | W | B |
+---+---+---+---+---+---+---+
7| B | B | | B | W | | W | B |
+---+---+---+---+---+---+---+
```

Enter your move (row and column, separated by space):

The terminal window displays a 7x7 minesweeper board with the following state:

0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	B
1	B	W	W	W	W	W	B
2	B	W	B	W	B	W	B
3	B	W	W	B	W	W	W
4	B	B	W	B	B	W	W
5	B	B	W	B	W	B	W
6	W	B	W	W	W	W	B
7	B	B	W	W	W	W	B

AI is thinking...
AI plays: 7, 5

0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	B
1	B	W	W	W	W	W	B
2	B	W	B	W	B	W	B
3	B	M	W	B	W	W	W
4	B	B	W	B	B	W	W
5	B	B	W	B	W	B	W
6	W	B	W	W	B	B	B
7	B	B	B	B	B	B	B

Game over. Final score - W: 32, B: 32
It's a tie!
PS C:\Users\persia> █

Ln 112, Col 39 (5 selected) Spaces:4 UTF-8 CRLF Python 3.12.0 64-bit

مراحل کامل بازی(منجر به برد مقابل AI)

File Edit Selection View Go Run Terminal Help ⏪ ⏩ Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 3 6

0	1	2	3	4	5	6	7
0							
1							
2	W	W					
3		W	W	W	W	W	
4			W	B	W		
5			W	B			
6		W					
7							

AI is thinking...

AI plays: 2, 4

0	1	2	3	4	5	6	7
0							
1							
2	W	W	B				
3		W	W	B	W	W	
4			W	B	W		
5			W	B			
6		W					
7							

Enter your move (row and column, separated by space): █

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 2 5

0	1	2	3	4	5	6	7
0							
1							
2	W	W	W	W	W		
3		W	W	W	W	W	
4			W	B	W		
5			W	B			
6			W				
7							

AI is thinking...
AI plays: 4, 2

0	1	2	3	4	5	6	7
0							
1							
2	W	W	W	W	W		
3		W	W	W	W	W	
4		B	B	W			
5			W	B			
6		W					
7							

Enter your move (row and column, separated by space): █

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Enter your move (row and column, separated by space): 4 1

0	1	2	3	4	5	6	7
0							
1							
2	W	W	W	W	W		
3		W	W	W	W	W	
4	W	W	W	W	W	W	
5			W	B			
6		W					
7							

AI is thinking...
AI plays: 1, 4

0	1	2	3	4	5	6	7
0							
1				B			
2	W	W	B	W			
3		W	W	B	W	W	
4	W	W	W	B	W		
5		W	B				
6		W					
7							

Enter your move (row and column, separated by space): █

```
File Edit Selection View Go Run Terminal Help < > Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 0 5
 0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0|   |   |   |   | W |   |
+---+---+---+---+---+---+---+
1|   |   |   | W |   |
+---+---+---+---+---+---+---+
2| W |   | W B | W |   |
+---+---+---+---+---+---+---+
3|   | W | W B | W | W |
+---+---+---+---+---+---+---+
4| W | W | W B | W |   |
+---+---+---+---+---+---+---+
5|   |   | W | B |   |
+---+---+---+---+---+---+---+
6|   | W |   |   |   |   |
+---+---+---+---+---+---+---+
7|   |   |   |   |   |   |
+---+---+---+---+---+---+---+
AI is thinking...
AI plays: 1, 2
 0 1 2 3 4 5 6 7
+---+---+---+---+---+---+---+
0|   |   |   |   | W |   |
+---+---+---+---+---+---+---+
1|   | B | W |   |
+---+---+---+---+---+---+---+
2| W |   | B B | W |   |
+---+---+---+---+---+---+---+
3|   | W | W B | W | W |
+---+---+---+---+---+---+---+
4| W | W | W B | W |   |
+---+---+---+---+---+---+---+
5|   |   | W | B |   |
+---+---+---+---+---+---+---+
6|   | W |   |   |   |   |
+---+---+---+---+---+---+---+
7|   |   |   |   |   |   |
+---+---+---+---+---+---+---+
Enter your move (row and column, separated by space):
```

File Edit Selection View Go Run Terminal Help ⏪ ⏪ ⏪ ⏪ ⏪ ⏪ ⏪

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Search

Enter your move (row and column, separated by space): 6 4

	0	1	2	3	4	5	6	7
0					W			
1		B	W					
2	W	B	W W					
3		W W W W W						
4	W W W W W							
5			W W					
6		W	W					
7								

AI is thinking...

AI plays: 6, 3

	0	1	2	3	4	5	6	7
0					W			
1		B	W					
2	W	B	W W					
3		W B W W W						
4	W W B W W							
5			B W					
6		W B W						
7								

Enter your move (row and column, separated by space): ■

Code + ⏪ ⏪ ⏪ ⏪ ⏪ ⏪ ⏪

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 0 1

0	W		W			
1		W	W			
2	W	W	W	W		
3		W	B	W	W	
4	W	W	B	W	W	
5		B	W			
6		W	B	W		
7						

AI is thinking...

AI plays: 3, 1

0	W		W			
1		W	W			
2	W	W	W	W		
3	B	B	B	W	W	
4	W	B	B	W	W	
5		B	W			
6		W	B	W		
7						

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

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Enter your move (row and column, separated by space): 3 0

0	W		W			
1		W	W			
2	W	W	W	W		
3	W	W	W	W	W	
4	W	B	B	W	W	
5		B	W			
6		W	B	W		
7						

AI is thinking...

AI plays: 2, 2

0	W		W			
1		W	W			
2	W	B	W	W		
3	W	W	B	W	W	
4	W	B	B	W	W	
5		B	W			
6		W	B	W		
7						

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 5 2

0	1	2	3	4	5	6	7
0	W		W				
1		W	W				
2	W	W	W	W			
3	W	W	W	W	W		
4	W	W	W	W	W		
5		W	W	W			
6		W	B	W			
7							

AI is thinking...
AI plays: 1, 3

0	1	2	3	4	5	6	7
0	W		W				
1		W	B	W			
2	W	W	B	W	W		
3	W	W	W	B	W	W	
4	W	W	B	W	W		
5		W	B	W			
6		W	B	W			
7							

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 0 2

0	1	2	3	4	5	6	7
0	W	W		W			
1		W	W	W			
2	W	W	B	W	W		
3	W	W	W	B	W	W	
4	W	W	B	W	W		
5		W	B	W			
6		W	B	W			
7							

AI is thinking...
AI plays: 5, 5

0	1	2	3	4	5	6	7
0	W	W		W			
1		W	W				
2	W	W	B	W	W		
3	W	W	W	B	W	W	
4	W	W	B	B	W		
5		W	B	B	B		
6		W	B	W			
7							

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

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Enter your move (row and column, separated by space): 7 3

0	1	2	3	4	5	6	7
0	W W		W				
1		W W W	W				
2	W W W W W W						
3	W W W W W W W						
4	W W W W B W						
5		W W B B					
6		W W W					
7		W					
+	-	-	-	-	-	-	-

AI is thinking...
AI plays: 1, 1
0 1 2 3 4 5 6 7

0	1	2	3	4	5	6	7
0	W W		W				
1	B W W W						
2	W B W W W						
3	W W W B W W W						
4	W W W B W						
5		W B B					
6		W W W					
7		W					
+	-	-	-	-	-	-	-

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 1 0

0	1	2	3	4	5	6	7
0	W W		W				
1	W W W W W						
2	W B W W W						
3	W W W B W W W						
4	W W W B W						
5		W B B					
6		W W W					
7		W					
+	-	-	-	-	-	-	-

AI is thinking...
AI plays: 2, 0
0 1 2 3 4 5 6 7

0	1	2	3	4	5	6	7
0	W W		W				
1	W W W W W						
2	B B B W W W						
3	W W W B W W W						
4	W W W B W						
5		W B B					
6		W W W					
7		W					
+	-	-	-	-	-	-	-

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 6 6

0	1	2	3	4	5	6	7
0	W	W	W	W	W	W	W
1	W	W	W	W	W	W	W
2	B	B	W	W	W	W	W
3	W	W	W	W	W	W	W
4	W	W	W	W	W	W	W
5	W	W	W	B	W	W	W
6	W	W	W	W	W	W	W
7	W	W	W	W	W	W	W

AI is thinking...

AI plays: 0, 0

0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	W
1	B	W	W	W	W	W	W
2	B	B	W	W	W	W	W
3	W	W	W	W	W	W	W
4	W	W	W	W	W	W	W
5	W	W	W	B	W	W	W
6	W	W	W	W	W	W	W
7	W	W	W	W	W	W	W

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 6 5

0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	W
1	B	W	W	W	W	W	W
2	B	B	W	W	W	W	W
3	W	W	W	W	W	W	W
4	W	W	W	W	W	W	W
5	W	W	W	W	W	W	W
6	W	W	W	W	W	W	W
7	W	W	W	W	W	W	W

AI is thinking...

AI plays: 2, 6

0	1	2	3	4	5	6	7
0	B	W	W	W	W	W	W
1	B	W	W	W	W	W	W
2	B	B	B	B	B	B	B
3	W	W	W	W	W	W	W
4	W	W	W	W	W	W	W
5	W	W	W	W	W	W	W
6	W	W	W	W	W	W	W
7	W	W	W	W	W	W	W

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 1 6

	0	1	2	3	4	5	6	7
0	B	W	W			W		
1	B	W	W	W	W		W	
2	B	B	B	B	B	W	W	
3	W	W	W	W	W	W	W	
4		W	W	W	W	W		
5			W	W	W	W		
6				W	W	W	W	
7					W			

AI is thinking...
AI plays: 7, 4

	0	1	2	3	4	5	6	7
0	B	W	W			W		
1	B	W	W	W	W		W	
2	B	B	B	B	B	W	W	
3	W	W	W	W	B	W	W	
4		W	W	W	B	W		
5			W	W	B	W		
6				W	W	B	W	
7					W	B		

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 7 5

	0	1	2	3	4	5	6	7
0	B	W	W			W		
1	B	W	W	W	W		W	
2	B	B	B	B	B	W	W	
3	W	W	W	W	B	W	W	
4		W	W	W	B	W		
5			W	W	B	W		
6				W	W	W	W	
7					W	W		

AI is thinking...
AI plays: 0, 4

	0	1	2	3	4	5	6	7
0	B	W	W		B	W		
1	B	W	W	B	B		W	
2	B	B	B	B	B	W	W	
3	W	W	W	W	B	W	W	
4		W	W	W	B	W		
5			W	W	B	W		
6				W	W	W	W	
7					W	W		

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 0 3

	0	1	2	3	4	5	6	7
0	B	W	W	W	W	W		
1	B	W	W	W	W		W	
2	B	B	B	W	B	W	W	
3	W	W	W	W	B	W	W	
4		W	W	W	B	W		
5			W	W	B	W		
6				W	W	W	W	W
7					W	W	W	

AI is thinking...

AI plays: 0, 7

	0	1	2	3	4	5	6	7
0	B	W	W	W	W	W		B
1	B	W	W	W	W		B	
2	B	B	B	W	B	B	W	
3	W	W	W	W	B	W	W	
4		W	W	W	B	W		
5			W	W	B	W		
6				W	W	W	W	
7					W	W	W	

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 1 5

	0	1	2	3	4	5	6	7
0	B	W	W	W	W	W		B
1	B	W	W	W	W	W	B	
2	B	B	B	W	W	W	W	
3	W	W	W	W	B	W	W	
4		W	W	W	B	W		
5			W	W	B	W		
6				W	W	W	W	
7					W	W	W	

AI is thinking...

AI plays: 5, 6

	0	1	2	3	4	5	6	7
0	B	W	W	W	W	W		B
1	B	W	W	W	W	W	B	
2	B	B	B	W	W	W	W	
3	W	W	W	W	B	W	W	
4		W	W	W	B	B		
5			W	W	B	B		
6				W	W	W	W	
7					W	W	W	

Enter your move (row and column, separated by space): 4 6

File Edit Selection View Go Run Terminal Help ← → Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 0 6

```
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
2| B | B | B | W | W | W | W |
+---+---+---+---+---+---+---+
3| B | B | W | W | B | W | W |
+---+---+---+---+---+---+---+
4| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
5|   | W | W | B | W | W | W |
+---+---+---+---+---+---+---+
6|   | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
7|   |   | W | W | W |   |   |
+---+---+---+---+---+---+---+
```

AI is thinking...

AI plays: 5, 1

```
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
2| B | B | B | W | W | W | W |
+---+---+---+---+---+---+---+
3| B | B | W | W | B | W | W |
+---+---+---+---+---+---+---+
4| B | B | W | W | W | W | W |
+---+---+---+---+---+---+---+
5| B | B | B | B | W | W | W |
+---+---+---+---+---+---+---+
6|   | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
7|   |   | W | W | W |   |   |
+---+---+---+---+---+---+---+
```

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 5 0

```
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
2| B | B | B | W | W | W | W |
+---+---+---+---+---+---+---+
3| B | B | W | W | B | W | W |
+---+---+---+---+---+---+---+
4| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
5| W | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
6|   | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
7|   |   | W | W | W |   |   |
+---+---+---+---+---+---+---+
```

AI is thinking...

AI plays: 7, 7

```
+---+---+---+---+---+---+---+
0| B | W | W | W | W | W | B |
+---+---+---+---+---+---+---+
1| B | W | W | W | W | W | W |
+---+---+---+---+---+---+---+
2| B | B | B | W | W | W | W |
+---+---+---+---+---+---+---+
3| B | B | W | B | B | W | W |
+---+---+---+---+---+---+---+
4| B | W | W | W | B | W | W |
+---+---+---+---+---+---+---+
5| W | W | W | W | W | B | W |
+---+---+---+---+---+---+---+
6|   | W | W | W | W | B | W |
+---+---+---+---+---+---+---+
7|   |   | W | W | W |   | B |
+---+---+---+---+---+---+---+
```

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

File Edit Selection View Go Run Terminal Help ← → Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 7 6

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| B | W | W | W | W | W | W |
+-----+
2| B | B | B | W | W | W | W |
+-----+
3| B | B | W | B | B | W | W |
+-----+
4| B | W | W | W | B | W | W |
+-----+
5| W | W | W | W | W | B | W |
+-----+
6|   |   | W | W | W | W | W |
+-----+
7|   |   |   | W | W | W | B |
+-----+
```

AI is thinking...

AI plays: 6, 0

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| B | W | W | W | W | W | W |
+-----+
2| B | B | B | W | W | W | W |
+-----+
3| B | B | W | B | B | W | W |
+-----+
4| B | W | B | W | B | W | W |
+-----+
5| B | B | W | W | B | W | W |
+-----+
6| B |   | W | W | W | W | W |
+-----+
7|   |   |   | W | W | W | B |
+-----+
```

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 6 1

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| B | W | W | W | W | W | W |
+-----+
2| B | B | B | W | W | W | W |
+-----+
3| B | B | W | B | B | W | W |
+-----+
4| B | W | B | W | B | W | W |
+-----+
5| B | W | W | W | W | B | W |
+-----+
6| B | W | W | W | W | W | W |
+-----+
7|   |   |   | W | W | W | B |
+-----+
```

AI is thinking...

AI plays: 4, 7

```
0 1 2 3 4 5 6 7
+-----+
0| B | W | W | W | W | W | B |
+-----+
1| B | W | W | W | W | W | W |
+-----+
2| B | B | B | W | W | W | W |
+-----+
3| B | B | W | B | B | W | W |
+-----+
4| B | W | B | W | B | B | B |
+-----+
5| B | W | W | W | W | B | W |
+-----+
6| B | W | W | W | W | W | W |
+-----+
7|   |   |   | W | W | W | B |
+-----+
```

Enter your move (row and column, separated by space):

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 5 7

```
+-----+-----+-----+-----+-----+-----+-----+
0| B | W | W | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
1| B | W | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
2| B | B | B | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
3| B | B | W | B | B | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
4| B | W | B | W | B | B | W | B |
+-----+-----+-----+-----+-----+-----+-----+
5| B | W | W | W | W | B | W | W |
+-----+-----+-----+-----+-----+-----+-----+
6| B | W | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
7| | | | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
```

AI is thinking...

AI plays: 3, 7

```
+-----+-----+-----+-----+-----+-----+-----+
0| B | W | W | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
1| B | W | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
2| B | B | B | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
3| B | B | W | B | B | B | B | B |
+-----+-----+-----+-----+-----+-----+-----+
4| B | W | B | W | B | B | B | B |
+-----+-----+-----+-----+-----+-----+-----+
5| B | W | W | W | B | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
6| B | W | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
7| | | | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
```

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

File Edit Selection View Go Run Terminal Help ← → Search PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Enter your move (row and column, separated by space): 2 7

```
+-----+-----+-----+-----+-----+-----+-----+
0| B | W | W | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
1| B | W | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
2| B | B | B | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
3| B | B | W | B | B | B | W | W |
+-----+-----+-----+-----+-----+-----+-----+
4| B | W | B | W | B | W | B | W |
+-----+-----+-----+-----+-----+-----+-----+
5| B | W | W | W | W | B | W | W |
+-----+-----+-----+-----+-----+-----+-----+
6| B | W | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
7| | | | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
```

AI is thinking...

AI plays: 7, 0

```
+-----+-----+-----+-----+-----+-----+-----+
0| B | W | W | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
1| B | W | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
2| B | B | B | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
3| B | B | W | B | B | B | W | W |
+-----+-----+-----+-----+-----+-----+-----+
4| B | W | B | B | B | W | B | W |
+-----+-----+-----+-----+-----+-----+-----+
5| B | W | B | W | W | B | W | W |
+-----+-----+-----+-----+-----+-----+-----+
6| B | B | W | W | W | W | W | W |
+-----+-----+-----+-----+-----+-----+-----+
7| B | | | W | W | W | W | B |
+-----+-----+-----+-----+-----+-----+-----+
```

Enter your move (row and column, separated by space): █

In 108, Col 1 Spaces: 4 UTF-8 CRLF Python 3.12.0 64-bit

The screenshot shows a terminal window with the following content:

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

AI is thinking...
AI plays: 1, 7

0 1 2 3 4 5 6 7
0| B | W | W | W | W | W | W | B |
1| B | W | W | W | W | W | W | |
2| B | B | B | W | W | W | W | W |
3| B | B | W | B | B | B | W | W |
4| B | W | B | B | B | W | B | W |
5| B | W | B | W | B | W | W | W |
6| B | W | W | W | W | W | W | |
7| B | W | | W | W | W | W | B |

Game over. Final score - W: 32, B: 30
You win!
PS C:\Users\persia> █