Final Project Report

Project Title: First to the Centre – An AI-Driven Chess Variant

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1. Introduction

This project presents 'First to the Centre', a novel chess variant where players can win not only by checkmate but also by safely moving their king to the central squares (d4, d5, e4, or e5). In this variant, rooks move diagonally (like bishops) and bishops move orthogonally (like rooks), adding a fresh layer of strategy. The primary focus of the project was to build an intelligent AI opponent using the Minimax algorithm with Alpha-Beta Pruning, enhanced with a custom evaluation heuristic.

2. Objectives

- Implement the unique rules of 'First to the Centre'.

- Develop a playable user interface using Pygame.

- Build an AI opponent that adapts to the modified rules.

- Employ Minimax and Alpha-Beta pruning for efficient decision-making.

- Create a balanced heuristic considering central control and traditional factors.

3. Game Mechanics and Rule Changes

Standard Rules Preserved:
- Turn-based movement
- Legal move generation
- Piece capturing and checkmate logic

Modifications Introduced:
- Victory Condition: A player can win by safely placing their king on a central square.
- Piece Movements:
  - Rooks → Diagonal (like Bishops)
  - Bishops → Orthogonal (like Rooks)

4. AI Strategy and Implementation

Algorithms Used:
- Minimax: Exhaustive move tree search for optimal decisions.
- Alpha-Beta Pruning: Reduces unnecessary computation, improving performance.

Heuristic Function Design:
- Material balance (weighted sum of piece values)
- King distance to center
- Penalization for being in check
- Adjusted values for bishops and rooks due to their new roles

Complexity: The AI search operates with O(b^d) complexity. With Alpha-Beta pruning and a depth of 3, performance remained acceptable.

5. Technology Stack

Component	**Tool/Library**
Programming Language	Python
Board Engine	Python-chess
Game UI	Pygame
AI Engine	Minimax + Alpha-Beta
Others	NumPy, Sys, OS

6. Features and Interface

- Human vs Human and Human vs AI modes
- Time controls (1, 3, 5, 10 minutes per player)
- Interactive GUI with:
  - Highlighted legal moves
  - Flashing red king on check
  - Turn and time display
  - Game result screen
- Pawn promotion selection UI
- Restart and menu return options

7. Implementation Challenges

- Overriding python-chess behavior to accommodate custom rook and bishop moves.
- Ensuring king safety with custom move sets.
- Integrating AI move logic with real-time UI responsiveness.
- Managing edge cases like promotions and draw conditions.

8. Results and Testing

- Successfully tested AI logic against both checkmate and center win conditions.
- Verified all game rules, including customized piece behavior.
- Time control and turn-based logic tested for fairness and accuracy.
- Smooth UI interactions confirmed across all game modes.

9. Conclusion

'First to the Centre' introduces a fun and strategic twist to traditional chess, making it suitable for both casual and competitive players. The integration of AI in a custom chess variant demonstrates how classical algorithms can be adapted creatively. This project not only meets academic objectives but also serves as a playable proof of concept.

10. Future Work

- Add multiplayer over LAN/Internet
- Improve AI with deeper search and opening databases
- Enable custom board setups or training modes
- Add sound effects and animations for better user engagement

11. References

- https://www.chessprogramming.org/
- python-chess GitHub Repository
- AI textbooks and guides on Minimax & Alpha-Beta pruning