COMP 3981 – Project Abalone

Problem Formulation

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Abstract

Project Abalone is an attempt to create a game-playing agent for the board game Abalone. This document will detail how we will represent the features of the game, so they can be interpreted by the agent; i.e. the problem formulation.

1 State Representation

At any time, the Abalone game exists in a state with contains the board, its squares, and the pieces for both players.

1.1 Board and squares

The Abalone board is a hexagonal grid of side length five. The board can be visualized as below.

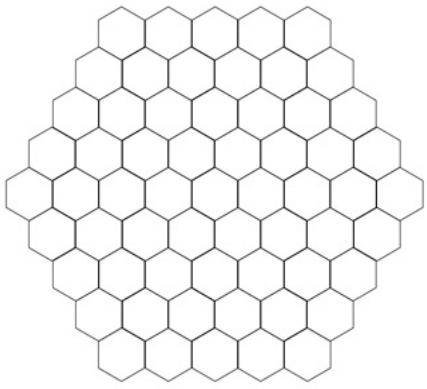

Figure 1 – The Abalone game board

The board is made up of 62 squares as seen, and labeled, as below.

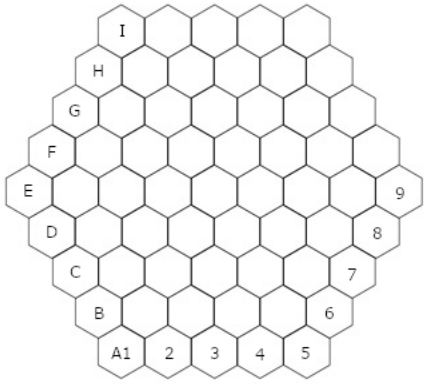

Figure 2 - Abalone board with labeled rows and diagonals

The board and its squares could thus be visualized as a 2-dimensional matrix, as seen below.

```
    * * * * *
   * * * * * *
  * * * * * * *
 * * * * * * * *
* * * * * * * * *
 * * * * * * * *
  * * * * * * *
   * * * * * *
    * * * * *
```

Figure 3 - Visualization of the Abalone board

This will be our board representation moving forward.

1.2 Pieces

Each player controls 14 pieces, each a different color (traditionally black and white). We can include the pieces in our representation as below.

Figure 4 - Visualization of the Abalone board with its pieces

In this visualization, $ corresponds to the 1st player, and ! to the 2nd player.

1.3 Knocked out pieces

Since the goal of Abalone is to knock your opponent's pieces off the board. We will need to represent the knocked-out pieces in a way. This will take the form of a number in the bottom right, and in the top left, to indicate the number of knocked out pieces for player one and player two respectively.

2 Initial State

Abalone allows for several initial setups. The three we will consider are the standard layout, the Belgian daisy, and the German daisy. Using our visualization defined in Figure 3, the setups look as follows.

Figure 5 - The standard setup

Figure 6 - The Belgian daisy setup

Figure 7 - The German daisy setup

3 Actions

3.1 Action definition and legal actions

Pieces move in Abalone in sets of one, two, or three. Pieces must all move in the same direction and must be adjacent to one another to move together. That is, one should be able to draw a straight line connecting all the pieces that are moving.

Pieces may only move one square. If the square the pieces are moving to is clear for all pieces, the move is legal. If there is a friendly piece blocking any of the moving pieces, the move is illegal. If there is an enemy piece blocking one of the pieces, the move may or may not be legal.

Let us define the direction of movement. This is how the player is moving his pieces. The movement can either be parallel to how the pieces are connected, or perpendicular. For one piece, these movements are identical. Enemy pieces can only be moved with a parallel direction of movement.

We say the enemies' pieces are 'connected' if they exist in the same direction of movement without a gap. This can be seen in the diagram below.

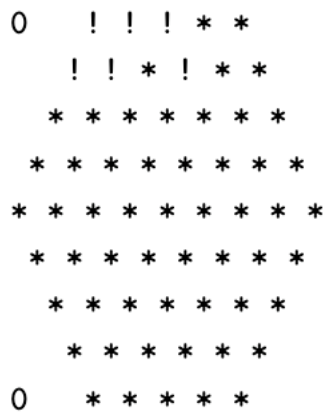

Figure 8 - The top row shows 3 connected pieces, in direction of movement left to right. While the second to top row shows two connected pieces, in the same direction of movement.

Similarly, a player's pieces can be said to be 'connected' in the same way. If the number of 'connected' player pieces outnumbers the number of 'connected' enemy pieces, in the same direction of movement the player's pieces are moving, then the move is legal, else it is illegal.

3.2 Possible actions

Considering our definition of action legality, the possible actions for a player are then:

Player pieces moving	Enemy pieces moved	Direction of movement
1, 2, OR 3	0	Parallel
1, 2, OR 3	0	Perpendicular
2	1	Parallel
3	2	Parallel

Table 1 - Possible player movements in Abalone

3.3 Representation of actions

Considering our possible actions, and the layout of the board, we can represent actions as the following.

[*Initial place of 1st piece moved, initial place of last piece moved, place first piece moved to*]

This contains all the information we need. It tells us how many pieces are being moved and in what direction they are going. If there are enemy pieces in the way they are either moved, or the move is considered invalid.

4 Transition model

The transition model is the actions and the resulting state. Since there are many actions that can be taken, and many more states and resulting states, it's not possible to list them all, but an example has been given below as to how they would look.

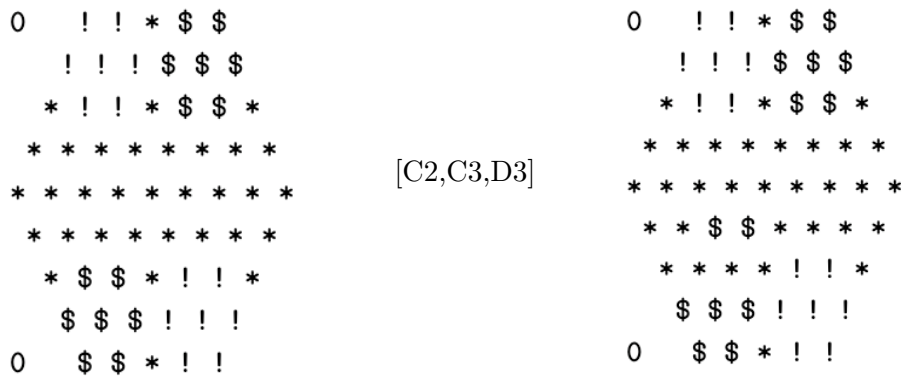

Figure 9 – An example action and transition model

5 Goal test

The game ends if one of the following conditions are met.

1. A player has had 6 of their pieces knocked off the board.

2. A player has exceeded their allotted time for a turn.
3. A stalemate condition is reached. This can be the maximum number of turns being reached, or maybe a certain number of moves happening without forward progress (defined beforehand).

The second and third points, which refer to a time and turn limit are not included in the state representation, so a goal test will look for only the following states (keeping in mind the board can be of any configuration).

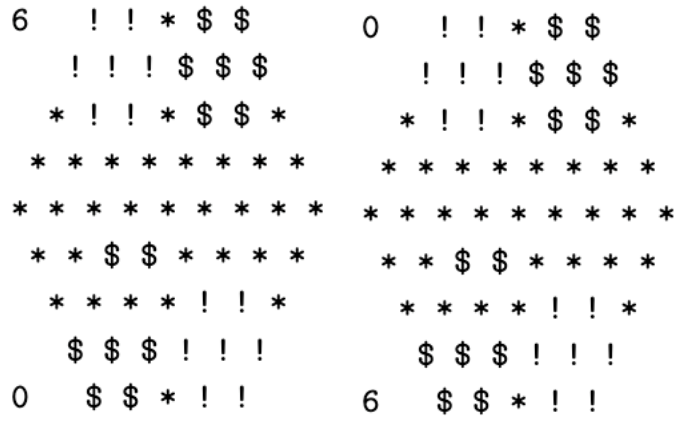

Figure 10 – The game ends when one of the following two states is reached. Note: the board can be of any configuration.