COMP 5560 Fall 2022 Assignment 2c

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1. Methodology

For the co-evolution of pacman and ghost controllers in a game of pacman, genetic programming was employed. For each game tick, all of the possible moves for a given controller are evaluated using an evolved value function, and the move with the highest value is performed. Value functions are represented by a binary tree with the functional set {ADD, SUB, MULT, DIV, RAND} and terminal set {GHOST, PAC, PILL, WALL, FRUIT, FLOAT}. They are implemented as follows:

(a) ADD - Adds two operands and returns the results

(b) SUB - Subtracts two operands and returns the results

(c) MULT - Multiplies two operands and returns the results

(d) DIV - Divides two operands and returns the results. If div by 0, return 100 or -100 depending on the sign of the numerator

(e) RAND - Returns a random float uniformly between two operands

(f) GHOST - Returns the nearest manhattan distance to a ghost not including the current controller

(g) PAC - Returns the manhattan distance to Pacman (Ghost terminal node only)

(h) PILL - Returns the nearest manhattan distance to a pill

(i) WALL - Returns the number of walls around the controller

(j) FRUIT - Returns the manhattan distance to the fruit. If no fruit present, return 100.

(k) FLOAT - Returns an arbitrary float in the range -10 to 10

Upon initialization, trees are created using a ramped half-and-half approach between a grow and full initialization. Grow randomly selects a node between the functional and terminal sets at each initialization, Full randomly selects a functional node until max depth is reached, then selects a terminal node. Max depth is configurable. Mutation and recombination are mutually exclusive, controlled by a configurable mutation rate.

Adversarial evaluations are performed between ghost and pacman controllers. Each controller is guaranteed to be evaluated once per generation. If a controller is used more than once, average all evaluations for evolution purposes. Fitness for pacman is given by $game\_score - node\_count * parsimony\_constant$. Fitness for ghosts are given by $remaining\_time - game\_score - node\_count * parsimony\_constant$.

2. Experiment Setup

A full experiment is given by a set number of runs with a set number of evaluations each. For our purposes, this was 30 runs with 2000 evaluations each, an evaluation counting as one game between a pacman and ghost controller. Each species starts with its own μ members and each generation spawns λ children. Thus, initialization necessitates $max(pac\_\mu, ghost\_\mu)$ evaluations, and each generation takes $max(pac\_\mu + pac\_\lambda, ghost\_\mu + ghost\_\lambda)$ evaluations. Each controller is re-evaluated each generation. Parent selection and survival selection can be performed any preferred way, this experiment used fitness dependant stochastic universal sampling (SUS) for parent selection and truncation for survival selection. Recombination and mutation each have a configurable max depth, the max depth for each and initialization was 10. μ for each species was set at 300, λ for each 150. This seemed to allow enough search of the space and sufficient evolution to better both species.

3. Results

pacman	
Mean	170.5666667
Standard Error	3.195788656
Median	172.5
Mode	165
Standard Deviation	17.50405536
Sample Variance	306.391954
Minimum	139
Maximum	210
Count	30

Table 1: Pacman Summary Stats

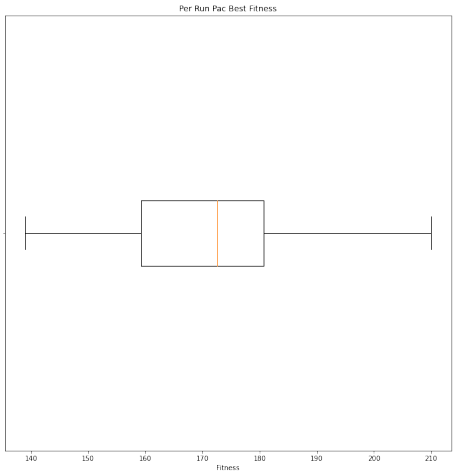

Figure 1: Pacman Box-and-Whisker of Best Fitness

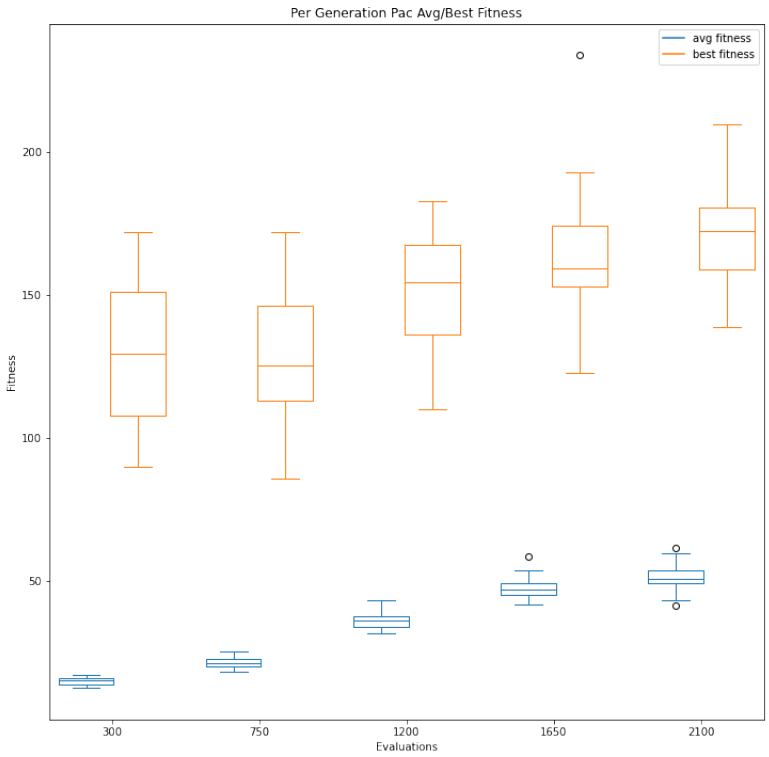

Figure 2: Pacman Box plots of the Averaged Per Generation Avg/Best Fitness

ghost	
Mean	1324.6
Standard Error	3.456328528
Median	1329.5
Mode	1314
Standard Deviation	18.93109101
Sample Variance	358.3862069
Minimum	1273
Maximum	1361
Count	30

Table 2: Ghost Summary Stats

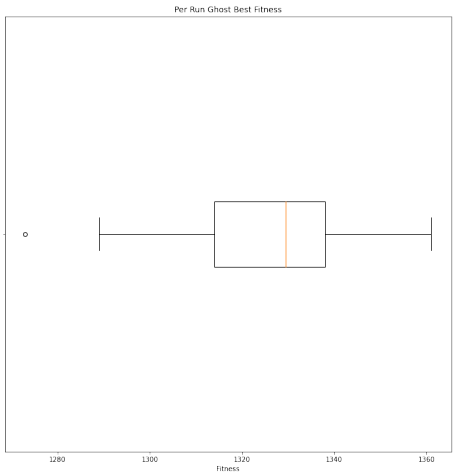

Figure 3: Ghost Box-and-Whisker of Best Fitness

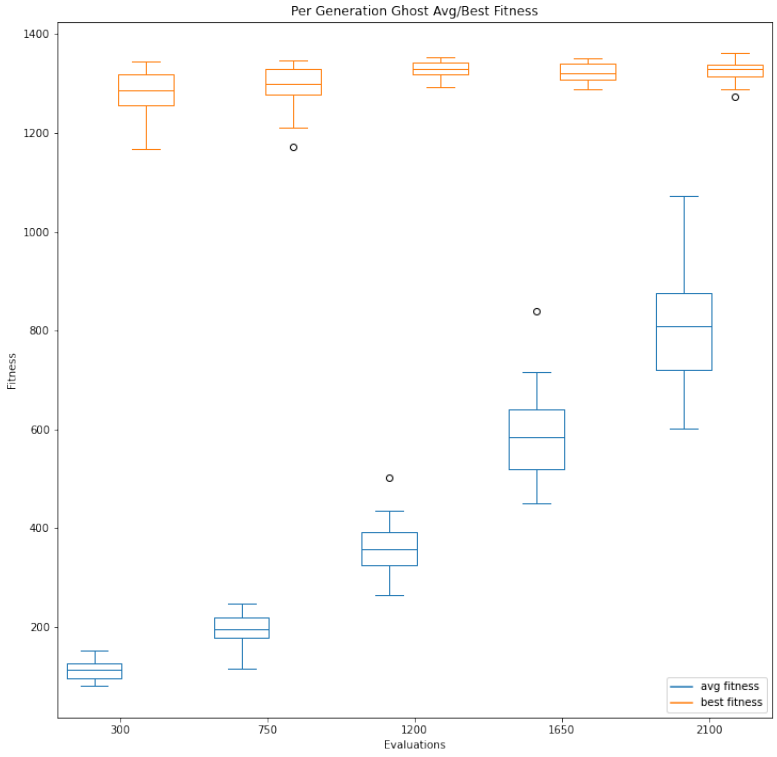

Figure 4: Ghost Box plots of the Averaged Per Generation Avg/Best Fitness

4. Discussion

Without co-evolving ghosts, evolved Pacman controllers largely ignore the ghosts as a threat and prioritize accruing points as much as possible. Generally, controllers do not evolve for speed, usually instead opting to hang around and collect fruit and any pills along the way. In the presence of evolving ghosts, Pacman controllers are much more skittish and will path away from ghosts should they get too close. Points are still valued but less so than overall safety. The exhibition match demonstrated a game where the Pacman controller collected all the pills and spent careful time avoiding the ghosts.

5. Conclusion

The addition of co-evolving ghosts altered Pacman's behavior significantly to be more averse to danger. Further improvements would include performing adversarial evaluations with a subset of each species instead of only guaranteeing one match-up.