

Jafar — Intelligent Othello Agent

Joshua Nelson, Tim Cosgrove, Andrew Haigh

COMP3130 Research Project

May 28, 2012

**Jafar —
Intelligent
Othello Agent**

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Outline

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Static Evaluation

TD- λ

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The EloArena

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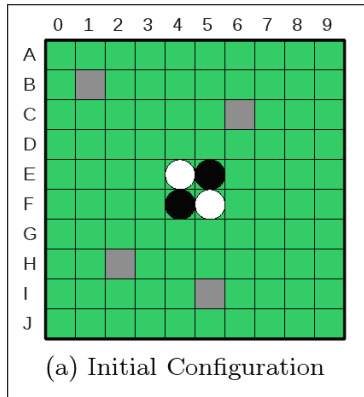
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- The Game — 10x10 Modified Othello



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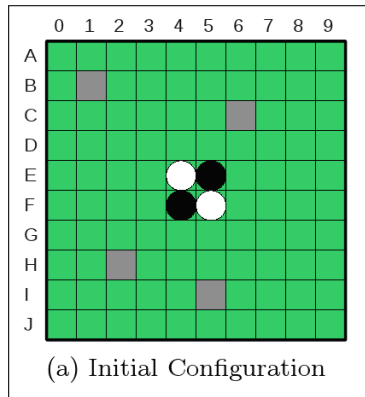
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- The Game — 10x10 Modified Othello
- The Problem — Intelligent AI player



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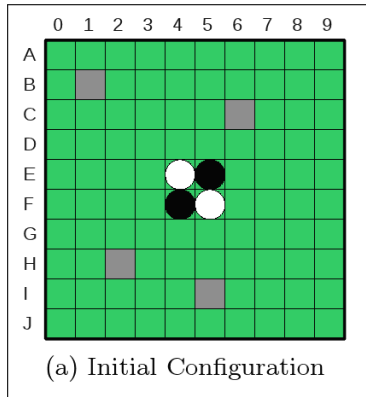
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- The Game — 10x10 Modified Othello
- The Problem — Intelligent AI player
- Solution basis



Solution Structure

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- The MetaPlayer class — Utilises knowledge of the game state and creates instances of other players accordingly

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- The MetaPlayer class — Utilises knowledge of the game state and creates instances of other players accordingly
- NegamaxPlayer (varying depth argument)
 - The 'main' AI player; performs a pruned Negamax search (simplification of Minimax)
 - Searches to a depth specified by the MetaPlayer; where it then evaluates the quality of the leaf states

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 - The 'main' AI player; performs a pruned Negamax search (simplification of Minimax)
 - Searches to a depth specified by the MetaPlayer; where it then evaluates the quality of the leaf states
- Other Player interfaces:
 - OpeningPlayer
 - GreedyPlayer
 - HumanPlayer

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- The FeatureSet class — Maintains a list of *features*; functions which evaluate a game state based on some criteria of strength

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- The FeatureSet class — Maintains a list of *features*; functions which evaluate a game state based on some criteria of strength
- LegalMoves Feature
 - Also known as 'mobility'; the number of moves available to the agent
 - Having only a few moves available is very limiting
 - Useful through all stages of the game

More Features

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- BlockedAdjacent, CornerPieces, SidePieces

More Features

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- BlockedAdjacent, CornerPieces, SidePieces
 - Count of how many pieces we have next to blocked squares, corners and edges
 - Useful as these pieces are harder to capture; easier to 'lock'

More Features

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- BlockedAdjacent, CornerPieces, SidePieces
 - Count of how many pieces we have next to blocked squares, corners and edges
 - Useful as these pieces are harder to capture; easier to 'lock'
- Visibility
- StoneCount

TD- λ

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- Remaining challenge: decide how important each feature is (the feature 'weights')

TD- λ

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- Remaining challenge: decide how important each feature is (the feature 'weights')
- Solution - use the TD λ (Temporal Difference) formula to calculate the new weights

$$\bullet \quad w := w + \alpha \sum_{T=1}^{N-1} \tilde{J}(x_t, w) * \left(\sum_{j=t}^{N-1} \lambda^{j-t} d_t \right)$$

The J Function

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$$w := w + \alpha \sum_{T=1}^{N-1} \Delta \tilde{J}(x_t, w) * (\sum_{j=t}^{N-1} \lambda^{j-t} d_t)$$

- The J function returns a probability of winning, given a set of weights and a board.
- The perfect J function would always return 0 or 1 precisely.
- We are trying to learn a good approximation to the J function

TD: Temporal difference

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$$w := w + \alpha \sum_{T=1}^{N-1} \Delta \tilde{J}(x_t, w) * (\sum_{j=t}^{N-1} \lambda^{j-t} d_t)$$

- d_t is the *Temporal Difference* between successive game states.
- The key observation is that for an ideal J function this would always be zero.
- $\Delta \tilde{J}(x_t, w)$ corrects each weight according to whether it was pointing us in the right direction.

Initial J function

Lost game

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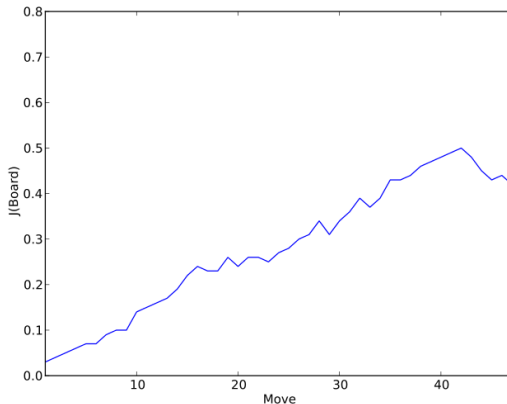
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J function after 6000 iterations

Lost game

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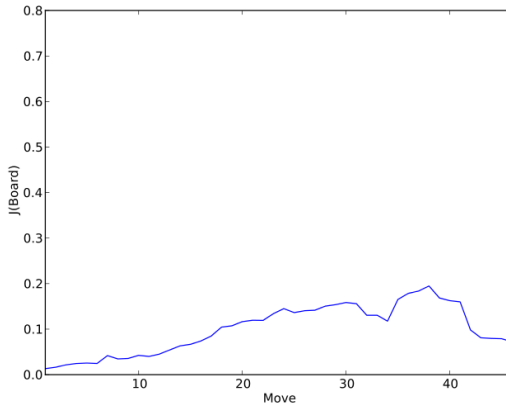
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J function after 6000 iterations

Won game

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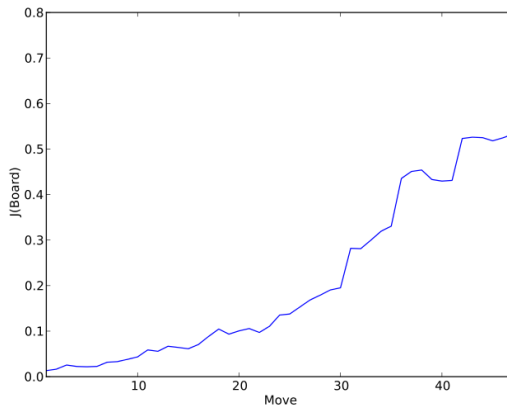
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The first 1000 learning iterations

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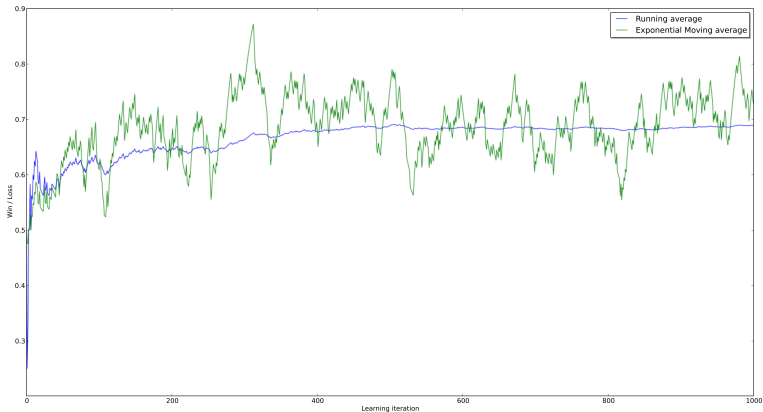
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The first 5000 learning iterations

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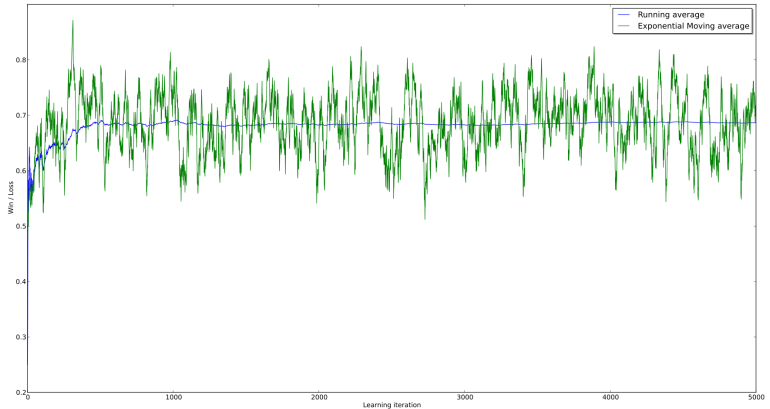
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Self play - learnt weights

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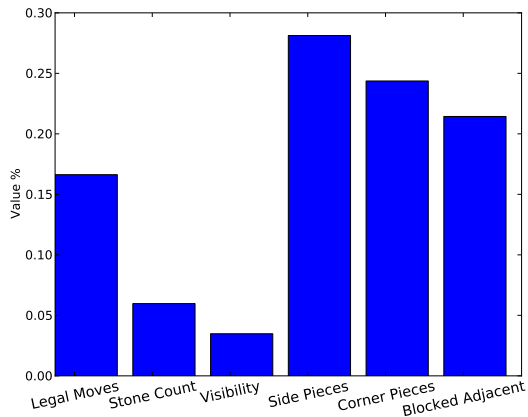
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Self play - learnt weights

White - Black

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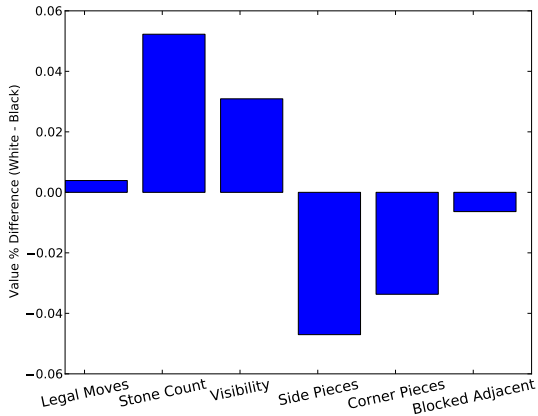
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Feature weight space visualisation

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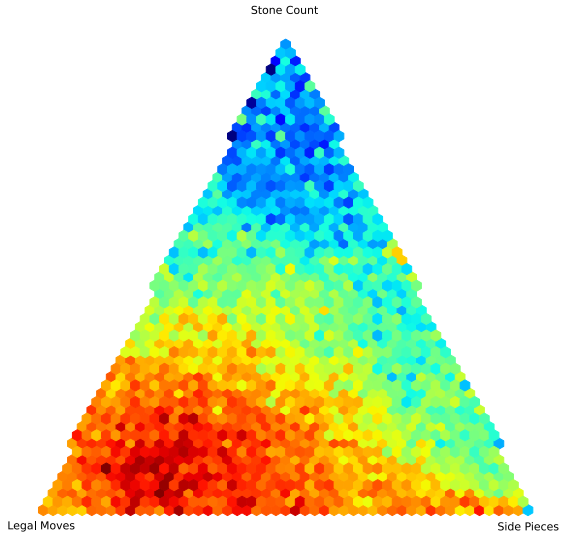
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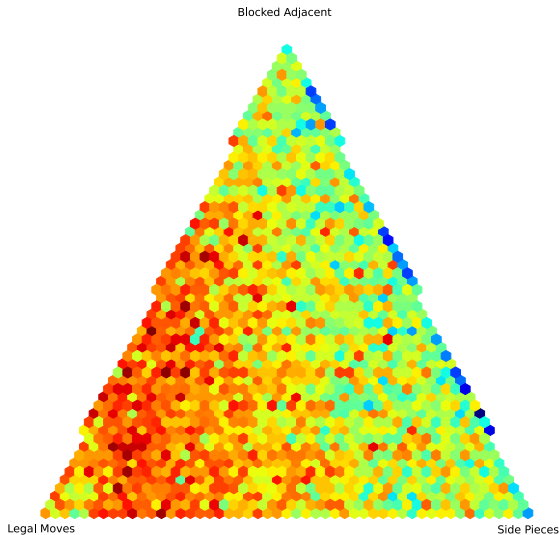
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The Elo Rankings Arena

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- Custom made genetic algorithm
- Pits a group of randomly generated agents against each other for Elo style ranking points
- Creates new agents from those who perform best

The Elo Rankings Arena

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- Custom made genetic algorithm
- Pits a group of randomly generated agents against each other for Elo style ranking points
- Creates new agents from those who perform best
- Used more as a demonstration of the learning process
- Interesting to see it come to the same conclusions as TD- λ

Future Improvements

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- More attention to blocked squares

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- More attention to blocked squares
- Negamax optimisations (better transposition tables, prob-cuts)

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- More attention to blocked squares
- Negamax optimisations (better transposition tables, prob-cuts)
- Better use of pre-computed data (such as the Opening Book)

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- Better use of pre-computed data (such as the Opening Book)
- More board features (locked squares, open squares, etc.)

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- Generic features (features learnt by the agent)

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- More board features (locked squares, open squares, etc.)
- Generic features (features learnt by the agent)
- More exploration in learning - randomise the initial board and play from that to explore more options

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- C with a python interface
 - Used this for tic-tac-toe warm up problem, decided against due to development overhead

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- C with a python interface
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- Java
 - Sacrifice low level speed improvements for high level language features and built in data structures.

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