

# Chess Trainer AI - Project Documentation

## 1. Introduction

Chess Trainer AI is an advanced system designed to analyze chess games and provide detailed feedback on player moves. By leveraging deep learning and the powerful Stockfish chess engine, this AI tool helps players improve their game through insights on move accuracy and quality. The project aims to bridge the gap between casual and professional players by offering automated analysis and recommendations.

## 2. Objectives

- Develop an AI-driven chess trainer that evaluates moves based on centipawn loss.
- Utilize deep learning models to classify and provide feedback on move quality.
- Improve chess decision-making skills for players by highlighting mistakes and blunders.
- Optimize the system for speed and accuracy using lightweight deep learning models.

## 3. Technologies Used

- Python: Primary programming language.
- python-chess: Library for handling chess game structures and moves.
- Stockfish: A powerful chess engine for move evaluation.
- PyTorch: Framework for implementing and training deep learning models.
- MobileNetV3-Small: A lightweight deep learning model optimized for faster inference.
- Google Colab: Cloud-based execution environment for ease of use.

## 4. System Architecture

The Chess Trainer AI follows a modular architecture:

1. PGN Parsing Module: Extracts moves from uploaded chess games in Portable Game Notation (PGN) format.
2. Move Analysis Module: Evaluates the quality of each move using the Stockfish engine.
3. Deep Learning Module: Uses MobileNetV3-Small to classify move quality.
4. Feedback Generation Module: Provides structured feedback based on centipawn loss.
5. User Interface: Accepts game uploads and displays move evaluations.

## 5. Workflow of Chess Trainer AI

1. The user uploads a PGN file containing a chess game.
2. The system extracts moves and converts them into a board state.
3. Stockfish evaluates each move and assigns a centipawn loss value.
4. A deep learning model (Feed-Forward Neural Network) classifies moves based on their impact on game outcome.
5. The system generates feedback indicating whether each move is excellent, good, inaccurate, a mistake, or a blunder.
6. The feedback is displayed to the user for analysis and improvement.

## 6. Move Evaluation Using Centipawn Loss

Centipawn loss measures the difference in evaluation between the best possible move and the played move. It is expressed in hundredths of a pawn (centipawns). A lower centipawn loss means a stronger move.

Centipawn Loss	Move Quality
0	Best Move (Ideal)
< 50	Good Move
50 - 99	Inaccuracy
100 - 199	Mistake
> 200	Blunder

## 7. Performance Optimization

Optimization Strategies Implemented:

- Stockfish Engine Depth Reduction: Reduced depth from 10 to 6 for faster analysis.
- MobileNetV3-Small Model: Chosen for its lightweight nature and quick inference speed.
- Batch Processing of Moves: Improves computational efficiency.
- Structured Feedback Mechanism: Allows quicker assessment of move quality.

## 8. Challenges Faced

- Balancing Speed and Accuracy: Higher-depth Stockfish evaluations provide better insights but slow down processing.
- Feature Engineering for Chess Positions: Ensuring the deep learning model accurately classifies moves.
- Handling Complex Chess Positions: Some moves require deeper strategic understanding beyond centipawn loss.
- PGN Parsing and Variations Handling: Chess games with multiple variations posed challenges in standardizing data input.

## 9. Future Enhancements

- Monte Carlo Tree Search (MCTS) for Move Selection: Implementing MCTS for better decision-making.
- Training a Custom Deep Learning Model: Enhancing move classification with a dedicated dataset of expert games.
- Graphical User Interface (GUI) Implementation: Improving user experience with an interactive UI.
- Real-Time Game Analysis: Enabling move-by-move feedback during live games.

## 10. Conclusion

Chess Trainer AI provides a powerful chess analysis platform by integrating Stockfish and deep learning for move evaluation. The tool aims to enhance decision-making and help players understand mistakes and improve their strategies. Future enhancements will focus on making the system more intuitive, real-time, and intelligent.