

**AI PROJECT REPORT**

**MINICHESSAI**

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# **MiniChessAI: Core Components**

MiniChessAI is an AI designed for MiniChess (6x5 board), leveraging a robust evaluation function and efficient algorithms to deliver strong gameplay. Below are the core components of its evaluation criteria and implementation.

## **Evaluation Criteria**

The AI assesses board positions using a weighted sum of key features:

1. **Material Balance**: Assigns values to pieces (Pawn: 1, Knight/Bishop: 3, Rook: 5, Queen: 9, King: high value) to prioritize capturing and preserving pieces.
2. **Piece Activity & Mobility**: Counts legal moves to favor positions with greater flexibility, subtracting opponent’s mobility.
3. **Pawn Structure**: Awards bonuses for connected/advanced pawns; penalizes doubled, isolated, or backward pawns.
4. **King Safety**: Penalizes exposed kings or those under threat, encouraging castling and protection.
5. **Center Control**: Grants bonuses for controlling/occupying central squares to enhance piece effectiveness.
6. **Threats & Tactics**: Adds bonuses for checks, forks, pins, and attacks on high-value pieces.
7. **Endgame Conditions**: Returns large values for checkmate (positive/negative), zero for stalemate or draws.

## **Implementation Details**

* **Search Algorithm**: Uses Minimax with Alpha-Beta Pruning to explore move sequences efficiently, with move ordering (captures, checks, threats first) to optimize pruning.
* **Optimizations**:
  + **Transposition Table**: Caches evaluated positions to skip redundant calculations.
  + **Move Generation**: Employs fast routines to reduce computation time.
* **Tech Stack**:
  + **Backend**: Python (FastAPI) for game logic, move validation, and AI computation.
  + **Frontend**: Next.js (React) for an interactive chessboard and user interface.
* **Game Modes**: Supports Human vs AI, AI vs AI, and Human vs Human.
* **Testing**: Validated through MiniChess puzzles, self-play, and unit tests for move generation, evaluation, and endgame detection.

## **Conclusion**

MiniChessAI delivers a challenging and adaptable opponent by balancing material, mobility, pawn structure, king safety, and tactics. Its modular design and optimizations ensure efficient performance on the 6x5 board, supporting diverse play modes.