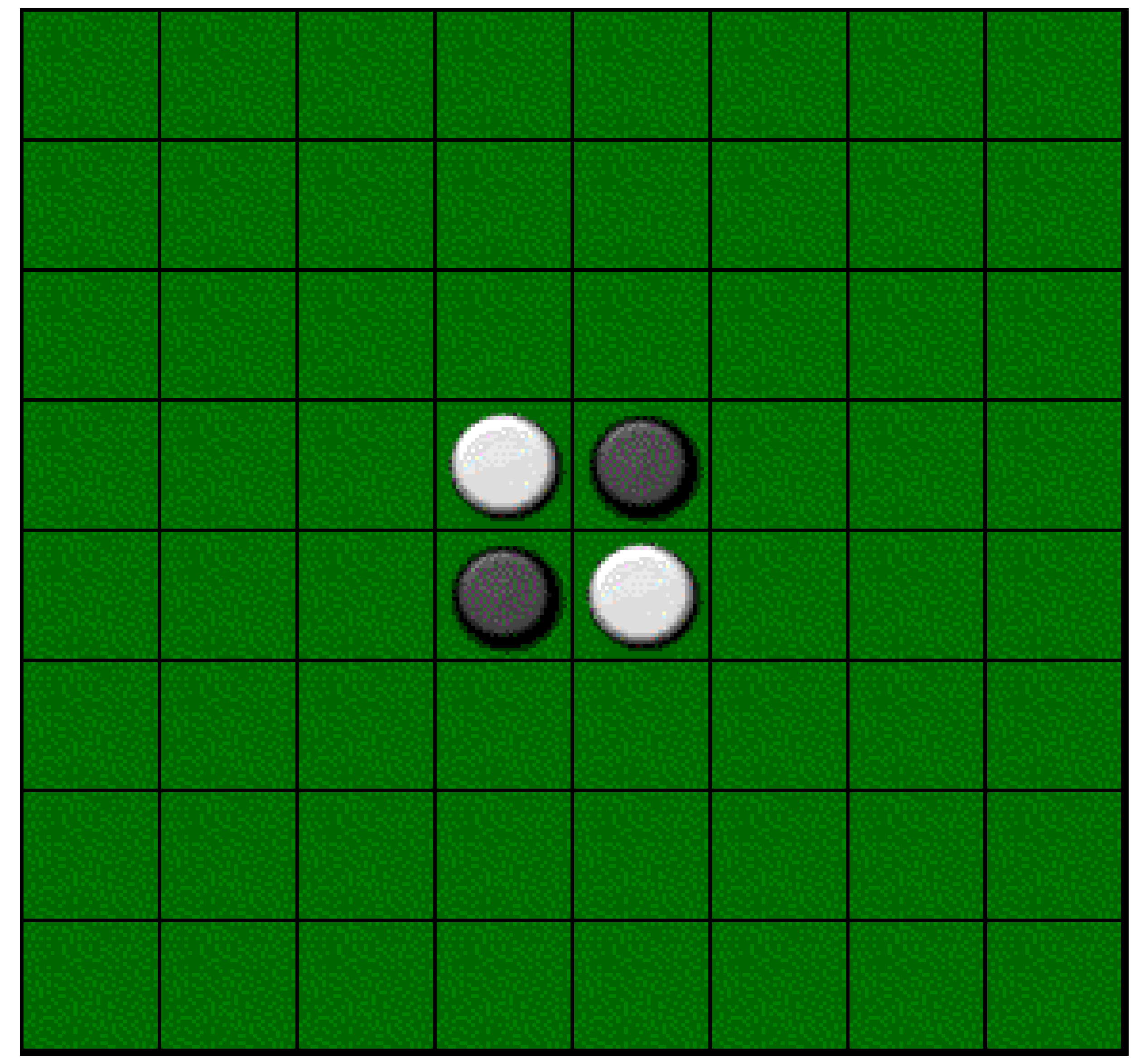
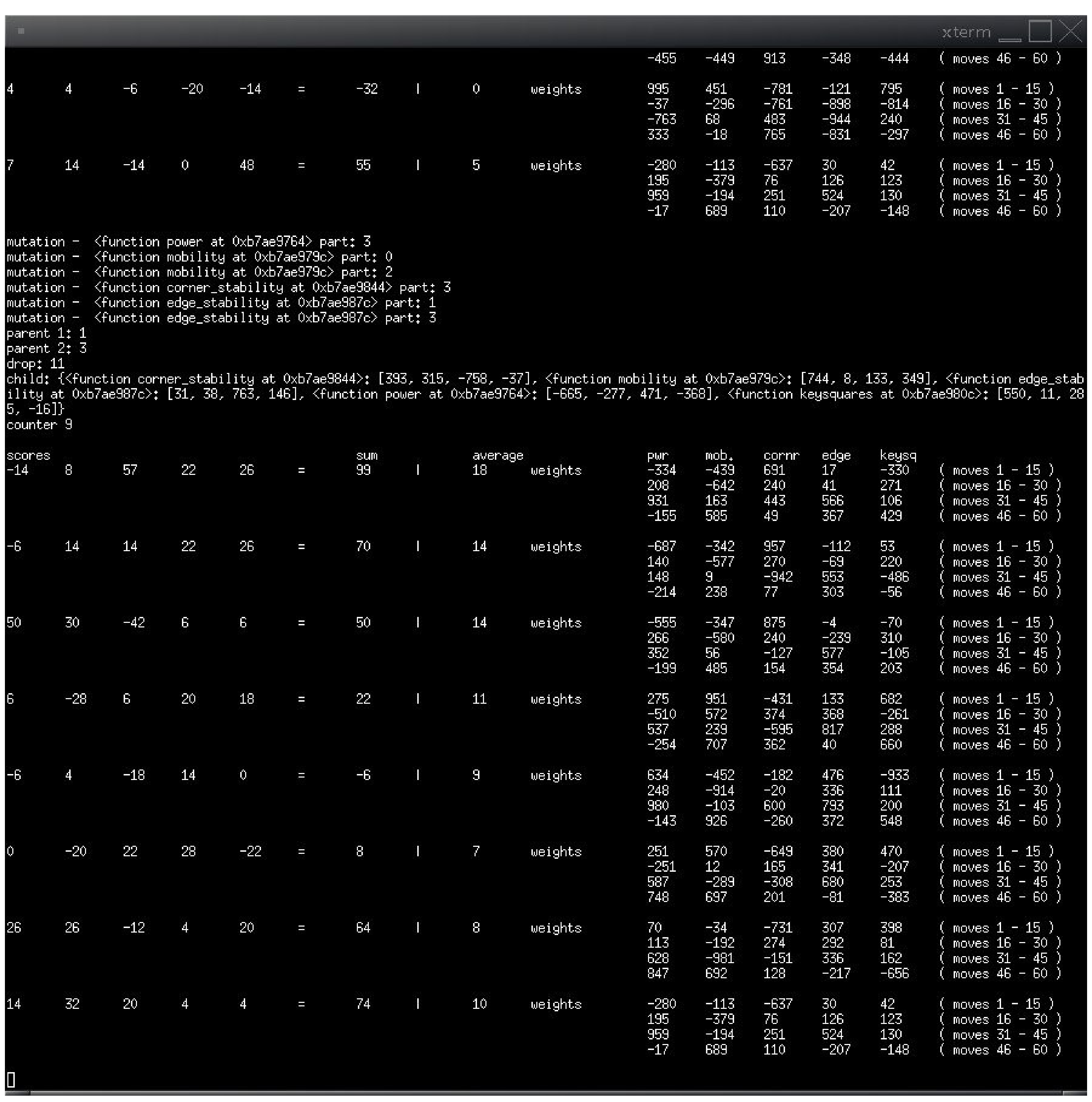
The Use of Genetic Algorithms in Machine Learning; Applications to Othello

Calvin Hayes, June 13, 2006

Background

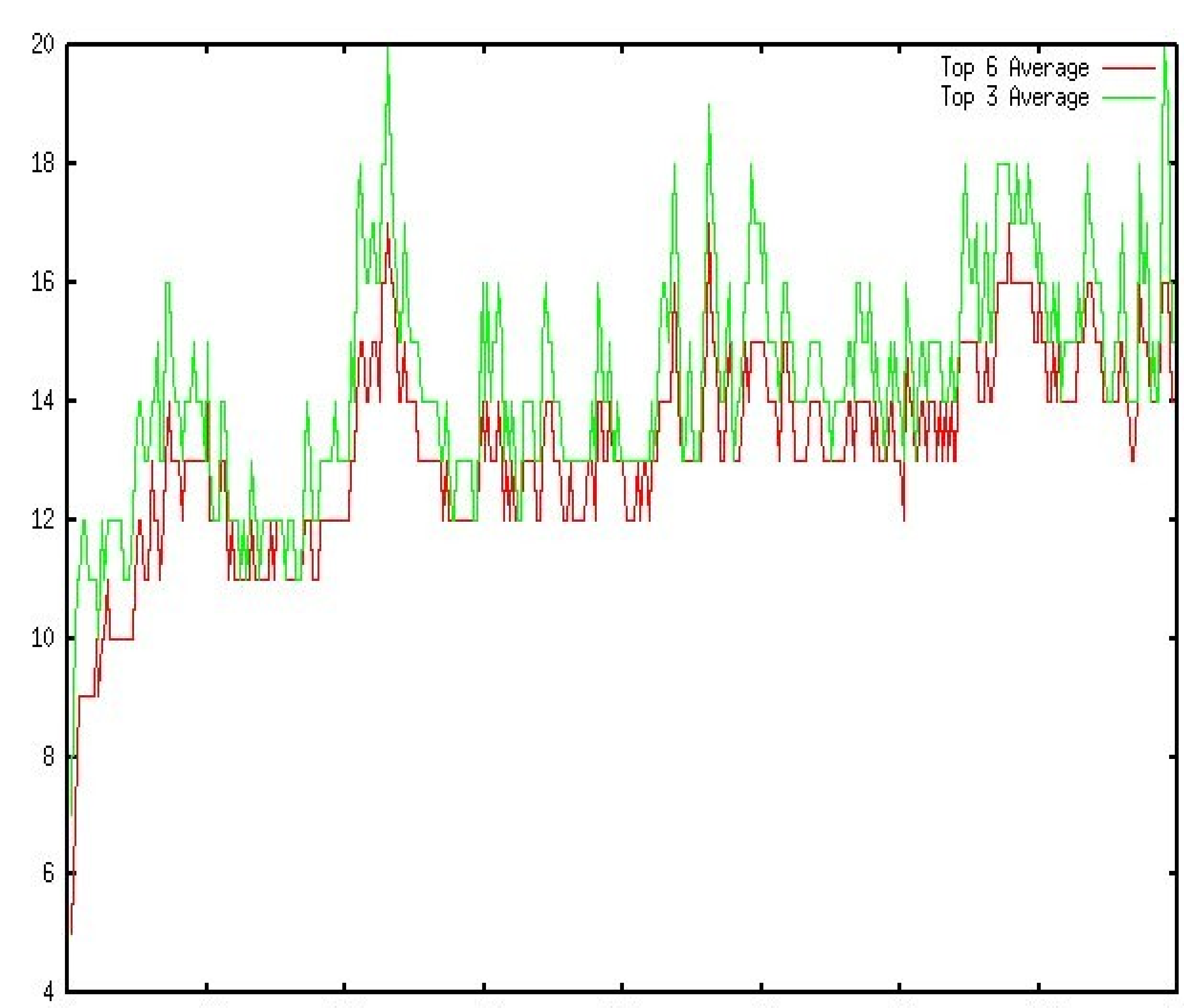
The project will be to design a program that is capable of playing the board game Othello at a high level. This program will use a genetic algorithm to optimize weights for specific heuristic values that will decide the machine's line of play. Genetic algorithms are becoming more and more popular in the field of artificial intelligence as a way to search many different combinations of settings to find an optimal state. The results of the project can be used to determine how successful this particular algorithm is in setting reasonable heuristic weights that can be used by the computer to play Othello better than a program with these weights set arbitrarily. These results can ideally be generalized to other, real-world uses of this algorithm. To achieve these results, some knowledge of Othello strategy is required, to determine useful heuristics to be weighted. Additionally, other AI techniques, such as minimax trees and alpha-beta pruning will be necessary to help the program run most effectively and efficiently.





Description

Heuristic utility functions were written to detect advantages for the player in several areas. For example, one such function analyzes the number of pieces on the board for the player, as opposed to its opponent; another considers the number of potential legal moves for the player and the opponent on the next turn. The heuristics were combined by making decisions based on a weighted sum of the values returned by each heuristic function. These weights could be set independently and modified at any time. It is the optimization of these weights that is the eventual goal of the genetic algorithm. The genetic algorithm was then put into place, containing 12 'players' (in fact, just combinations of weights) that follow basic rules of Darwinian natural selection, with their winning percentage against a random opponent serving as their evolutionary fitness: propensity for reproduction and a longer lifespan. Eventually the algorithm should result in a 'player' with perfectly balanced weights that are optimal for success in Othello against a random opponent.



Results

Repeated trials confirmed that the program was, in fact, improving as a result of the genetic algorithm. As expected, drastic improvements over the first 50 iterations gave way to more variable, but steadily increasing results. Important to note, also, are the 'spikes' exhibited when a mutation results in an improved set of weights. Both the average margin of victory of the top 6 and top 3 players showed steady improvement over 400 iterations. A player formed by melding the weights of the top 6 players performed at a level approximately 20 pieces better, on average, than a random opponent. Future experiments could determine whether or not these increases would continue, even if to a lesser amount, over up to 100 iterations.