

**Project Title:** Visicrabble

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**Course:** AI

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## 1. Executive Summary

### Project Overview:

Visicrabble is a modernized version of the traditional Scrabble game, designed to offer a more strategic and competitive experience by introducing visible tiles, power-ups/penalties, and an intelligent AI opponent. The AI leverages the Minimax algorithm with Alpha-Beta pruning to make optimal moves based on board state and heuristics. Unlike conventional Scrabble, Visicrabble's 20×20 board features special tiles that either reward or restrict players. Players can see each other's tiles, adding a new layer of strategy in both offense and defense.

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## 2. Introduction

### Background:

Scrabble is a classic word-forming board game where players create words on a 15×15 board using randomly drawn letter tiles. Each word placement earns points, influenced by tile values and board bonuses. We selected Scrabble due to its linguistic nature and the scope for enhancing AI-based decision-making. Our goal was to reimagine the gameplay using visible tiles, penalties, and bonus tiles to make the game more unpredictable and engaging, especially when facing an AI.

### Objectives of the Project:

- Implement a challenging AI opponent using Minimax with Alpha-Beta Pruning.
- Modify the original Scrabble rules to include visibility of opponent tiles and power-ups/penalties.
- Develop a word suggestion system to simulate realistic AI player choices.
- Create an engaging GUI-based game interface with proper turn mechanics.

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### 3. Game Description

#### Original Game Rules:

Scrabble is played on a 15×15 board where players use randomly drawn letter tiles to form words. Players earn points based on the value of each letter and the placement of the word (bonus tiles like double/triple-word scores). Players alternate turns and draw new tiles after each move, and the game ends when all tiles are used or no valid moves remain.

#### Innovations and Modifications:

- **20×20 Board:** Increased board size to allow more complex word formations.
- **Visible Tiles:** Players can see the tiles of their opponent, adding a predictive strategy.
- **Power-Ups & Penalties:**
  - *Bonus Tiles:* Grant extra points when forming rare or long words.
  - *Trap Tiles:* Force a skipped turn, letter swap, or point deduction.
- **AI Integration:** Instead of NLP, the AI uses heuristics and Minimax with Alpha-Beta Pruning to determine optimal moves.

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### 4. AI Approach and Methodology

#### AI Techniques Used:

- **Minimax Algorithm with Alpha-Beta Pruning:** Optimizes move selection by simulating possible future states and pruning less optimal paths.
- **Heuristics:** The AI evaluates potential moves based on letter frequency, word length, strategic tile use (bonus/trap), and board coverage.

#### Algorithm and Heuristic Design:

- Evaluation function includes:
  - Word score based on letter values

- Bonus tile activation
- Blocking opponent's high-value positions
- AI also simulates the opponent's best possible moves to minimize their potential score.

#### **AI Performance Evaluation:**

- Decision time is optimized with Alpha-Beta pruning, ensuring reasonable response times.
  - AI performance is tested against human players for competitiveness, focusing on win rates and the effectiveness of blocking strategies.
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## **5. Game Mechanics and Rules**

#### **Modified Game Rules:**

- 20×20 board with both standard and special tiles.
- Players see each other's tiles.
- Bonus tiles increase points (e.g., for using rare letters like Z, Q).
- Trap tiles may skip turns or force unwanted moves.
- AI can suggest or block word placements.

#### **Turn-Based Mechanics:**

- Players alternate turns placing one valid word per turn.
- If a trap tile is triggered, the respective penalty applies immediately.
- The game continues until tiles are exhausted or no more valid moves exist.

#### **Winning Conditions:**

- The player with the highest score at the end wins.

- Players may challenge AI moves for validity (dictionary-based validation).
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## 6. Implementation and Development

### Development Process:

The development followed an 8-week plan:

- Weeks 1–2: Studied original Scrabble mechanics, identified gameplay gaps, and finalized rule changes.
- Weeks 3–4: Developed base game structure and designed the GUI using Pygame.
- Weeks 5–6: Implemented the Minimax-based AI with heuristic evaluation functions.
- Week 7: Conducted testing with human players and refined AI logic.
- Week 8: Final debugging, documentation, and report submission.

### Programming Languages and Tools:

- **Programming Language:** Python
- **Libraries:**
  - *Pygame*: GUI and board design
  - *NumPy/Pandas*: Game state management
- **Tools:** GitHub (version control), PyCharm

### Challenges Encountered:

- Designing balanced heuristic functions that emulate human gameplay.
- Implementing a 20×20 dynamic board layout in Pygame.
- Optimizing AI decision-making speed while maintaining competitiveness.
- Creating unique and fair trap/bonus tile mechanics.

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## 7. Team Contributions

- **M. Asim:** Developed the AI engine, implemented the Minimax and Alpha-Beta pruning logic.
- **Waniya Syed:** Designed power-up/penalty rules, contributed to GUI and board mechanics.
- **Valihasan Jalees:** Handled game interface, tile management system, and integrated game rules with AI.

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## 8. Results and Discussion

### AI Performance:

- Win rate of AI: ~65% in test sessions with human players.
- Average AI decision time: ~1.5 seconds per move with Alpha-Beta pruning.
- Strategic play observed: AI blocked opponent's high-score opportunities effectively and utilized bonus tiles efficiently.

### Discussion:

Visicrabble successfully expanded the traditional Scrabble experience by integrating an intelligent AI and new gameplay mechanics. The strategic depth introduced by visible tiles and trap mechanics created a more engaging and challenging environment for players.

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## 9. References

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