Project 3 - Adversarial search

Documentation

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Task: **Advanced Heuristic**

What features of the game does your heuristic incorporate, and why do you think those features matter in evaluating states during the search?

The heuristic incorporates these aspects of the game:

1. The distance to the center
    a. Staying in the center is related to the liberties of the player, since a game can get lost because a player in stuck at an edge or corner
2. The progress of the game
    a. It is suggested that a player should act differently when a game's state has progressed
3. The liberties of the players
    a. A state is evaluated higher when it gives the player more liberties while reducing the liberties of the opponent

The heuristic used in this analysis is:

```
progress = state.ply_count / 80
remainder = 1 - progress

h(s) = (remainder * a * distance) + (progress * b * len(own_liberties) / len(opp_liberties))
```

With a = -5 and b = 1.5 after a bit of trying.

Moreover, the agent favors the center position as first move.

Analyze the search depth your agent achieves using your custom heuristic. Does search speed matter more or less than accuracy to the performance of your heuristic?

I started with a heuristic that didn't take into account the progress but only

- the distance to the center,
- and the ratio of liberties

and used this as a baseline to optimize my heuristic. The variables progress and remainder were set to constant 1. It won 53% of the matches against the MINIMAX agent.

Dist to center, depth 3, favor center at first move
Running 200 games:
"++--++-++-++-++--++-+-++-+-+-+-++-+++----+-+--+-++-----++--+--++++--+----+++--++---++--+---++--++----++--+++-+++--+-+-++++-+-+-----+++-++-++--+-+--++-++++-+----++++-+--++-++++++---+++-++-+++--++--+-"
Your agent won 53.0% of matches against Minimax Agent

Increasing the search depth to five on both sides showed no additional gain:

Dist to center, depth 5, favor center at first move
Running 200 games:
-++--+++--+-+++-+-++-+---+---+-+-+-++++-++-+-+----+--+++-++--++---+-++++++++++----++-++--+-++--++-+++----++++-+---+--+--+++-+++-++----++-+++-+++++-+--+--+--+-++----+-+-+--++++----+++++-+++++++-
Your agent won 53.7% of matches against Minimax Agent (depth 5)

Introducing the progress as weight to parameterize both distance and liberties causes the agent to focus on the middle of the board first while moving to a more offensive strategy later (blocking the opponent's moves). This showed significant differences:

Progress-weighted (a:-5, b:2.5) dist to center, depth 5, favor center at first move
Running 200 games:
"-+---++-+-+++---+++--+-------++---+-+++-+++-+------+++---++--+-+----+-+++-+-++++++-+-++-+---+-++-++-----+--++--++-++-++++++--++--+-+++-----+-+++--+---+++++-++--+++-+-++--++-++++++--+-++---++-+++-"
Your agent won 51.5% of matches against Minimax Agent (depth 5)

Progress-weighted (a:-7, b:1.5) dist to center, depth 5, favor center at first move
Running 200 games:
"++++--+++++-+++-+-+++---++--------+--+----+--+-+--+++--+++++---++-+-++-++-+---+-+++++-++++-++--++++--++++-----+++--+---+++-+++-+-++-++-+-++++++++-+-+---+---+++-+++-----++++---+-+--++--++++++--++--+
Your agent won 54.8% of matches against Minimax Agent (depth 5)

Progress-weighted (a:-5, b:1.5) dist to center, depth 5, favor center at first move
Running 200 games:
"+++++---+-+--+---+-+++++-+----+-++-++++++---+++++-+++----++---+++---+-++--++-++-++++++++++---+-++--+++++-+--++-+++-+++-+++---+-+++--+------++-----+++-++-++-+------++---++++++--+++---+-+-++++++-"
Your agent won 56.4% of matches against Minimax Agent (depth 5)