

Project Report

Project Title: Nine Men's Morris

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Course: AI-Lab

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1. Executive Summary

- **Project Overview:**

This project enhances the classic Nine Men's Morris by introducing new mechanics, Time Bombs and an Undo option and implementing a Minimax-based AI with alpha-beta pruning. The goal was to make the game more engaging and strategically rich while allowing competitive play between a human and an AI.

2. Introduction

- **Background:**

Nine Men's Morris is a traditional two-player strategy game focused on forming mills and removing the opponent's pieces. It was chosen for its simple rules and tactical depth. This project adds innovation through Time Bombs, which affect nearby pieces after a countdown, and an Undo feature to support player learning.

- **Objectives of the Project:**

- *Develop a playable version of Nine Men's Morris with enhancements*
- *Implement an AI using Minimax with alpha-beta pruning*
- *Introduce bombs and undo functionality*

3. Game Description

- **Original Game Rules:**

Each player places 9 pieces on a 24-position board, then moves them to form mills (three aligned pieces) to remove opponents' pieces. The game has three phases: placing, moving, and flying (when a player has only 3 pieces left).

- **Innovations and Modifications:**

- *Time Bombs: One per player, explodes after a timer, affecting adjacent pieces*
- *Undo Option: Up to 3 move undos for the player*

4. AI Approach and Methodology

- **AI Techniques Used:**

The AI uses the Minimax algorithm with Alpha-Beta pruning to evaluate possible game states and select the most optimal move. This helps reduce the number of explored states while maintaining strong decision-making.

- **Algorithm and Heuristic Design:**

The evaluation function considers factors such as:

- *Number of pieces on the board*
- *Mills formed and potential mills*
- *Number of valid moves*
- *Blocking the opponent*

- **AI Performance Evaluation:**

The AI was tested against human players, showing strong play and strategic bomb placement. Performance was also evaluated by measuring decision quality based on board advantage.

5. Game Mechanics and Rules

- **Modified Game Rules:**

- *Each player can place one Time Bomb on their own piece*
- *Bombs detonate after 3 of the owner's turns and destroy adjacent pieces*
- *Undo feature: The player can undo up to 3 moves*
- *Bombed pieces return to the placement pool if destroyed*

- **Turn-based Mechanics:**

Players alternate turns. On each turn, they can place, move, fly according to the different phases of the game, or use a bomb. Bombs tick down at the start of the player's turn. Detonations and undo actions are handled before the next player acts.

- **Winning Conditions:**

A player loses if they have fewer than 3 pieces after placing is done or if they cannot make a valid move. The opponent is then declared the winner.

6. Implementation and Development

- **Development Process:**

The game was implemented in Python with a text-based interface. The logic includes bomb mechanics, undo functionality, and an AI opponent. The game loop manages turns, bomb countdowns, and game state updates.

- **Programming Languages and Tools:**
 - *Programming Language: Python*
 - *Libraries: Standard Python libraries (time, random, os)*
 - *Tools: GitHub for version control*
- **Challenges Encountered:**
 - *Handling bomb detonation timing and board updates dynamically*
 - *Integrating bombs into AI decision-making without breaking the Minimax logic*
 - *Managing undo states cleanly, especially with bombs and removals*
 - *These were solved by maintaining detailed game state backups and isolating bomb logic from the main Minimax tree.*

7. Team Contributions

- **Team Members and Responsibilities:**
 - **Rafay Ahmad:** Led AI development using Minimax and Alpha-Beta pruning; conducted AI performance testing and analysis.
 - **Ahmad Ali Ansari:** Co-developed AI logic; managed game rule modifications, including bomb mechanics and board layout.
 - **Muhammad Hassaan:** Created the demonstration video and managed GitHub version control and code repository.

8. Results and Discussion

- **AI Performance:**

The AI demonstrated effective strategic play, winning approximately 60% of games against human testers. With Alpha-Beta pruning, average decision-making time was reduced to around 2 seconds per move, maintaining good response speed while evaluating complex game states. Bomb usage by the AI added tactical depth and increased unpredictability in gameplay.

9. References

- *Nine Men's Morris game rules and history – Wikipedia*
- *Minimax and Alpha-Beta Pruning tutorials – GeeksforGeeks*
- *Python documentation – <https://docs.python.org/3/>*
- *GitHub for version control – <https://github.com/>*