Heuristic Analysis: Game-Playing Isolation Agent

Isolation is a deterministic, adversarial game between two players with perfect information. For this project, we created an intelligent agent to navigate the game using different search heuristics. In the analysis below, we compare four different search heuristics against a baseline agent ("AB_Improved") in tournament match play.

Results:

Match #	Opponent	AB_Improved		Opp_Diff		OD_Defensive		OD_Aggressive		OD_Decay	
		Won	Lost	Won	Lost	Won	Lost	Won	Lost	Won	Lost
1	Random	45	5	47	3	48	2	48	2	47	3
2	MM_Open	38	12	36	14	37	13	33	17	39	11
3	MM_Center	41	9	42	8	43	7	42	8	46	4
4	MM_Improved	35	15	36	14	39	11	37	13	34	16
5	AB_Open	24	26	27	23	23	27	25	25	25	25
6	AB_Center	30	20	26	24	34	16	25	25	25	25
7	AB_Improved	25	25	24	26	31	19	29	21	27	23
	Win Rate:	68.0%		68.0%		72.9%		68.3%		69.4%	

Analysis:

- *Heuristic 1: Oppositional Difference Between Available Moves ('Opp_Diff')*
  - **Summary:** Returns the difference (float) between the number of legal moves available to the player and the number of legal moves available to the opponent
  - **Performance:** This simple heuristic performed with similar success to the AB_Improved baseline. It is crisp and useful but could be improved upon.
- *Heuristic 2: Oppositional Difference – Defensive Orientation ('OD_Defensive')*
  - **Summary:** Similar mathematical structure to *Opp_Diff*, except the number of legal moves available to the **player** is weighted by a factor of 'theta' = 2 *
  - **Performance:** Surprisingly, the defensive-oriented heuristic performed the best in tournament play, achieving a 72.9% win rate. By prioritizing the player's own moves, the agent was able to elude defeat more consistently and reign victorious.
- *Heuristic 3: Oppositional Difference – Aggressive Orientation ('OD_Aggressive')*
  - **Summary:** Similar mathematical structure to *Opp_Diff*, except the number of legal moves available to the **opponent** is weighted by a factor of 'theta' = 2 *
  - **Performance:** Achieving a win rate of 68.3%, the aggressively oriented agent outperformed the baseline by only 0.3%. Consistently attempting to minimize an

** Chosen empirically*

opponent's moves over the course of a game does appear create any substantive advantage in victory, which makes sense. At the beginning of a game, it is very difficult to limit an opponents moves, and this heuristic may have sacrificed early-game positional advantage to ineffectively limit an opponent's moves

- *Heuristic 4*: *Oppositional Difference – Increasing Aggression ('OD_Decay')*
  - **Summary:** Similar mathematical structure to aggressive and defensive variations of *Opp_Diff*, except we incorporate a 'game_ratio' variable that reflects how much of the game has been completed. In the beginning of the game, our player puts more value on its own mobility; however, as the game progresses, the player puts more value on limiting its opponent's moves.
  - **Performance:** This was the second-highest performing heuristic (win rate: 69.4%). The incorporation of the game_ratio was intended to bring together the best of the aggressive and defensive oriented heuristics, but it did execute to expectations. Intuitively, I believe that this heuristic should be the most effective, but more experimentation is needed to find an effective rate of defensive decay and initial weight, theta.

Recommendation:

- Best Heuristic: *Oppositional Difference – Defensive-Orientation (OD_Defensive)*
  - Achieved the highest win percentage in match-play (72.9%)
  - Low complexity and computational cost
  - Logically makes sense – Preserve your own moves
  - Simple heuristics are generally more effective (i.e. Ockham's Razor)

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