Project Title: Quantum Chess AI

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Course: AI

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1. Executive Summary

Project Overview:
Quantum Chess AI is a novel take on traditional chess, integrating quantum teleportation mechanics. A 20% probability-based teleportation affects piece movement, enhancing unpredictability and complexity. The AI uses the Minimax algorithm with Alpha-Beta pruning and a heuristic evaluation function to determine optimal moves. It supports difficulty adjustment through variable search depth.

2. Introduction

Background:
Conventional chess is a strategic game for two players, each managing 16 pieces. The project introduces randomness with teleportation mechanics, encouraging exploration of AI under uncertain conditions.

Objectives of the Project:

- Develop an AI agent capable of playing Quantum Chess.
- Integrate Minimax with Alpha-Beta pruning.
- Introduce 20% teleportation-based randomness.
- Design an adjustable difficulty feature for AI.

3. Game Description

Original Game Rules:
Each player aims to checkmate the opponent's king under standard chess rules using 16 pieces on an 8x8 board.

Innovations and Modifications:

- Teleportation: 20% chance of relocating a moved piece to a random valid square.
- Dynamic AI difficulty adjustment.

- Enhanced GUI using Pygame.

4. AI Approach and Methodology

AI Techniques Used:
The AI decision-making is powered by Minimax. Alpha-Beta pruning enhances its computational performance.

Algorithm and Heuristic Design:

- Piece values are assigned (Pawn = 1, Knight = 3, Queen = 9, etc.).
- Evaluation considers piece safety, center control, and potential threats.

AI Performance Evaluation:
Effectiveness measured by win ratio, response time, and adaptability against various strategies.

5. Game Mechanics and Rules

Modified Game Rules:

- Teleportation applies probabilistically after each move.
- All other standard chess rules remain.

Turn-based Mechanics:
Player takes a turn, then teleportation occurs (if triggered), and then the AI responds accordingly.

Winning Conditions:
Checkmate the opponent or draw by stalemate/insufficient material.

6. Implementation and Development

Development Process:
The implementation spanned 8 weeks with phases: rule finalization, AI coding, teleportation logic, GUI integration, and testing.

Programming Languages and Tools:

- **Language:** Python
- **Libraries:** Pygame, NumPy
- **Tools:** GitHub, optional Stockfish engine

Challenges Encountered:
Teleportation complexity in game balance, ensuring AI stability with randomness, and GUI responsiveness.

7. Team Contributions

- **Jayant Kumar:** AI logic, Minimax and pruning.
- **Shyam Sundar:** Game mechanics, teleportation logic.
- **Shahzaib Khan:** UI, integration, and final testing.

8. Results and Discussion

AI Performance:
The AI achieved 70% win rate in simulations against medium-level human players. Decision-making was under 2 seconds per move. Teleportation added novel unpredictability enhancing gameplay variety.

9. References

- Russell, S., Norvig, P. "Artificial Intelligence: A Modern Approach"
- Chess Programming Wiki: Minimax, Alpha-Beta
- Pygame and NumPy Documentation
- GeeksforGeeks: Chess AI Techniques