Life of PAI: Pathwayz AI

CS 221 Final Project by Louis Lafair, Nikhil Prabala, and Michael Tucker

Introduction

Pathwayz: 2-player strategy board game, invented by Louis Lafair and published in 2014.

Goal: Build a Pathwayz AI (PAI) that can beat the inventor 3/5 times at his own game.

Challenge: Pathwayz has a larger tree breadth and size than Chess.

Game	Breadth	Depth	Size (b^d)
Pathwayz	135	60	$6.60*10^{127}$
Chess	35	80	$3.35*10^{123}$
Go	250	150	$4.91*10^{359}$

State-Based Model: Each state describes the current player ('w' or 'b') and board layout (8x12 matrix).

Gameplay: Place pieces and flip opponent's to create a path across long side of board.

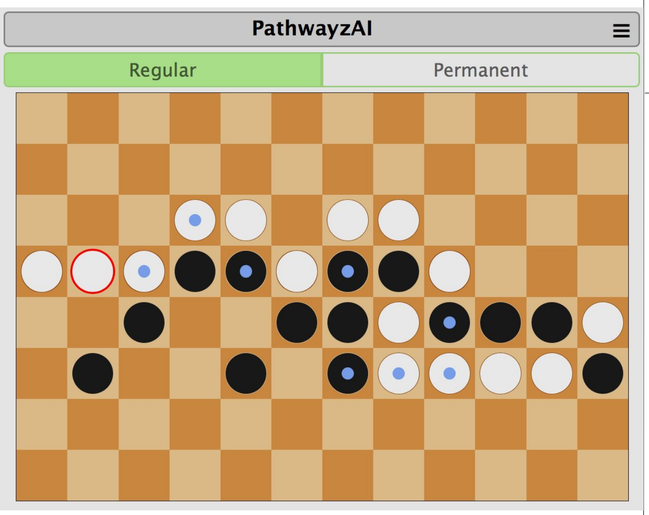

Figure 1: Pathwayz GUI for efficient and informative testing

Methods

Reflex Models: Choose greedy move based on evaluation function.
- **Baseline**: Longest path (number of contiguous column)
- **Adv. Baseline**: Longest path minus 40% opponent's longest path
- **Dumb PAI**: 3x3 feature grids
- **Smart PAI**: 52 features, chosen via domain knowledge

General Search Models: Sample end states with random depth charges to rank moves.
- **Monte Carlo Search**: Average score of end states based on eval function
- **Monte Carlo Tree Search**: Fraction of winning states over total end states

Adversarial Search Models: Explore depth of tree maximizing on opponent policy
- **Minimax**: Depth limited with Alpha-Beta Pruning
- **Expectimax**: Assumes average opponent play
- **Beam Minimax**: Narrows breadth of search at every new depth

PAI: 52 smart features with weight training in 5000+ games using TD learning, applied to a narrowing beam minimax. It simulates the top 15 moves for AI, top 10 resulting moves for opponent, and finally the best resulting move for PAI.

Figure 2: Diagram illustrating variable beam width minimax

Features

Feature	Weight
ahead	135
onlyTurnAway	35
futureAhead	250
myOneTurnAway	
yourOneTurnAway	
diffLongestPath	
myLongestPathSquared	
myLongestPath	
yourLongestPathSquared	
myLongestFuturePathSquared	

Figure 3: Top smart features

Learning

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Results

	Random	Baseline	Adv. Baseline	Minimax	Beam Minimax	Expectimax	MCS	MCTS
Random		100%	100%	100%	100%	100%	100%	100%
Baseline	0%		60%	70%	100%	0%	10%	60%
Adv. Baseline	0%	40%		70%	90%	0%	10%	30%
Minimax	0%	30%	30%		90%	0%	0%	0%
Beam Minimax	0%	0%	10%	10%		0%	0%	0%
Expectimax	0%	100%	100%	100%	100%		100%	100%
MCS	0%	90%	90%	100%	100%	0%		40%
MCTS	0%	40%	70%	100%	100%	0%	60%	

Figure 4: Bracket play of different algorithms against each other

PAI Beats the Rest: PAI is able to consistently win against every other algorithm. Against our team PAI beats Nikhil 5/5 times, Michael 4/5 times, and Louis 3/5 times.

Future Development

Neural Nets: Scale testing by 10^3.

Features: Add new complex features and dumb features for better evaluation.

Training: Play millions of games against self and human experts.

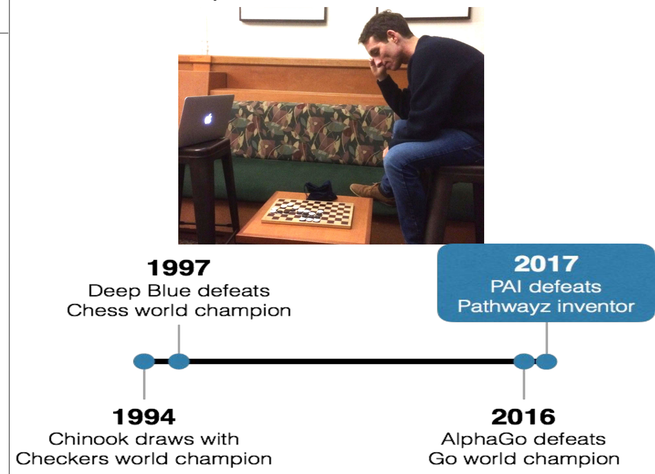

Figure 5: PAI beats Louis Lafair, inventor of Pathwayz, in ⅗ games