Project Report

Connect-Four Android Application

David Tony Veliath, AM.EN.U4CSE21219

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1. Introduction

1.1 Overview

The **Connect-Four** Android application is a mobile-based implementation of the classic Connect-Four board game. It features both single-player and local multiplayer modes, providing users with an engaging and visually appealing experience. The app emphasizes simplicity, responsiveness, and modern design.

1.2 Objectives

- Provide an intuitive and enjoyable user interface for playing Connect-Four.
- Implement an intelligent AI opponent using the Minimax algorithm with Alpha-Beta Pruning.
- Ensure compatibility with a wide range of Android devices.

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2. Project Description

2.1 Features

- **Single-Player Mode**: Users can play against an AI with competitive gameplay.
- **Multiplayer Mode**: Two users can play locally on the same device.
- **Game Board**: A 6x7 grid that dynamically updates as tokens are placed.
- **Undo Option**: Allows users to reverse their last move.
- **Winner Detection**: Highlights the winning combination or declares a draw.
- **Responsive Animations**: Smooth transitions enhance the visual experience.

2.2 Tools and Technologies

- **Development Environment**: Android Studio.

- **Programming Languages**: Kotlin or Java.
- **Algorithm**: Minimax with Alpha-Beta Pruning for AI logic.
- **UI Design**: XML-based layouts and Animator APIs.

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3. System Design

3.1 Architecture

The application follows a modular structure:

- **Game Logic**: Handles the game rules, token placement, and winner detection.
- **UI Module**: Manages the game board, animations, and player interactions.
- **AI Module**: Executes the Minimax algorithm to determine optimal moves in single-player mode.

3.2 Data Structures

- **Game Board**:
  A 2D array (`int[][]`) represents the game grid, where:
  - `0` = Empty cell.
  - `1` = Player 1's token.
  - `2` = Player 2's token.
- **Undo Stack**: Tracks move history for the undo feature.

3.3 User Interface

The UI is designed for ease of use with the following key components:

- A grid layout for the game board.
- Buttons for "Undo" and "Restart."
- Animated token drop effects using `ObjectAnimator`.

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4. Implementation

4.1 Core Features

1. **Game Initialization**:
    - Initializes a 6x7 grid.
    - Sets players to alternate turns.
2. **AI Logic: Minimax Algorithm with Alpha-Beta Pruning**
    - **Minimax Algorithm**:
        - A decision-making algorithm used in two-player games to find the best move by evaluating possible future moves.
        - The algorithm assumes that one player aims to maximize the score (AI) while the opponent aims to minimize it.
    - **Alpha-Beta Pruning**:
        - Optimizes Minimax by eliminating branches of the search tree that don't need evaluation, reducing computational overhead.
    - **Implementation in Connect-Four**:
        - The AI evaluates potential moves by simulating placements on the game grid.
        - A heuristic function scores the board based on potential winning opportunities and blocking opponent moves.
        - The algorithm recursively explores possible moves up to a certain depth to predict the best outcome.
    - **Challenges**: Balancing depth of search for strong AI and real-time responsiveness.
3. **Token Placement**:
    - Tokens are dropped to the lowest available row in the selected column.
4. **Win/Draw Detection**:
    - Checks for four consecutive tokens horizontally, vertically, or diagonally.
    - Declares a draw if all cells are filled with no winner.

4.2 Challenges

- **AI Optimization**: Ensuring Minimax operates efficiently without slowing down gameplay.
- **Animation Performance**: Balancing smooth animations with responsiveness on low-end devices.

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5. Results

5.1 Functionality Achieved

- Fully functional single-player and multiplayer modes.

- Competitive AI gameplay using Minimax with Alpha-Beta Pruning.
- Seamless UI with responsive animations.
- Accurate win and draw detection.

5.2 Testing

- Manual testing on various Android devices for gameplay and UI responsiveness.
- Validation of Minimax AI moves and win detection accuracy.

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6. Future Enhancements

- Add online multiplayer support.
- Introduce customizable board sizes and difficulty levels.
- Enhance sound effects and animations.

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7. Conclusion

The Connect-Four Android application successfully recreates the classic board game with a modern touch. Its intelligent AI and smooth gameplay provide a challenging and enjoyable experience for players of all skill levels.

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8. References

- Android Development Documentation: Android Developers.
- Minimax Algorithm: Wikipedia.