

# Applications of Artificial Intelligence and Machine Learning in Othello

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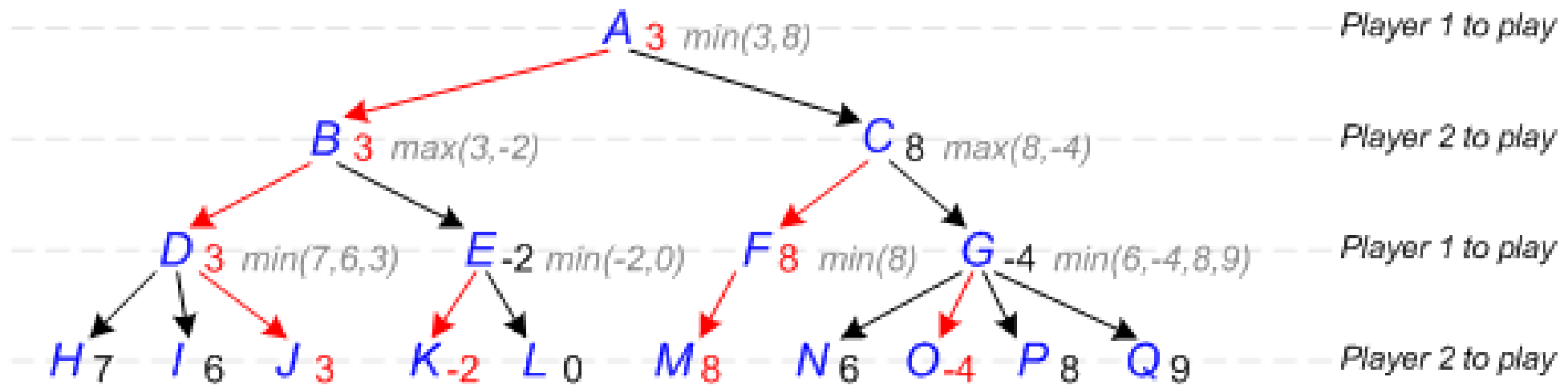
# Abstract

This project explores Artificial Intelligence techniques in the board game Othello. Several Othello-playing programs were implemented and compared. The performance of minimax search algorithms, including alpha-beta, NegaScout and MTD(f), and of other search improvements such as transposition tables, was analyzed. In addition, the use of machine learning to enable AI players to improve play automatically through training was investigated.

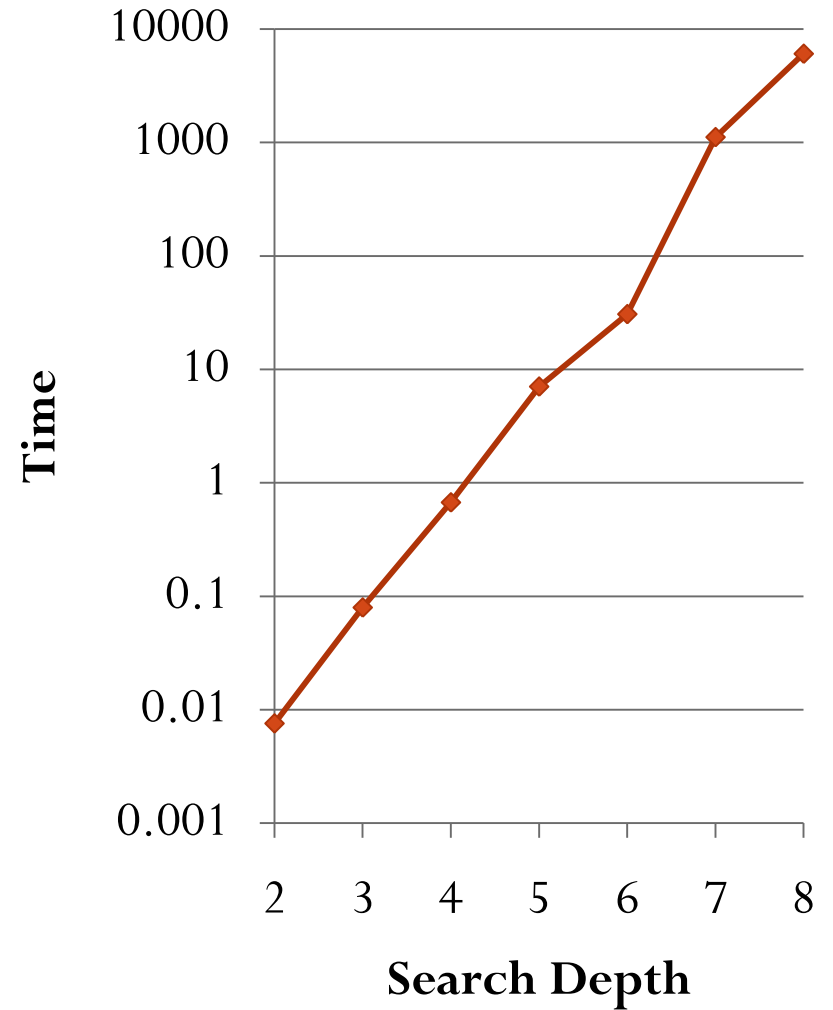
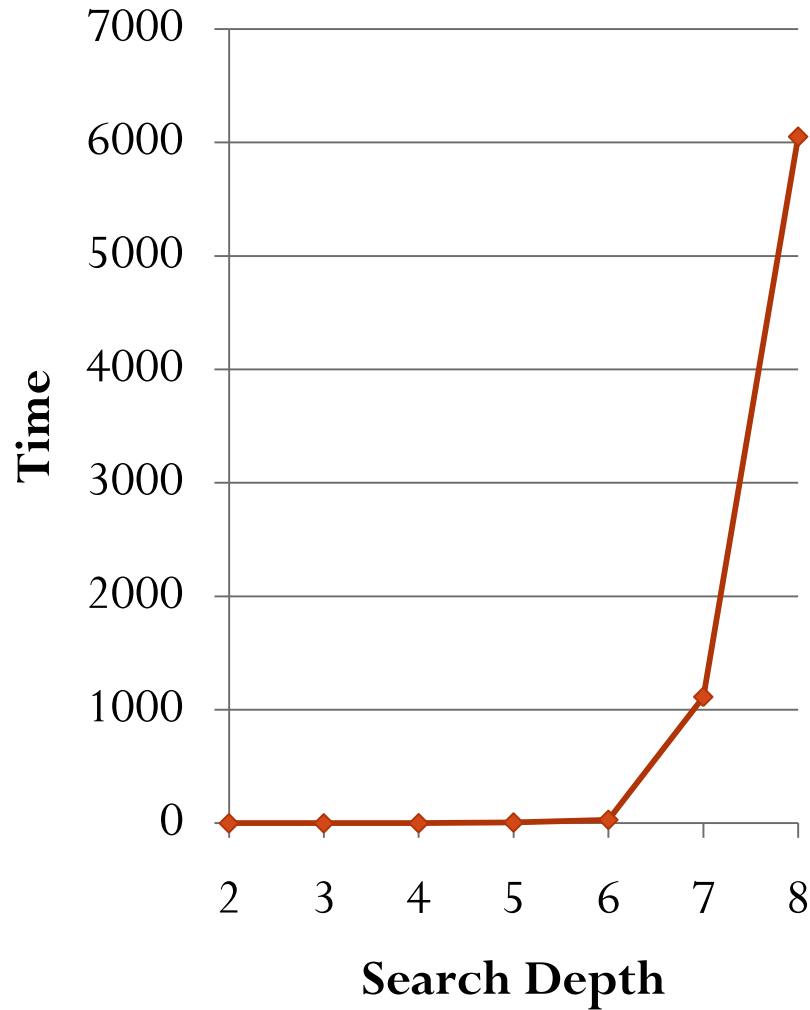
# Static Position Evaluation

- Heuristically evaluate position without exploring moves
- Useful features:
  - Piece differential
  - Corners and adjacent squares
  - Mobility
  - Parity
- Game stages

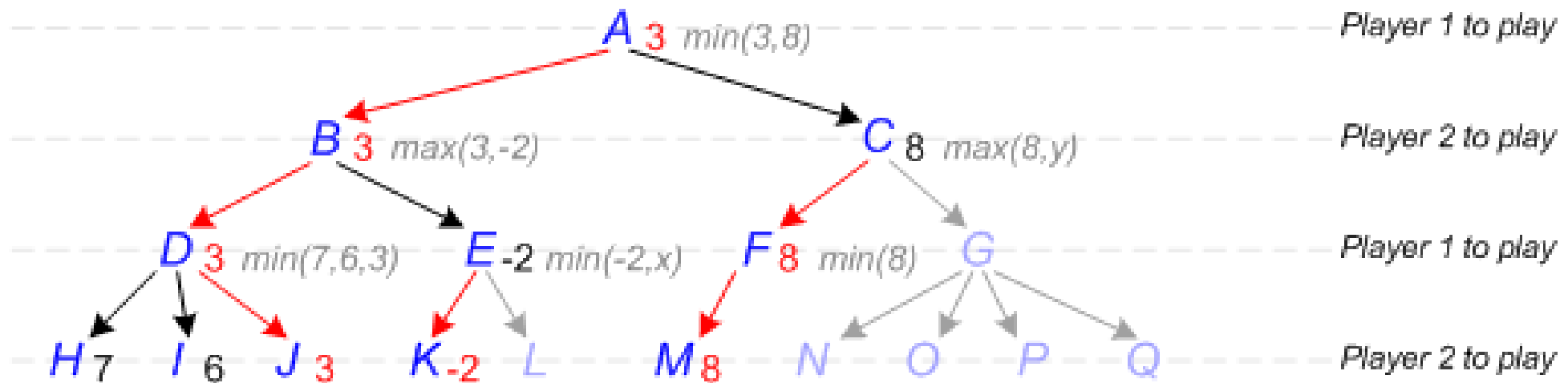
# Minimax



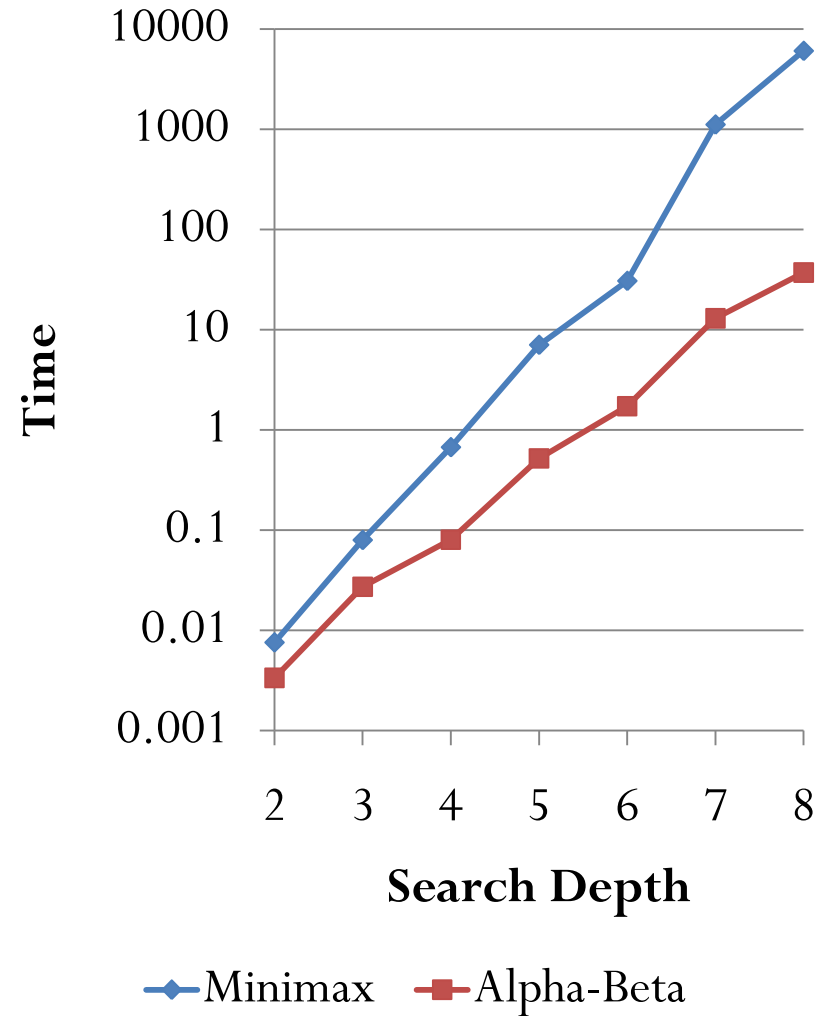
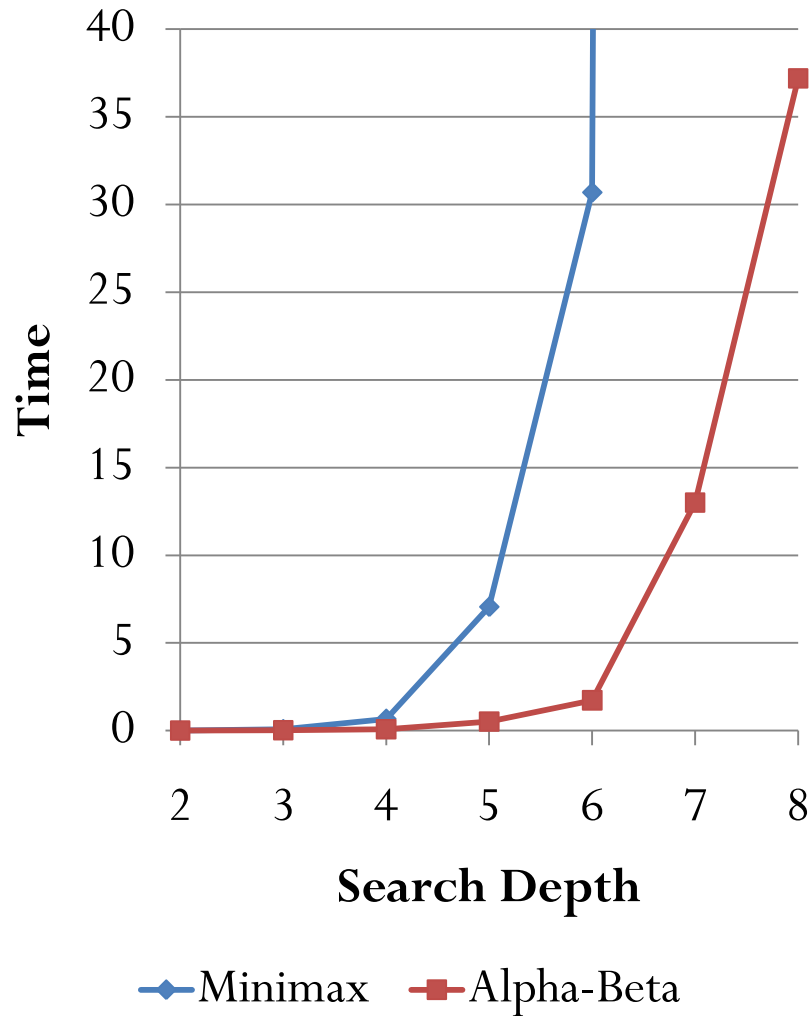
# Minimax Performance



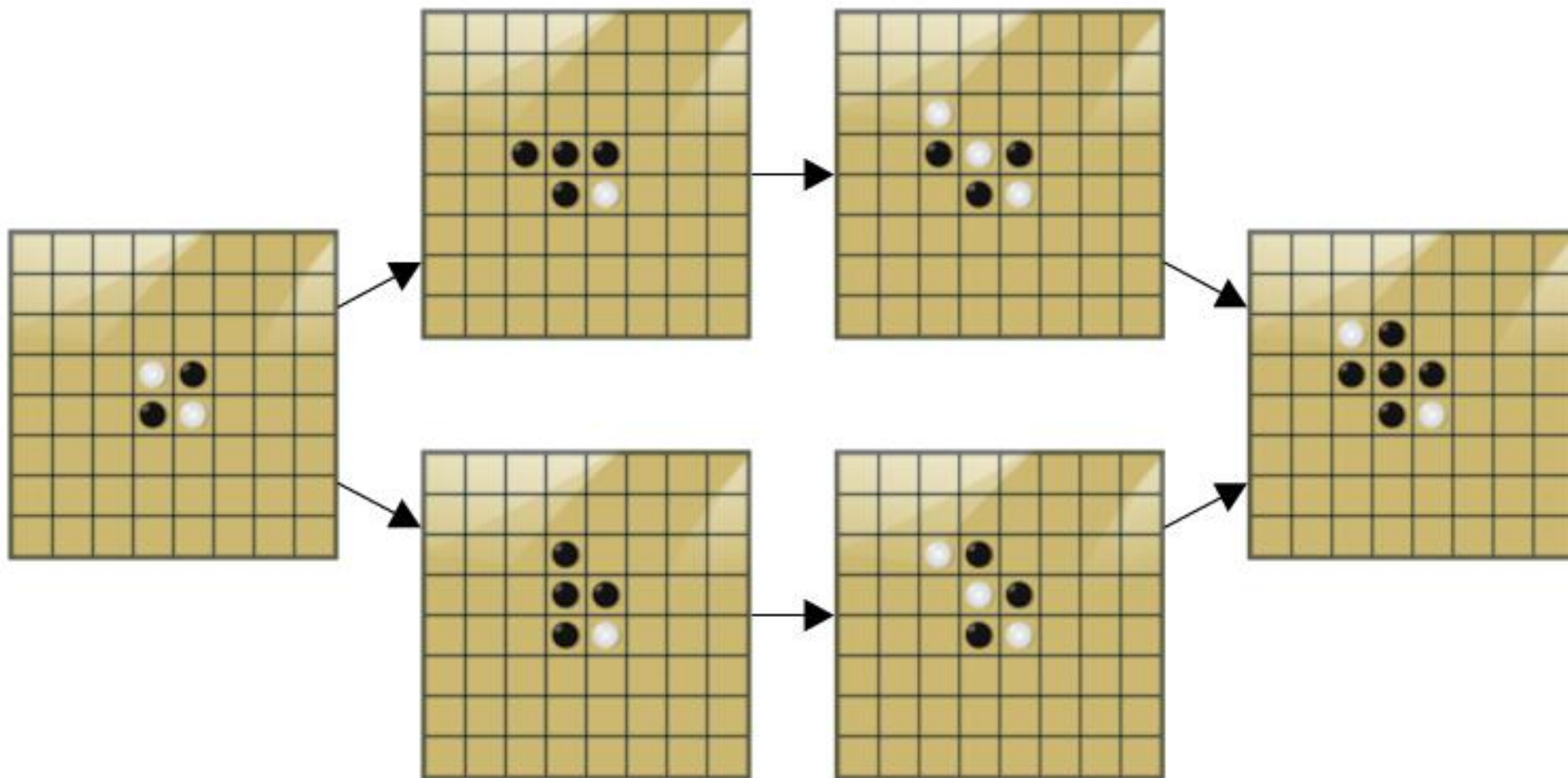
# Alpha-Beta Pruning



# Alpha-Beta Performance



# Transpositions

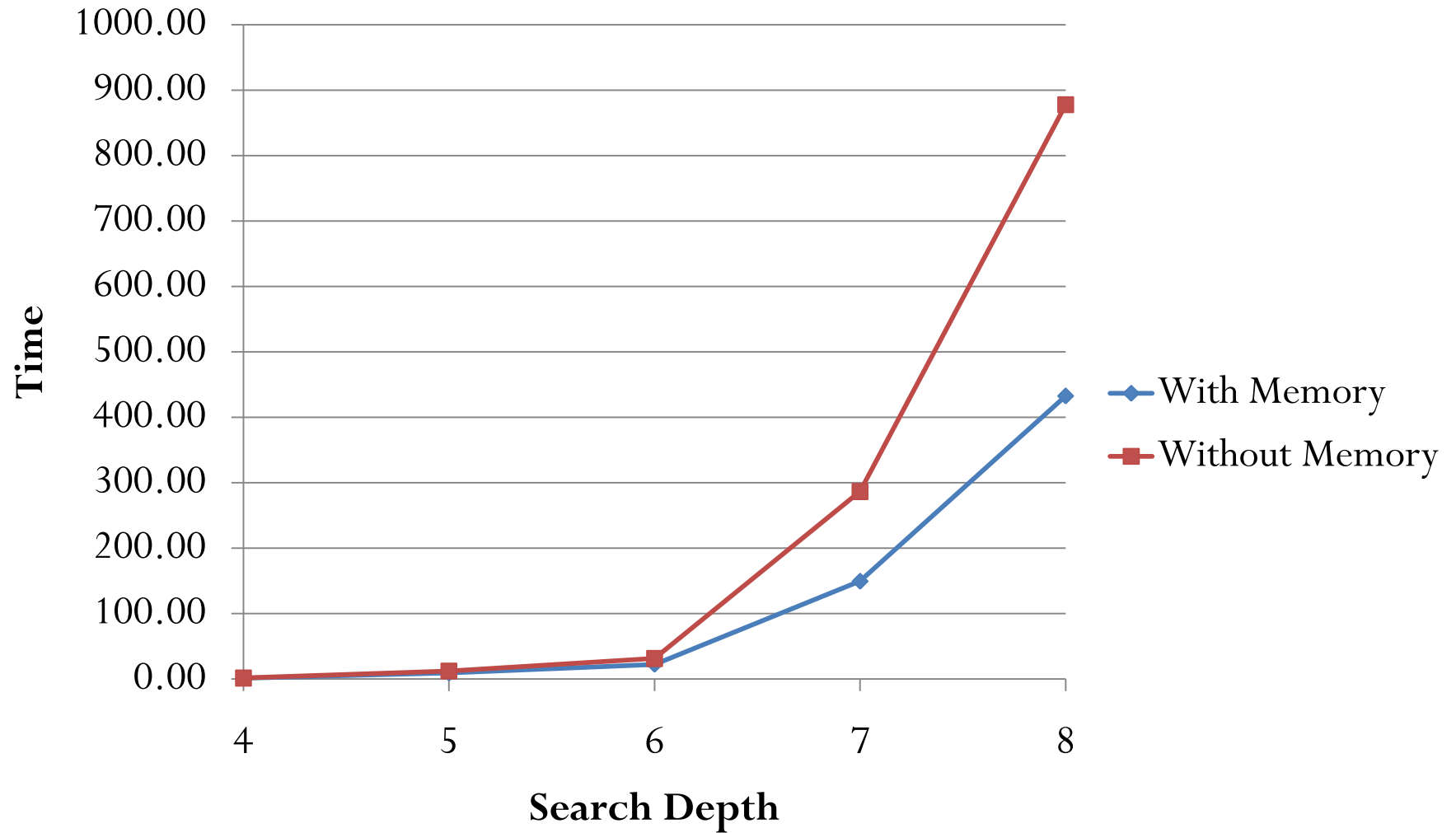




# Transposition Table

- Cache information about positions
- Avoid re-searching
- Improve move ordering

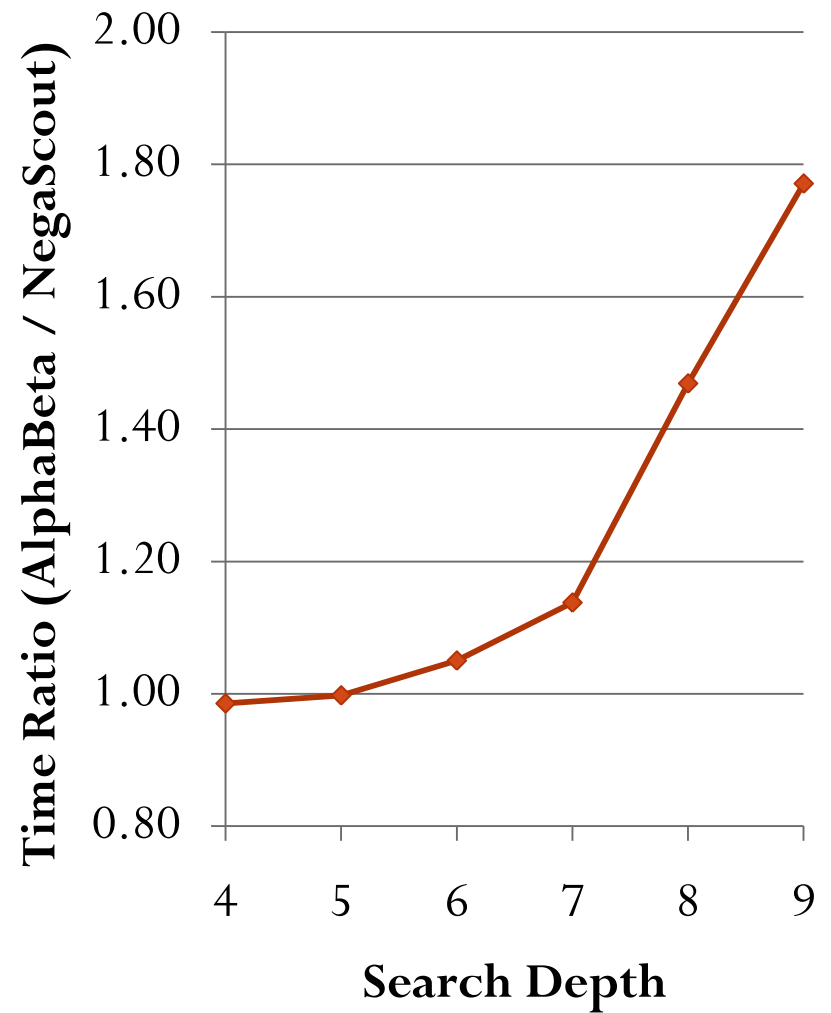
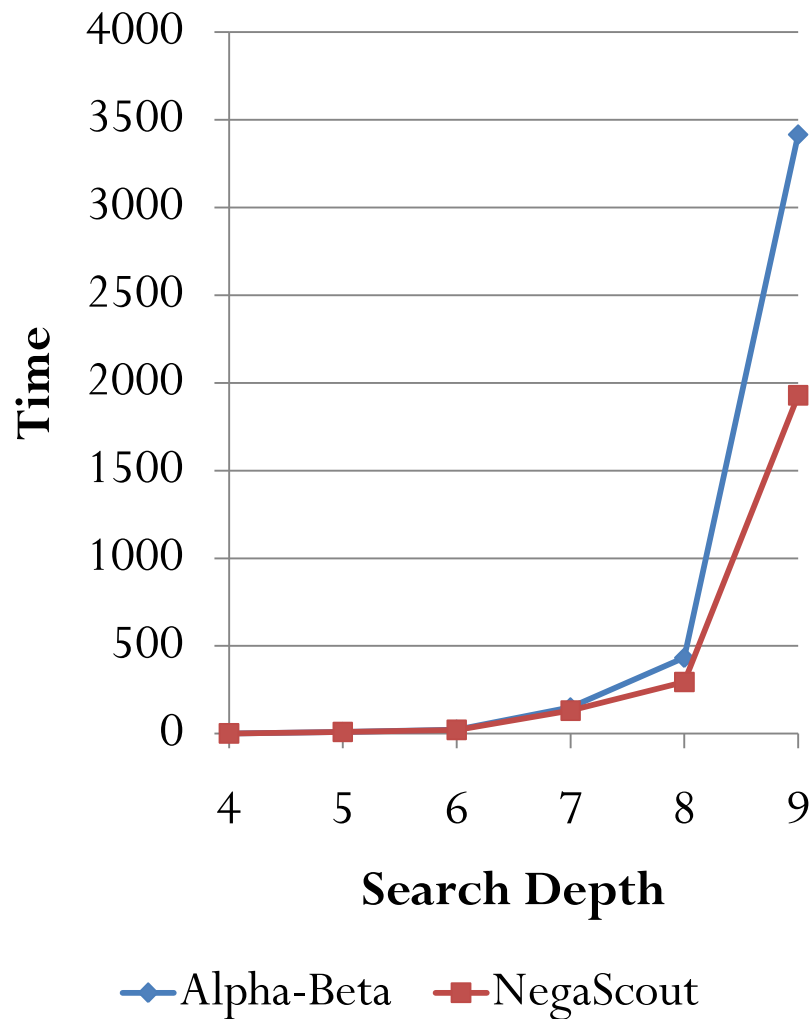
# Transposition Table Performance



# NegaScout

- More efficient than alpha-beta
- Null-window search
- Principal variation search
- Importance of move ordering

# NegaScout Performance

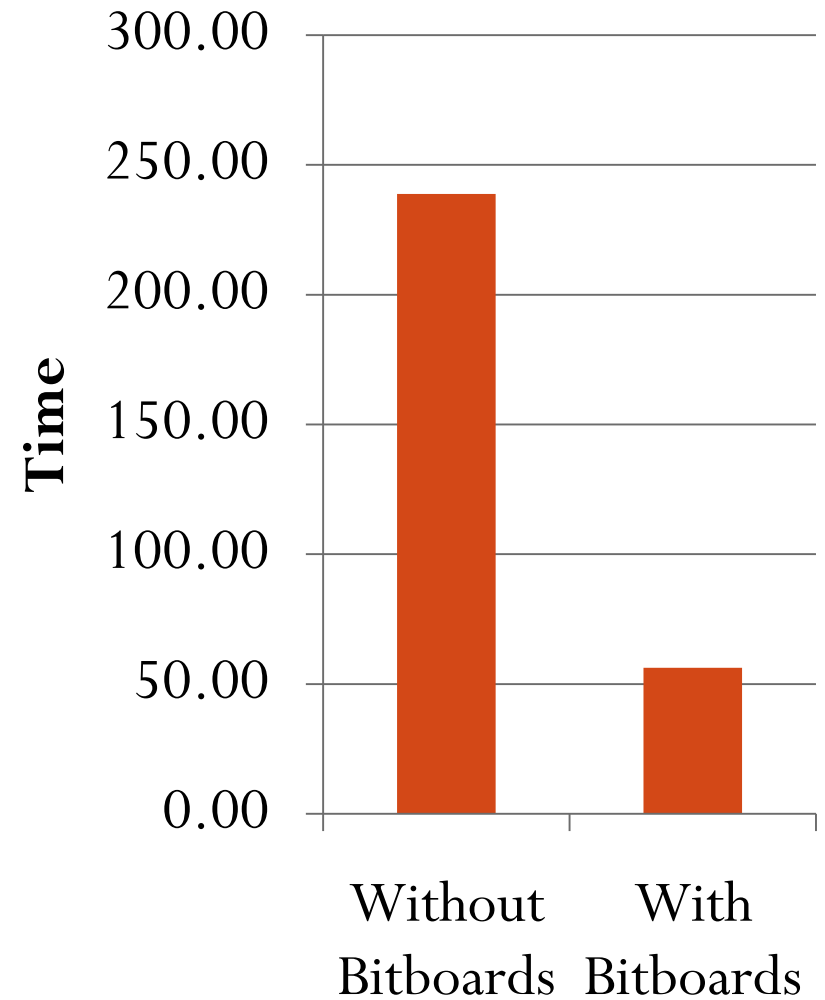


# MTD(f)

- More efficient than both alpha-beta and NegaScout
- Only null-window searches
- Heavy reliance on transposition table
- Iterative deepening for better “first guess”

# Bitboards

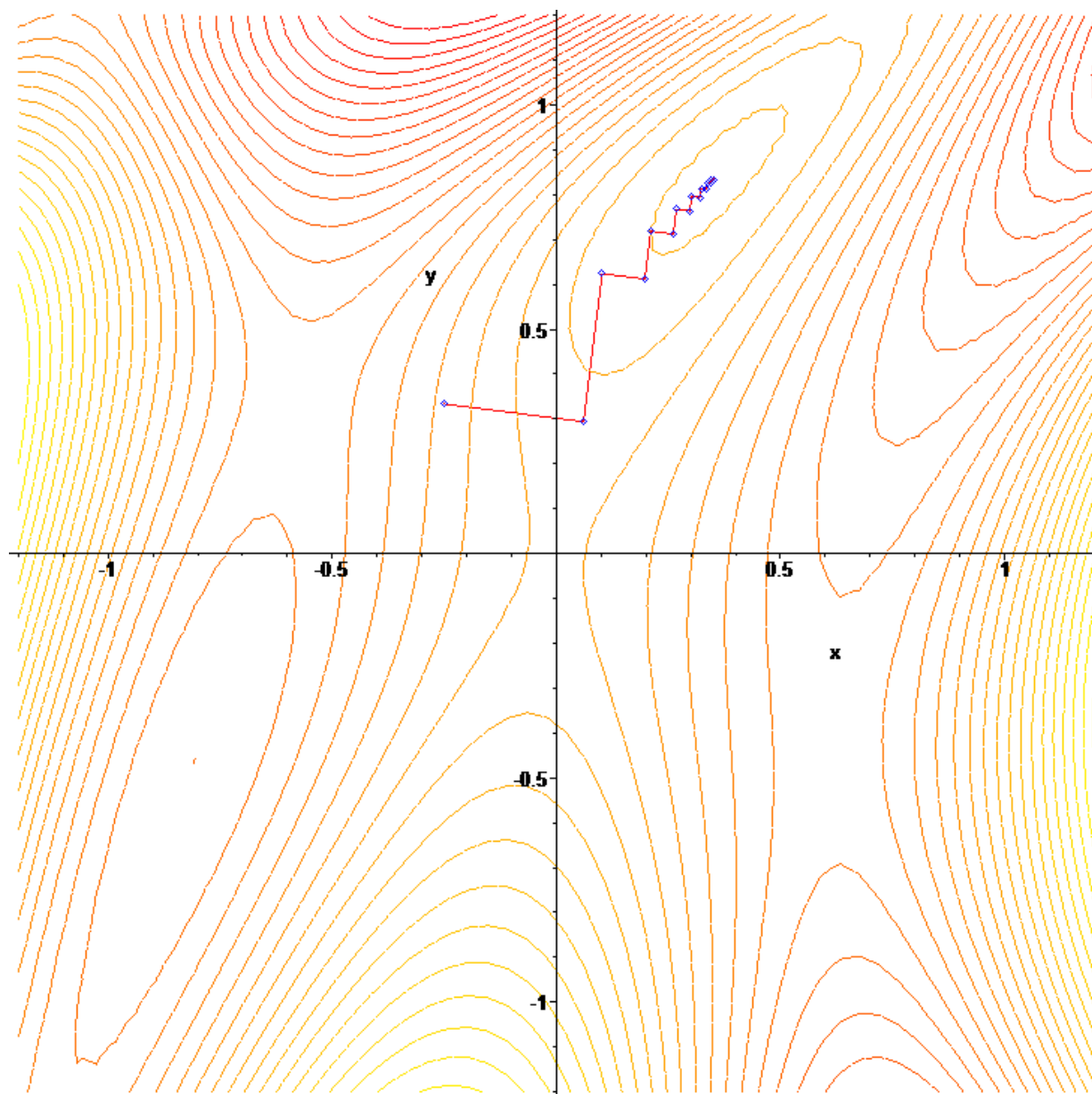
- Store boards as bitstrings
- Speed improvements
- Compactness



# Training Static Position Evaluation

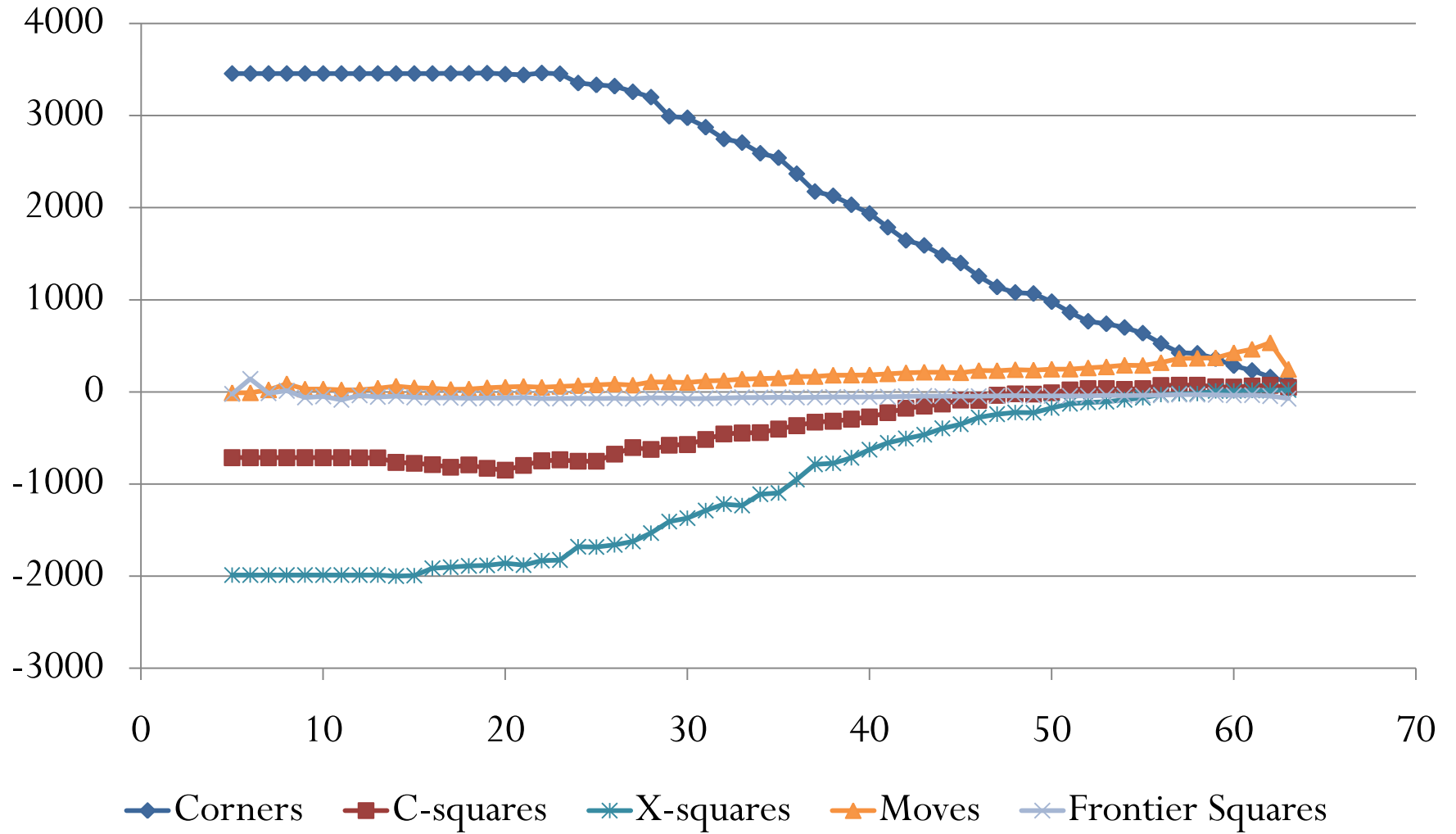
- Improve static position evaluation function automatically
- Optimize feature weights with machine learning
- Train separate set of weights for each stage

# Gradient Descent





# Training Results



# Referee

- Program to run games
- Interface between AI programs
- Supports programs in multiple languages and humans
- Displays board on GUI

# Future Research

- Selective search
- Opening book
- Parallelization
- Simple evaluation features
- Artificial neural networks
- Other machine learning methods