Project 2 – Build a Game-Playing Agent

Heuristics Analysis

1 The Task

For each of your three custom heuristic functions, evaluate the performance of the heuristic using the included `tournament.py` *script. Then write up a brief summary of your results, describing the performance of the agent using the different heuristic functions verbally and using appropriate visualizations.*
Your analysis should conclude with a comparison of the different heuristics and your reasoning for choosing the heuristic you ultimately use in your submitted agent.

2 Heuristic Evaluation Functions

The standard heuristic evaluation functions provided to us are described as followed:

1. Open (move) score: This basic evaluation function returns the number of available moves open for a player on the board.
2. Center score: Retunrs a score equal to square of the distance from the center of the board to the position of the player.
3. Improved score: This "improved" evaluation function returns a score equal to the difference in the number of moves available to the players.

Additionally we propose three different heuristic evaluation functions, which are described as followed:

1. Look ahead heuristic: In addition to calculating the difference between legal moves of player versus opponent for the “improved score“, it calculates how many moves each of those next legal moves has. As a result, this heuristic favors legal moves which have a larger number of possible future moves.

2. Weighted moves alt heuristic: Based on the “Open score” heuristic, each open move gets modified by a weight that depends on the position the move leads to on the game board. The goal is to stay more in positions in the center region of the board because it provides more possible moves than those near the edges or corners. The weight for every position is set as the maximum number of possible moves from that position on the board as shown below.

Thomas Dang, 2017

2	3	4	4	4	3	2
3	4	6	6	6	4	3
4	6	8	8	8	6	4
4	6	8	8	8	6	4
4	6	8	8	8	6	4
3	4	6	6	6	4	3
2	3	4	4	4	3	2

Additionally, we calculate the difference between the current player and its opponent and use that as the score of the current game state.

3. Run away heuristic: Based on the “improved score”, it favors player moves which are farther away from the opponent. This can be achieved by adding the Euclidian distance from player to opponent to the number of legal moves of the player. As a result, player moves which have a greater distance from the opponent’s location will have a higher score and thus be favored by this heuristic.

3 Results

In the tournament setup there are 7 different AI agents given. One moves randomly, and a set of AI agents is uitilizing minimax search (MM) and minimax with alpha-beta pruning search (AB) algorithms with fixed depth game trees. The opponents use the Open, Center and Improved heuristic evaluation functions and the players include agents that use iterative deepening (ID) with the Improved (Impr.), ID-1, ID-2 and ID-3 heuristic evaluation functions.
To compare the performance of the proposed heuristic evaluation functions to the ID-Improved agent, we simulate 7 tournaments each consisting of 10 matches against every opponent for a particular heuristic evaluation function with a total of 280 matches per opponent for a particular heuristic evaluation function as shown in Table 1 and Table 2 respectively. We observe that in most of the tournaments the player ID-1 performs better than all the other heuristics considered. The average gain in performance compared to the other players is between 3.6 and 7.1%.

The heuristic evaluation function used for player ID-1, is recommended to be used.

1. Due to the L-shaped movement it is difficult to predict the value of a game state by just counting the number of available moves in the current state of the game. This leads to the advantage of looking ahead into future moves compared to the improved heuristic. Hence a more accurate evaluation function is the result.
2. As noted from the results, the ID-1 heuristic does perform better in practice and hence can be recommended.

Table 1: Results for every agent with different heuristics in a tournament consisting of 70 matches per opponent

	Impr.	ID-1	ID-2	ID-3			Impr.	ID-1	ID-2	ID-3		
Random	66	67	65	68	**266**	**95,0%**	4	3	5	2	**14**	**5,0%**
MM_Open	55	56	51	46	**208**	**74,3%**	15	14	19	24	**72**	**25,7%**
MM_Center	63	62	62	62	**249**	**88,9%**	7	8	8	8	**31**	**11,1%**
MM_Improved	48	53	59	48	**208**	**74,3%**	22	17	11	22	**72**	**25,7%**
AB_Open	38	43	36	32	**149**	**53,2%**	32	27	34	38	**131**	**46,8%**
AB_Center	36	46	44	36	**162**	**57,9%**	34	24	26	34	**118**	**42,1%**
AB_Improved	33	47	39	32	**151**	**53,9%**	37	23	31	38	**129**	**46,1%**
	339	**374**	**356**	**324**	1393		**151**	**116**	**134**	**166**	567	
	69,2%	**76,3%**	**72,7%**	**66,1%**		71,1%	**30,8%**	**23,7%**	**27,3%**	**33,9%**		28,9%

Table 2: Results for every agent with different heuristics in 7 tournaments each consisting of 10 matches per opponent

	Impr. [%]	ID-1 [%]	ID-2 [%]	ID-3 [%]
No.1	71,4	77,1	72,9	72,9
No.2	72,9	80,0	68,6	70,0
No.3	72,9	74,3	71,4	61,4
No.4	70,0	72,9	68,6	68,6
No.5	65,7	70,0	77,1	70,0
No.6	60,0	81,4	78,6	60,0
No.7	71,4	78,6	71,4	60,0
Mean	**69,2**	**76,3**	**72,7**	**66,1**
Std.Dev.	**4,7**	**4,1**	**3,9**	**5,5**