Kingdomino AI

In the game of Kingdomino, a computer has little to no advantage over a human player. In games like chess, checkers, and even go, a computer can plan multiple turns ahead and plan accordingly. However, in the game of Kingdomino, future tiles available for selection are chosen randomly, meaning that future turns cannot be predicted. This means that a Kingdomino AI must play like a human player – weighing the pros and cons of each move accordingly.

In Kingdomino, an agent (human or computer) must make two decisions:

1. Which domino to select
2. Where to put the domino they selected the turn before

# Choosing a Domino

When taking a turn, it is best for the human or AI to imagine what the piece would look like when it was placed. For this reason, when deciding 1. Which domino to select, an agent has the following information at his disposal:

* The agents’ board.
* their competitor’s board(s).
* the “value” of each piece – indicated with a number on the back of a domino.
* the order of each piece.

With this given information, the agent should be able to score each piece with a formula based off the given information. A simple implementation of this would look something like this:

Where represents the value of domino , represents the score of kingdom , and represents the kingdom’s possible configurations with the domino. This would make for a component of serviceable AI which could present a small challenge to beat, but it would completely omit important factors when making decisions. For this reason, a better way to calculate the value of a piece would be with the following formula:

Where represents the positioning advantage of moving to the domino at position . This could be a number between 0 and 1 for simplicity, but it would be important not to make the difference as drastic as 1 – 4, especially if a large portion of the valuable tiles have already been selected or there are a small number of turns remaining. Therefore, a possible calculation for would be:

Where avg(n(D)) is the average number on the back of each tile, is a mysterious coefficient that ultimately decides the value of a piece, represents the number of turns taken in the game, and is just a placeholder for the given formula. A potential solution could also include different values for the exponent 2.

# Placing Dominoes

The advantage of placing a domino at position with orientation could include factors including, but not limited to:

* score increase.
* size of groups.
* ability to expand groups.
* ability to place any color.
* Future piece availability

Let me explain what I mean.

Score increase is as simple as the difference in score from before the domino was placed and after the domino was placed.

Size of groups is the magnitude of the groups in the agent’s kingdom – this matters because a big group can easily be expanded on and adding a single crown can increase the score by a fair amount. However, the value of this metric is questionable: it doesn’t matter so much how big a group is if it has a great deal of crowns already. That way adding even a scoreless piece to the group the score can increase significantly. This size of groups metric should be relative to the number of crowns in the group.

Ability to expand groups is how easy it would be to expand each group. The twist on this is that it doesn’t matter so much about having many groups that can be expanded as much as it matters about being able to expand a couple of valuable groups.

Ability to place any color describes whether a color can be added to the agent’s kingdom. This metric is worth watching since a piece that is lost because it does not have any matching colors that could be expanded on is highly unlikely to help significantly. Contrary to what feels natural, the best way to use this metric is to try and limit the number of possible placements of each color down to 0 as fast as possible, but keep the number above 1 or 2 otherwise, since it is better to lose a piece than to have to place it in a spot that messes with the current strategy. – This metric probably won’t be implemented in the first iterations of the AI.

Future piece availability describes the quantity and quality of pieces available in the future of a certain color. An agent would be unwise to invest a lot of realty to try and expand their brown tiles if 80% of the brown tiles have already been taken, or if there are only a few turns left in the game to grab said pieces. This metric only matters when evaluating the value of a group and how important it is to keep open spots.

A way to value the positioning of each piece could be represented as

The earlier equation should sort the value of each group and multiply the value of each group by a coefficient describing the availability of future pieces, the ability to grow said groups and decrease the value of each group the further they get from the 1st place group, eventually moving into negative values.

Interestingly, by this logic, potential score increase should be a good metric when calculating the value of a piece even when it is left on its own because ideally it will focus as much as possible on a couple groups instead of the