

# Udacity Artificial Intelligence Nanodegree – Adversarial Game Playing Agent

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This report evaluates different search algorithms used for adversarial game playing agent in the game of “Knights Isolation”. Refer to the github repository for programming code, readme with problem description.

[https://github.com/cristiandatum/AI\\_projects.git](https://github.com/cristiandatum/AI_projects.git)

The game playing agent algorithm was modified to beat the opponents highest rated algorithm: mini-max with random opening move.

Different configurations and game opening strategies were evaluated. These were tested by creating different Classes (CustomPlayer\_#). The configuration used in the different Classes and the results are summarised in this Table.

## 1. Results & Discussion

#	Strategy	Result % (#games)	Review
0	Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.  Opening 1 <sup>st</sup> and 2 <sup>nd</sup> move: move 1: opponent (random); move 2: me (random)	49 (100 games)	This configuration is the <b>base case</b> from which minor adjustments are made to see if the algorithm is improved.
1	Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in <b>steps of size 2.</b>  Opening 1 <sup>st</sup> and 2 <sup>nd</sup> move: move 1: opponent (random); move 2: me (random)	44 (100 games)	Increasing the speed of iterative deepening does not appear to result in a positive impact.
2	Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.  Opening 1 <sup>st</sup> and 2 <sup>nd</sup> move: <b>move 1: CustomPlayer (cell o)</b> ; move 2: Opponent (random)	50 (100 games)	If CustomPlayer starts, starting from a corner square (cell o) appears to be a good move.
3	Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.  Opening 1 <sup>st</sup> and 2 <sup>nd</sup> move: <b>move 1: CustomPlayer (cell 1)</b> ; move 2: Opponent (random)	44 (100 games)	If CustomPlayer starts, starting from next to a corner square (cell 1) appears to be a bad move.

4	<p>This configuration is the <b>base case</b> from which minor adjustments are made to see if the algorithm is improved.</p> <p>Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.</p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: <b>move 1: CustomPlayer (cell 5); move 2: Opponent (random)</b></p>	53 (100 games)	If CustomPlayer starts, starting from next to a corner square (cell 5) appears to be a good move.
5	<p>Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.</p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: <b>move 1: CustomPlayer (cell 57); move 2: Opponent (random)</b></p>	48 (100 games)	If CustomPlayer starts, starting from the middle of the board (cell 57) appears to be a neutral move.
6	<p>Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.</p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: move 1: Opponent (random); <b>move 2: Custom Player (map 1)</b></p> <p>Map 1 configuration and strategy is defined in the Para 3. Opening Move Strategy.</p>	31 (100 games)	If Opponent starts, Map 1 is a bad configuration to for CustomPlayer next move.
7	<p>Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.</p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: move 1: Opponent (random); <b>move 2: Custom Player (map 2)</b></p> <p>Map 2 configuration and strategy is defined in the Para 3. Opening Move Strategy.</p>	53 (100 games)	If Opponent starts, Map 2 is a bad configuration to for CustomPlayer next move.
8	<p>Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.</p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: move 1: Opponent (random); <b>move 2: Custom Player (map 3)</b></p> <p>Map 3 configuration and strategy is defined in the Para 3. Opening Move Strategy.</p>	48 (100 games)	If Opponent starts, Map 3 is a neutral configuration to for CustomPlayer next move.

9	<p>Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.</p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: move 1: Opponent (random); <b>move 2: Custom Player (map 4)</b></p> <p>Map 4 configuration and strategy is defined in the Para 3. Opening Move Strategy.</p>	47 (100 games)	If Opponent starts, Map 2 is a neutral configuration to for CustomPlayer next move.
10	<p>This configuration is a mixture of the most successful configurations from 1 to 9 above.</p> <p>Algorithm: mini-max with alpha-beta pruning Initial depth = 3 Followed by iterative deepening in range: 4 to 9 in steps of size 1.</p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: move 1: Opponent (random); <b>move 2: Custom Player (map 2)</b></p> <p>Opening 1<sup>st</sup> and 2<sup>nd</sup> move: <b>move 1: CustomPlayer (cell 5);</b> move 2: Opponent (random)</p>	52.8 (400 games)	

## Discussion and Further work:

Iterative deepening did not appear to have a significant impact in improving the chance of winning.

Correctly identifying the best heuristic is complicated by the fact that the number of simulations to be carried out is high in order to make the results statistically significant. Further, the background processes in the PC used for carrying out the simulation can have an impact on the simulation runs and results. This adds noise to the selection process of the best heuristic.

If CustomPlayer moves first, a good move is cell (5) or similar. That is, a cell that is located in the middle of one of the board edges.

If the Opponent moves first, CustomPlayer first move should be on an opposite colour tile as close as possible to the Opponent, using the board edges if available.

**Opening move Strategy:**

When the Opponent 1<sup>st</sup> move is any of the cells below. The move by CustomPlayer is followed by the strategies 1 to 4 below:

0	1	2	3	4	5	6	7	8	9	10
13	14	15	16	17	18	19	20	21	22	23
26	27	28	29	30	31	32	33	34	35	36
39	40	41	42	43	44	45	46	47	48	49
52	53	54	55	56	57	58	59	60	61	62
65	66	67	68	69	70	71	72	73	74	75
78	79	80	81	82	83	84	85	86	87	88
91	92	93	94	95	96	97	98	99	100	101
104	105	106	107	108	109	110	111	112	113	114

### Map 1 Strategy:

- Make CustomPlayer first move on the same colour tile as Opponent.
- As close as possible to opponent move.
- Avoid edges of the board.
- Move towards the center of the board.

14	15	16	15	18	17	18	19	20	21	22
27	28	29	28	31	30	31	32	33	34	35
14	41	42	43	44	45	46	45	46	47	22
53	54	55	56	57	56	57	58	59	60	61
40	67	42	69	70	71	70	71	46	47	48
53	54	55	56	57	84	85	58	59	60	61
66	67	68	69	70	69	70	71	72	73	74
79	80	81	82	83	82	83	84	85	86	87
92	93	94	95	96	97	98	97	98	99	100

**Map 2 Strategy:**

- Make CustomPlayer first move on the opposite colour tile as Opponent.
- As close as possible to opponent move.
- Use edges of the board if possible.

13	0	1	2	3	4	5	6	7	10	23
26	27	28	29	30	31	32	33	34	35	36
39	40	41	42	43	44	45	46	47	48	49
52	53	54	55	56	57	58	59	60	61	62
65	66	67	68	69	70	71	72	73	74	75
52	53	54	55	56	57	58	59	60	61	62
65	66	67	68	69	70	71	72	73	74	75
78	79	80	81	82	83	84	85	86	87	88
91	104	105	106	107	108	109	110	111	112	101

### Map 3 Strategy:

- Make CustomPlayer first move on the same colour tile as Opponent.
- As far as possible to opponent move.
- Symmetrical move if possible."

114	113	112	111	110	109	108	107	106	105	104
101	100	99	98	97	96	95	94	93	92	91
88	87	86	85	84	83	82	81	80	79	78
75	74	73	72	71	70	69	68	67	66	65
23	22	21	20	19	18	17	16	15	14	13
49	48	47	46	45	44	43	42	41	40	39
36	35	34	33	32	31	30	29	28	27	26
23	22	21	20	19	18	17	16	15	14	13
10	9	8	7	6	5	4	3	2	1	0

#### Map 4 Strategy:

- Make CustomPlayer first move on the opposite colour tile as Opponent.
- As far as possible to opponent move.
- Symmetrical move if possible."

113	112	111	110	109	108	107	106	105	104	103
100	99	98	97	96	95	94	93	92	91	90
87	86	85	84	83	82	81	80	79	78	77
74	73	72	71	70	69	68	67	66	65	64
22	21	20	19	18	17	16	15	14	13	12
48	47	46	45	44	43	42	41	40	39	38
35	34	33	32	31	30	29	28	27	26	25
22	21	20	19	18	17	16	15	14	13	12
9	8	7	6	5	4	3	2	1	0	1