# Project Title: Hexagonal Scrabble - A Strategic Word Game Redefined

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**Course:** AI
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## 1. Project Overview

**Project Topic:**

Hexagonal Scrabble is a reimagined version of the classic Scrabble game that replaces the conventional square board with a hexagonal grid. Players can form words in six different directions, adding new layers of complexity and strategy. The game also includes power-up tiles that introduce dynamic gameplay elements.

**Objective:**

The main objective of this project is to develop an AI-driven Hexagonal Scrabble game that enhances word-building strategies and increases gameplay complexity. The AI will use heuristic-based decision-making and Minimax algorithm variations to optimize word placements. The game aims to provide a challenging and intelligent opponent for players.

## 2. Game Description

**Original Game Background:**

Scrabble is a popular word game where players place letter tiles on a board to form words. Points are awarded based on letter values and special board positions that modify scores. Players compete to maximize their scores by strategically placing high-value words.

**Innovations Introduced:**

- **Hexagonal Board Layout:** The traditional square grid is replaced with hexagonal tiles, allowing words to be placed in six directions instead of four.
- **New Special Tiles:** Power-up tiles grant special abilities such as swapping letters, earning extra points, or blocking an opponent's move.
- **AI-Driven Opponent:** An intelligent AI opponent will analyze potential word placements using Minimax with heuristic evaluations.

- **Heuristic-based Decision Making:** The AI will assess board state, word possibilities, and bonus tile advantages to determine optimal moves.

## 3. AI Approach and Methodology

**AI Techniques to be Used:**

- **Minimax Algorithm:** Modified to evaluate multi-directional word placement in a hexagonal board.
- **Alpha-Beta Pruning:** Used to optimize decision-making by pruning less favorable moves.
- **Reinforcement Learning (Optional):** Training the AI through self-play to improve decision-making strategies.

**Heuristic Design:**

- Letter value weighting based on Scrabble scoring rules.
- Bonus tile prioritization to maximize scoring potential.
- Board space evaluation to determine the best word placement opportunities.

**Complexity Analysis:**

- Increased branching factor due to six possible move directions.
- AI complexity will be evaluated based on execution time and move prediction accuracy.
- Expected time complexity of the AI algorithm will be O(b^d), where ‘b’ is the branching factor and ‘d’ is the depth of search.

## 4. Game Rules and Mechanics

**Modified Rules:**

- Words can be placed in six different directions instead of four.
- Special power-up tiles provide strategic advantages.
- Players can swap tiles or block opponent moves under certain conditions.

**Winning Conditions:**

- The player with the highest score when all tiles are used or no valid moves remain wins.

**Turn Sequence:**

- Players take turns forming words by placing tiles on the hexagonal board.
- The AI or human opponent then places their move based on available options.
- New tiles are drawn to maintain a full rack of seven tiles.

## 5. Implementation Plan

**Programming Language: Python**

**Libraries and Tools:**

- **Pygame:** For graphical user interface (GUI) development.
- **NumPy:** For efficient handling of game state and AI computations.
- **NLTK (Natural Language Toolkit):** For word validation.
- **Scikit-learn / TensorFlow:** If reinforcement learning is incorporated.

**Milestones and Timeline:**

- **Week 1-2:** Game design and rule finalization.
- **Week 3-4:** AI strategy development (Minimax and heuristics).
- **Week 5-6:** Coding and testing game mechanics.
- **Week 7:** AI integration and testing.
- **Week 8:** Final testing and report preparation.

## 6. References


- Scrabble Official Rulebook.
- Research papers on AI strategies for board games.
- Online resources on heuristic-based AI decision-making.