Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Jafar — Intelligent Othello Agent

Joshua Nelson, Tim Cosgrove, Andrew Haigh

COMP3130 Research Project

May 28, 2012

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Outline

Problem
Overview

Solution
Structure

Static Evaluation

TD-λ
Algorithm
description
Results

The EloArena

Future
Improvements

Design
Methodology

Problem Overview

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Outline

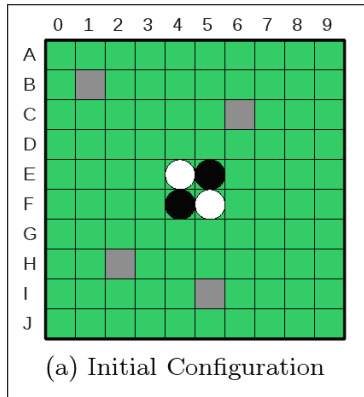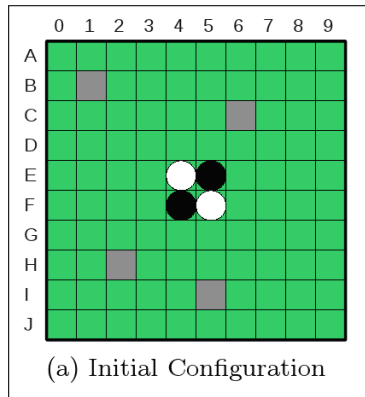Problem
Overview

Solution
Structure

Static Evaluation

TD-λ

Algorithm
description
Results

The EloArena

Future
Improvements

Design
Methodology

- The Game — 10x10 Modified Othello

(a) Initial Configuration

Problem Overview

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

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

(a) Initial Configuration

Problem Overview

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Outline

Problem
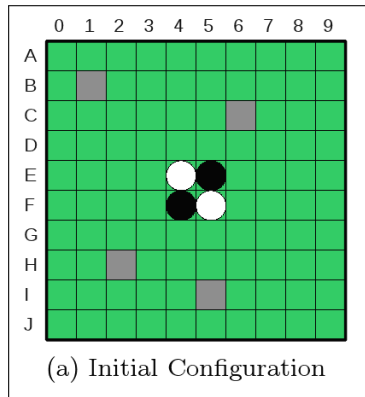Overview

Solution
Structure

Static Evaluation

TD-λ
Algorithm
description
Results

The EloArena

Future
Improvements

Design
Methodology

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

(a) Initial Configuration

Solution Structure

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

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

Solution Structure

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- The MetaPlayer class — Utilises knowledge of the game state and creates instances of other players accordingly
- NegamaxPlayer (varying depth argument)
- OpeningPlayer
- GreedyPlayer

Static Evaluation

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

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

Static Evaluation

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- The FeatureSet class — Maintains a list of *features*; functions which evaluate a game state based on some criteria of strength
- LegalMoves
- Visibility
- StoneCount
- BlockedAdjacent, CornerPieces, SidePieces

TD-λ

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

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

TD-λ

- Remaining challenge: decide how important each feature is (the feature 'weights')
- Solution - use the TD λ formula to calculate the new weights
- $w := w + \alpha \sum_{T=1}^{N-1} \tilde{J}(x_t, w) * (\sum_{j=t}^{N-1} \lambda^{j-t} d_t)$

The J Function

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Outline

Problem
Overview

Solution
Structure

Static Evaluation

TD-λ

Algorithm
description

Results

The EloArena

Future
Improvements

Design
Methodology

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

- 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

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Outline

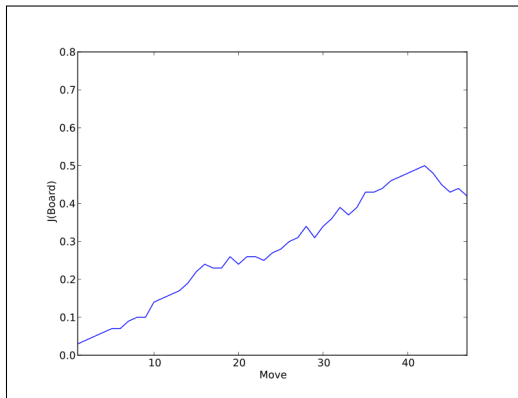Problem
Overview

Solution
Structure

Static Evaluation

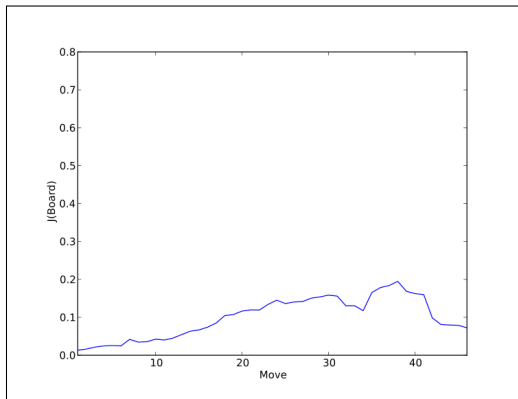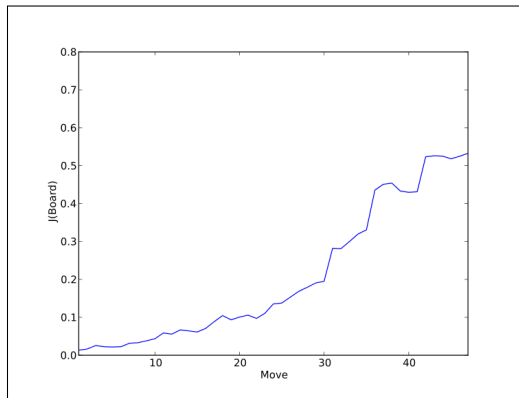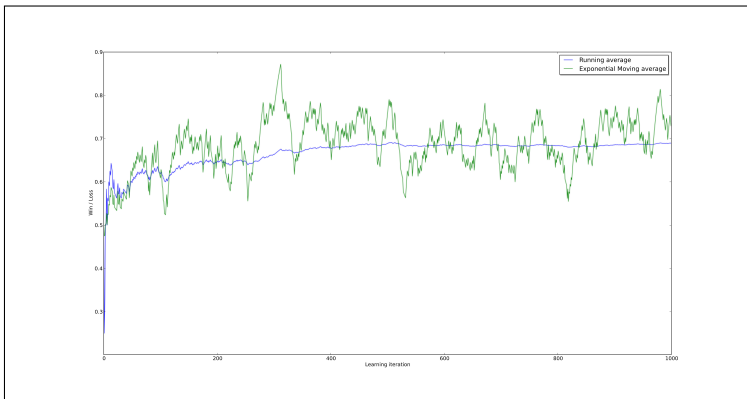TD-λ

Algorithm
description

Results

The EloArena

Future
Improvements

Design
Methodology

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

- 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

J function after 6000 iterations
Lost game

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

J function after 6000 iterations
Won game

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

The first 1000 learning iterations

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

The first 5000 learning iterations

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Self play - learnt weights

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Outline

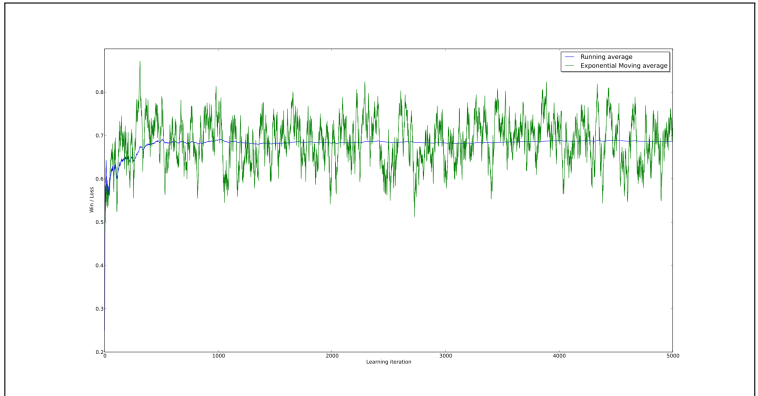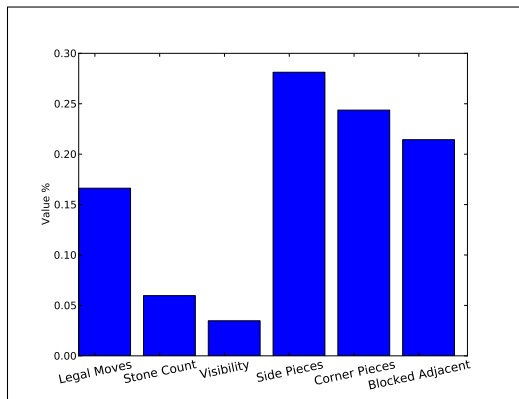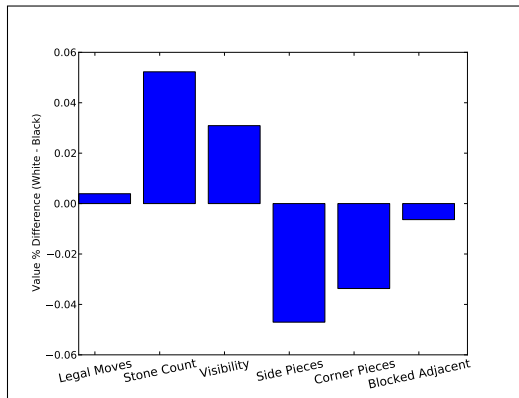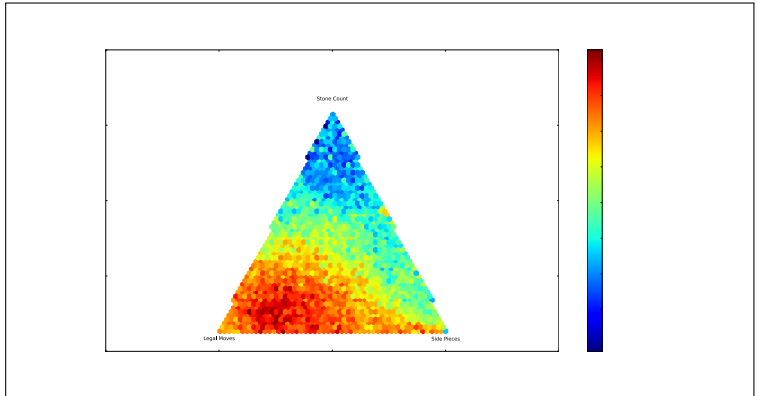Problem
Overview

Solution
Structure

Static Evaluation

TD-λ
Algorithm
description
Results

The EloArena

Future
Improvements

Design
Methodology

Self play - learnt weights
White - Black

Feature weight space visualisation

Feature weight space visualisation

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

The Elo Rankings Arena

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- 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

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- 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

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- More attention to blocked squares

Future Improvements

- More attention to blocked squares
- Negamax optimisations (better transposition tables, ... etc.)

Future Improvements

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- More attention to blocked squares
- Negamax optimisations (better transposition tables, ... etc.)
- Better use of pre-computed data

Future Improvements

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- More attention to blocked squares
- Negamax optimisations (better transposition tables, ... etc.)
- Better use of pre-computed data
- More board features (locked squares, open squares, etc.)

Future Improvements

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

- More attention to blocked squares
- Negamax optimisations (better transposition tables, ... etc.)
- Better use of pre-computed data
- More board features (locked squares, open squares, etc.)
- More exploration in learning - randomise the initial board and play from that to explore more options

Design Methodology

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

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

Design Methodology

**Jafar —
Intelligent
Othello Agent**

**Joshua Nelson,
Tim Cosgrove,
Andrew Haigh**

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

Java
  - Sacrifice low level speed improvements for high level language features and built in data structures.

Design Methodology

Jafar —
Intelligent
Othello Agent

Joshua Nelson,
Tim Cosgrove,
Andrew Haigh

Outline

Problem
Overview

Solution
Structure

Static Evaluation

TD-λ
Algorithm
description
Results

The EloArena

Future
Improvements

Design
Methodology