Build a game-playing agent project

Part 1: Heuristic analysis

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In this project, I coded two classes of game-playing agents. One implementing minimax *(MM agent)* with maximum depth of search equal to 3 and one implementing alpha beta pruning with iterative deepening *(AB agent)*. I coded three different types of heuristics. First, one equal to 10 times the number of legal moves of a player divided by the number of legal moves of the opponent plus one, to avoid division by zero *(named: custom)*. Second, one equal to the number of legal moves of a player minus twice the number of legal moves of the opponent *(named: custom 2)*. Third, one equal to the average number of legal moves of both players *(named: custom 3)*. In addition, I used three pre-coded heuristics. First, one equal to the number of legal moves of a player *(named: open)*. Second, one equal to the distance of the player from the center of the board *(named: center)*. Third, one equal to the number of legal moves of a player minus the legal moves of the opponent *(named: improved)*.

I evaluated the agents and the heuristics by playing head-to-head games of a random-playing agent, the MM agent (open, center, improved) and the AB agent (open, center, improved) against the AB agent (improved, custom, custom 2, custom 3). In total, there were 24 different types of head-to-head matches which were played 100 times each. Results are seen in Table 1.

Table 1: Number of wins of each algorithm and heuristic in each set of 100 head-to-head matches

Opponent	AB_Improved	AB_Custom	AB_Custom_2	AB_Custom_3
Random	95	91	98	92
MM_Open	73	78	72	70
MM_Center	87	87	88	89
MM_Improved	67	69	81	68
AB_Open	56	54	52	49
AB_Center	60	53	55	56
AB_Improved	49	52	45	46
Total wins	487	484	491	470

The performance of an AB agent with a heuristic (improved, custom, custom 2 or custom 3) was mostly similar with small variations depending on the opponent. In terms of total wins the best heuristic was the *AB_custom_2* (491 wins) and the worst was *AB_custom_3* (470 wins). The AB agent with *custom_2* heuristic won, in total, the most matches against both random and MM agents (open, center and improved). Especially, it won the most times against *MM_Improved* as compared to the rest of competing AB agents. However, when the

AB agents were tested against each other (by varying the heuristic) the *AB_Improved* performed the best. It won in total 165 times, while the worst performance was from *AB_Custom_3* which won 151 times. Finally, *AB_Custom* was the only agent that managed to win more times against *AB_Improved* than lose (52 wins).

From the above results, we can conclude that different heuristics do not greatly alter the chances of winning for an AB agent. However, they may give a slight boost to its performance if one choses it wisely according to the opponent. Therefore, against another AB agent the heuristic more likely to win is the *improved*, while against random and MM agents is *custom 2*.