Android App for Dot and Boxes Game using Alpha-Beta Pruning

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***Abstract*— AI is an interesting field which helps in development of Bot versus Human kind of games. In order to perform the fast processing and early decisions, alpha-beta pruning can be used. This actually prunes the game tree based on current alpha-beta values. Android app development using android studio is very useful for developing such mobile applications. In this project, we developed a Dot-And-Boxes Game Application using Alpha-Beta Pruning.**

Keywords— Alpha Beta Pruning, Mini-Max Algorithm, Dot-And-Boxes Game

I. Introduction

Dots and Boxes is a pencil-and-paper game for two players (sometimes more). This game starts with an empty grid of dots. A turn is given to each player and they add a horizontal or vertical line between 2 un-joined adjacent dots. Once a player completes fourth side of a 1×1 box then they earn one point. The game ends when no more lines can be placed. Greater will be the number of points, greater will be the chance of winning. The board may be of any size grid. When short on time, or to learn the game, a 2×2 board (3×3 dots) is suitable. A 5×5 board, on the other hand, is good for experts.

In this project, an android game application is developed for popular Dot and Boxes game using the Alpha Beta Pruning. This game is developed such that a player plays against artificial intelligence. AI bases its decisions on two methods:

i. Min-Max and
ii. Alpha-Beta Pruning

to defeat the player.
It starts with an empty grid of dots. The player takes turn and adds a line or edge between two un-connected adjacent dots.
Alpha-Beta Pruning is a search algorithm that is used to decrease the number of nodes that are evaluated by mini-max algorithm in its search tree [1]. It is adversarial based algorithm.
A mini-max algorithm is a recursive algorithm for choosing the next move in an n-player game, usually a two-player game. A value is associated with each position or state of the game.
Alpha Beta Pruning is an optimization technique for the mini-max algorithm. This algorithm passes two extra parameters to the mini-max function.
At each instance of the game, we will keep the data of number of dotes and boxes available in the game. Once player makes a move, it's going to update the available dots and boxes. Then, AI will evaluate the next best move based on Alpha-Beta Pruning Algorithm.

II. Important Terms And Definations

Following are some definitions and terms which will be mostly used in this paper:

- **Box:** A 1x1 basic unit of a grid which consists of 4 dots and is bounded by 4 lines.
- **Grid:** Many boxes makes a single grid.
- **Activity:** A screen or page of an application of a mobile is called as activity

A. Alpha Beta Prunning

For the optimization of time as well the space, a mini-max algorithm is used. Alpha-Beta Pruning is a variation of mini-max algorithm. This algorithm is used to prune those game tress based on comparison of Mini-Max values. In order to perform such pruning, track of two values

i. Alpha (a maximizer)
ii. Beta (a minimizer)

is maintained. These are to represent the current maximum and minimum values. At current node, comparison is made with these current values and based on that comparison, pruning is performed.

III. Methodology

In order to create android app, screens of the application are created. The screens of the app are called as Activities in the android app development. Since already discussed above, each activity of an android app has its own activity life-cycle. The methods of the activity life-cycle can be programmed or written in android studio. An activity is written in java code.
So, for each activity, we have :

i. a respective **layout/design file**
ii. a back-end **functionality java code**

In this project, design files are created and then the functionality files are developed to create the app.

A. Activites

Design or .xml files are created for Splash Activity, Main Activity, and Game Activity.

Following Activity files are developed:

i. **Splash Activity:** It just shows the logo of the game at the start of the game for an assigned time.

ii. **Main Activity:** selection of the grid size as well as the Robot versus Human is made on this activity.

iii. **Game Activity :** Board as well as interaction for game is made on this Activity. It displays the box/board size which is selected already in Main Activity, we have a board of size which we have selected on main activity already. We play game on that activity, so I named it Game Activity.

iv. **Music Enabled Activity**: is used to enable or disable the music file

v. **Music Player Activity:** is used to play the music when music is enabled

B. Other Functions or classes

Other than activity folder, other folders are created and each of that folder consists of its own java files which are helpful for the activities :

i. Controller: this consist of the alpha-beta pruning algorithm of the program.
   a. Game.java
   b. Player_Bot.java

ii. Utils
   a. Constants.java
   b. PrefUtils.java
   c. FileUtils.java
   d. GifImageView.java

iii. Fragments: this file consists of fragments for the activities
   a. GameFragment.java
   b. ResultFragment.java
   c. WonLostFragment.java
   d. ChooseTurnFragment.java

iv. Models
   a. Board.java
   b. Edge.java
   c. Graph.java
   d. Node.java

v. Views
   a. Board_View.java
   b. MusicIntentReciever.java

IV. Initial Experiment Results

For getting the definitive results, this game had been played many times and results are given in the TABLE 1

TABLE 1. COMPARISON OF PLAYER VERSUS BOT WINS

Grid Size	Player Wins	Bot Wins	Draws
4x4	4	10	4
5x5	5	20	-
6x6	8	15	2
7x7	10	20	
8x8	6	13	-
9x9	7	15	-

V. Conclusion

In this project, an android app for Dot and Boxes game has been developed using Alpha-Beta Pruning algorithm to enable the AI to make the decision.

References

[1] "Minimax algorithm in Game theory: Set 4 (alpha-beta pruning)," *GeeksforGeeks*, 18-Aug-2021. [Online]. Available: https://www.geeksforgeeks.org/minimax-algorithm-in-game-theory-set-4-alpha-beta-pruning/. [Accessed: 22-Oct-2021].