Initial Plan – Investigation of Dots and Boxes with AI Agents.

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Dots and Boxes

Dots and Boxes is a classic pencil and paper game that often goes by other names such as ‘game of dots’, ‘dot to dot grid’, ‘boxes’, and ‘pigs in a pen’. It was first formally published as a game in the 19th century by French mathematician Édouard Lucas (Lucas, 1895), who called it ‘la pipopipette’. The game is played on a grid of dots and players take turns drawing lines between adjacent dots. The grids often range in size from 3x3, for short games, up to 5x5 for expert players.

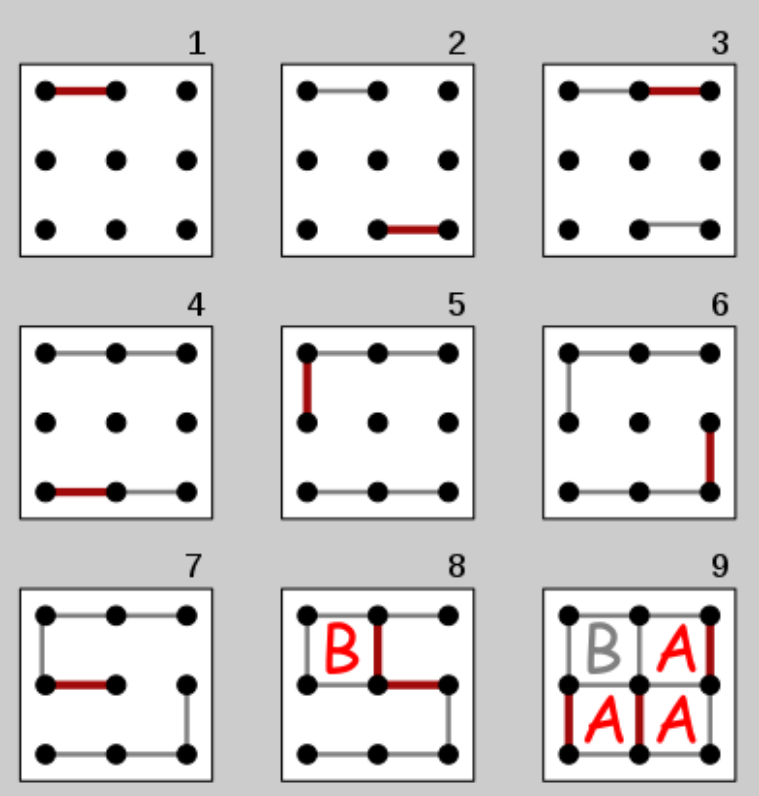


Figure 1 - (Tiger66, 2011)

Figure 1 shows a full game of dots and boxes on a 3x3 grid. The aim of the game is to add lines to the grid and enclose the most boxes possible. When three edges of a box are created and a fourth is added, the player who drew that line claims the box, and gets another turn.

The players in the game shown in figure 1 add lines in turns up until turn 8. Then player B adds another line to finish the box in the top-left corner and adds another line as they have another turn. Player A then wins the game by finishing the other three remaining boxes in one turn.

Aims

In game theory, games can be said to be ‘solved’. There are different levels to solving a particular game, defined as ‘ultra-weakly solved’, ‘weakly solved’ and ‘strongly solved’ (Allis, 1994).

My main aims for this project are to analyse different AI approaches to the game Dots and Boxes. I will use various different AI and game strategies to analyse the complexity of Dots and Boxes and discover if the game can be solved in any way by an AI. Other games have had ultra-weak or weak solutions found by AI, such as draughts. I will search for a way to find an ultra-weak solution for Dots and Boxes. I don’t believe I could find a weak solution for the game, as it took the team behind the Chinook computer player 18 years and up to 200 desktop computers to achieve a weak solution for draughts.

To achieve this, I must first create a functional version of Dots and Boxes that can be played by one, two or zero human players, and can also be played by AI.

I aim to make an implementation of the game that can be played on a grid of any size and shape, allowing for more interesting games and spaces and more interesting analysis of different AI strategies.

Once I have implemented the game I will be able to create various different AI to play and learn about the complexity of the game.

I also aim to trial the different AI I create against each other, to give an indication of which AI strategy is best suited to Dots and Boxes.

As a list, my aims are:

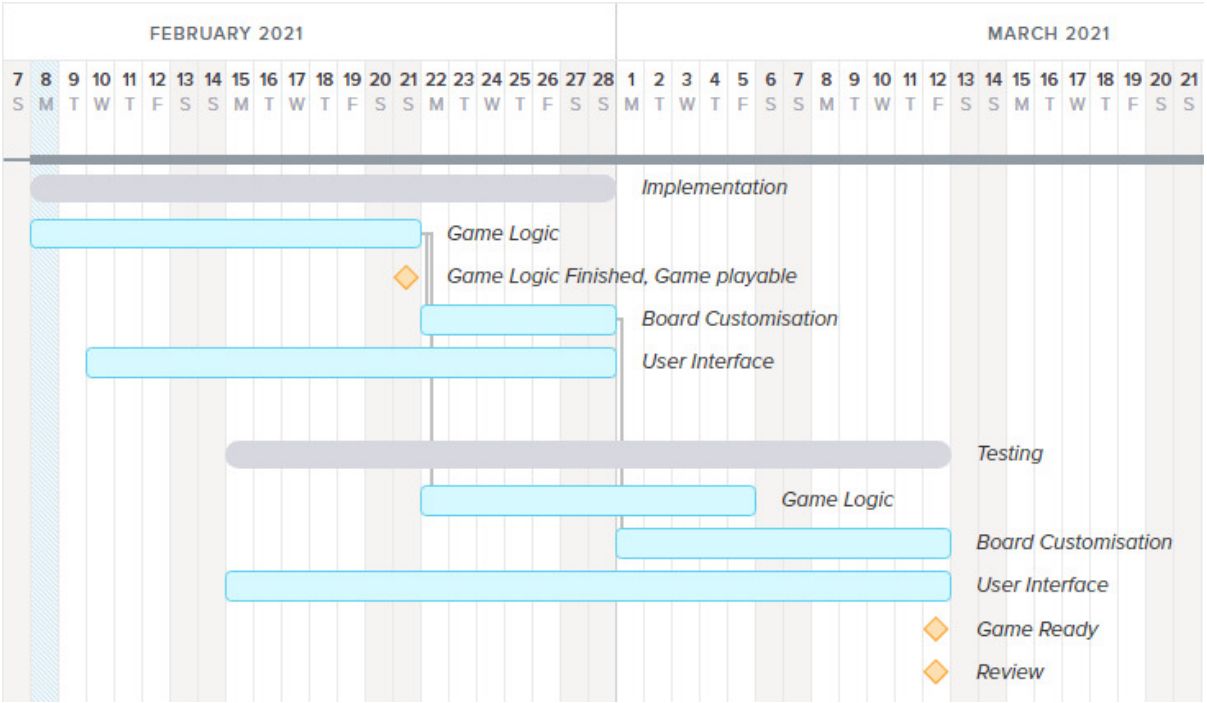
- Create a functional implementation of the game Dots and Boxes.
- Create a suitable user interface for the game.
- Add the option to modify the size and shape of the game board.
- Create various AI agents to play the game.
    - The first of these will implement the Minimax algorithm.
    - Future AI agents will be chosen and created once I have created the game and know more about it.
- Analyse these AI agents to find the best approach to the game.
- Use these agents to analyse the game itself and discover if the game is solvable.

Justification

The game dots and boxes poses a fair challenge for a potential AI agent as it is comparable to other games, and can be generalised as a graph search problem.
Any turn in a game of dots and boxes has a large number of potential moves for either player, as they are allowed to draw a line at any position on the board. This makes the game comparable to Go as it has a very high branching factor, making a simple Minimax approach less feasible. However, dots and boxes is less complex than a game like chess, with no difference in types of pieces. Dots and boxes also has the advantage of symmetry, similar to the game noughts and crosses. This property of the game can be used to reduce the search space.

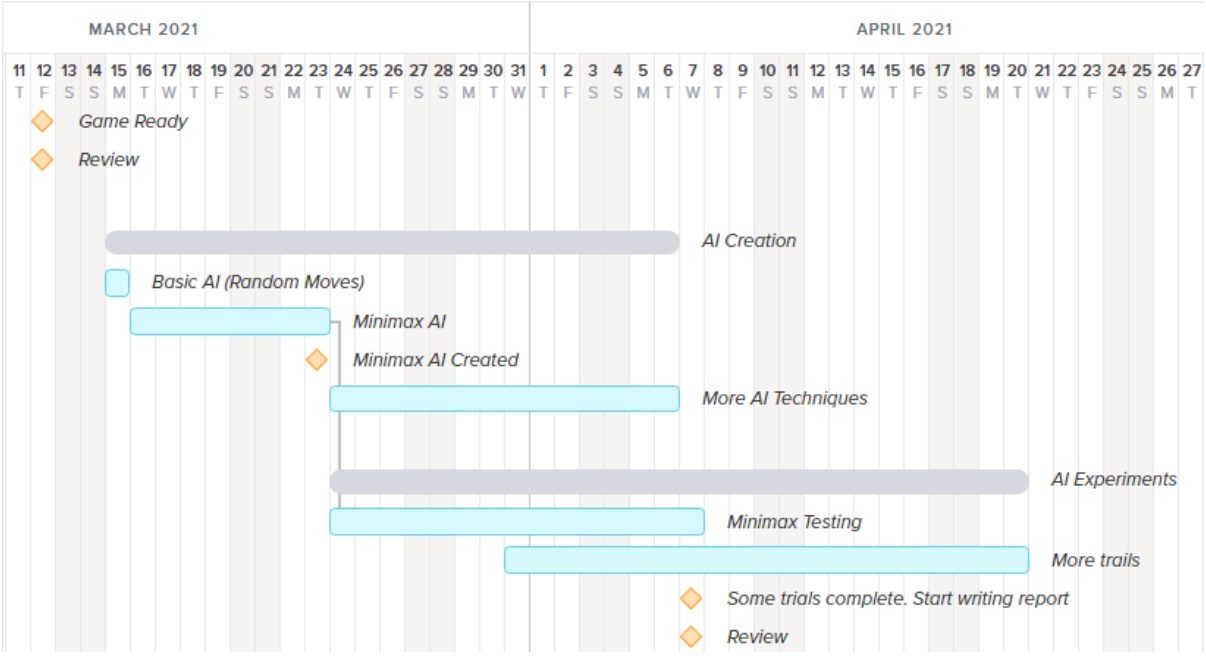
Time Plan

I have created a Gantt chart to illustrate the time I intend to spend on various tasks:



During the first few weeks of the project I will create the game itself. Once the game logic is complete the game will be playable via command line on simple 4x4 grids. The user interface and

board customisation features will come second.
After these features have been created and tested, the game will be ready for me to develop some AI agents. I will have a review meeting around this time, when the AI agents are ready to be implemented.



Once the game is ready I will start creating AI agents. First, a simple agent that performs moves at random, to create a framework for more AI.
Once I have created a Minimax player I will be able to begin trialling the AI and experimenting with it. This is a major milestone for the project as I can then start learning about the complexity of Dots and Boxes first-hand.
At this point I will know more about the problem and the game itself, so I will be able to decide what kind of AI agents will be best for the game. I will then implement these, and experiment with them all.
Once more trials are complete, I will be able to collate my research and start writing the final report. At this point I will schedule another review meeting.