Heuristic Analysis - Board Position Scoring

Three heuristic evaluation function was implemented based on the `Improved Player` which computes the difference in the legal move available to both players.

One shortcoming of the `Improved Player` is that it does not take into account of the board positions. If we can incorporate this information, then the resulting heuristic should be superior to the `Improved Player`.

Based on this observation, we have come up with three adjustment factors to the improved player based on three different methods to score the board position.

The new heuristics all have the following form:

$$V_c = V_{IP} + \delta_i \qquad \delta \in [0, 1)$$

Where V_c is the new customised heuristic function, V_{IP} the `Improved Player` heuristic and δ_i is the bonus for occupying a favourable position. The bonus is intentionally scaled to fall within the range of 0 and 1. This property ensures the bonus does not alter the decision of the `Improved Player` when a clear move is available; yet when a tie does exist, then the agent will take the position scored favourably by the new bonus.

The three methods implemented for calculating the bonuses are:

- Custom: Reciprocal Euclidean distance from the center. - figure **d)**
- Custom 2: Reciprocal Manhattan distance from the center. - figure **c)**
- Custom 3: One step legal move assuming the board is empty. - figure **b)**

The reasoning behind the calculation of `Custom` and `Custom 2` is because the further away you are from the center, the closer you are towards the boundary which poses a restriction on the freedom of movement.

When we compare the legal move scoring as opposed to the distance based method, we can see that it is indifferent in the centre as they all have maximum freedom. However, the centre position (3, 3) is clearly preferred over the neighbouring eight positions.

On the other hand, the Manhattan distance is indifferent diagonally, diagonal positions such as (3, 0) and (2, 1) are valued identically. However, due to the restriction of the boundary imposed on (3, 0), it is clear that the position (2, 1) is superior and this illustrates the shortcoming of Manhattan distance in this particular scenario.

This leads us to believe that of the three heuristics, the Euclidean is likely to perform superior to the two alternatives and is supported by the playing score below.
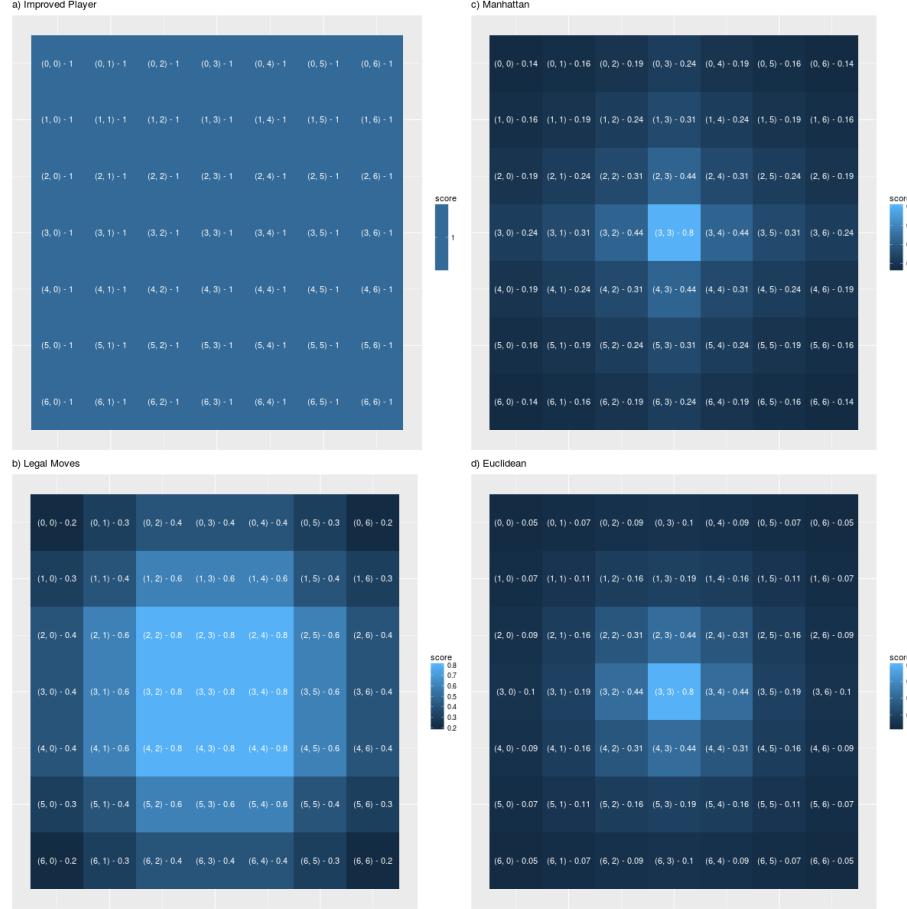
Figure 1: Board Scoring Heuristics: Shown above are the different methods of scoring the position of a board. The bracket corresponds to the position then followed by the value composed by each heuristic method. The lighter the colour, the higher the value assigned. In figure a), we have the uniform scoring where every position is scored equally as in the case of Improved Player. Following in figure b) is the one step ahead legal moves available. The number of moves is scaled, so the returned value is between 0 and 1. In figure c) and d) we have the reciprocal Manhattan and Euclidean distance respectively.

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Opponent	AB_Custom	AB_Custom_2	AB_Custom_3
AB_Improved	54 - 46	50 - 50	52 - 48