COMP SCI 5401 FS2018 Assignment 2b

William Lorey
wwlytc@mst.edu

Contents

Main Assignment Deliverables

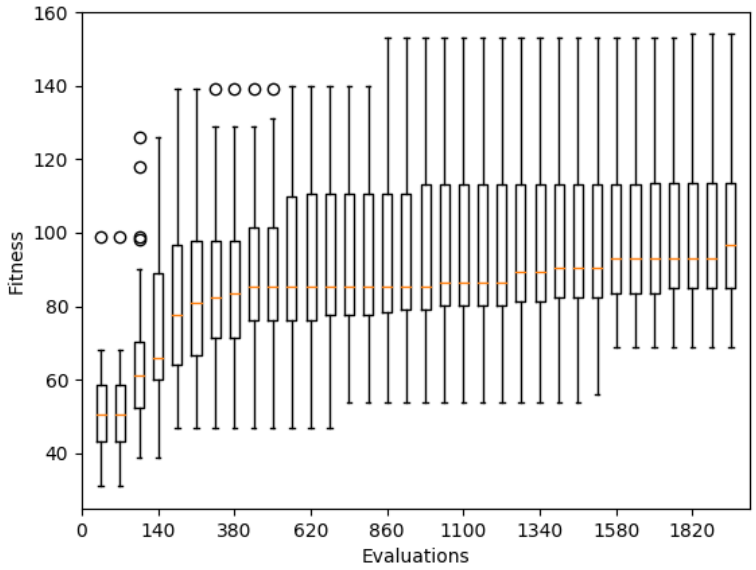

Figure 1: Global Best Fitness versus Fitness Evaluations for the **Small**, Randomly Generated World. The figure was generated with data obtained by running the GP with the **small.cfg** configuration file.

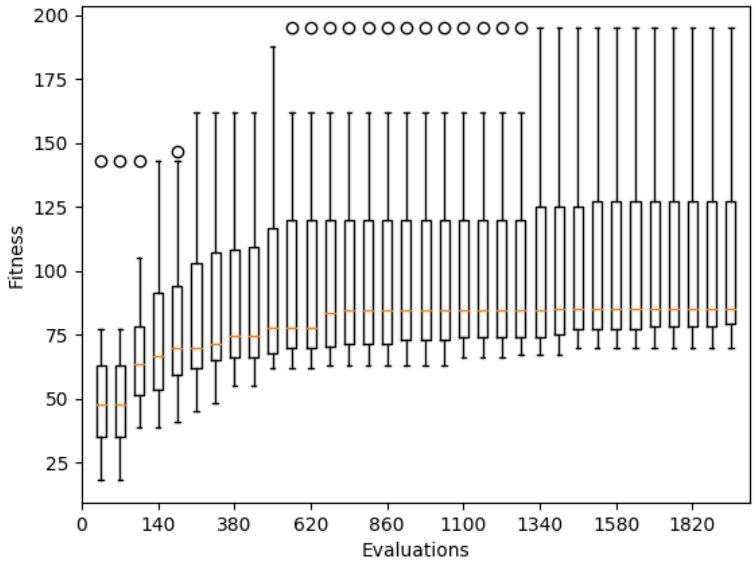

Figure 2: Global Best Fitness versus Fitness Evaluations for the **Large**, Randomly Generated World. The figure was generated with data obtained by running the GP with the **large.cfg** configuration file.

BONUS1: Multiple Pacmen Employing the Same Controller

Support for multiple pacmen was included the main assignment, however, all standard project deliverables were supplied with only one pacman spawned. For BONUS1, two pacmen were spawned for each world, each employing the same controller. Both pacmen had to die for each game to end and both pacmen shared the fitness (or score) obtained after completing a game. To give the pacmen an opportunity for a sense of space relative to each other, an additional terminal was added to the GP tree's terminal set, namely the Manhattan distance between the current pacman and the nearest other pacman.

Changes from the main assignment to this bonus assignment involved a mixture of cosmetic changes, such as renaming a function `move_pacman` to `move_pacmen` to better describe the situation, and real algorithmic changes. One such algorithmic change was the game over check. As per the bonus specification, each game would only end if all pacmen were dead, or if the other pre-existing conditions were met. To satisfy this, As soon as a pacman was seen as either colliding with a ghost or sharing a cell with a ghost, it was removed from that world's list of pacmen. Only after the length of that list was zero would the game end, not including all pills being consumed and the time running out.

Another algorithmic change involved adding an additional Manhattan distance terminal node for the distance to the nearest pacman. This was implemented by mirroring the implementation of existing distance terminal nodes, implementing another distance calculation. Since the main assignment encoded a given world's pacman as a member of a list, adding additional pacmen was not particularly intensive.

Figure 3 depicts the evaluations versus fitness for the experiments involving two pacmen per world employing the same controller. This figure offered fairly small variance with outliers

demonstrated as performing far beyond the average of the population in some cases.

Note that only the small world was used to examine BONUS1.

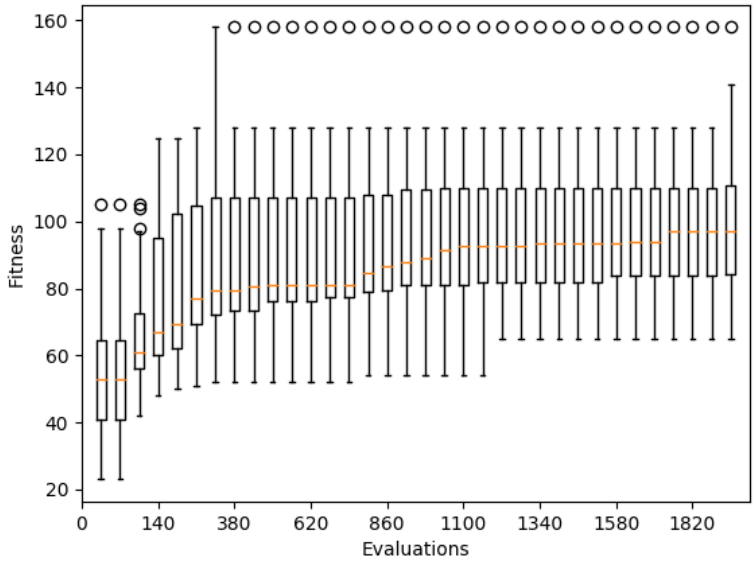

Figure 3: Global Best Fitness versus Fitness Evaluations for the **BONUS1 (Multiple Pacmen Employing the Same Controller) Small**, Randomly Generated World. The figure was generated with data obtained by running the GP with the **BONUS_small.cfg** configuration file.

BONUS2: Multiple Pacmen Employing Different Controllers

The second bonus involved implementing support for multiple pacmen in a world as well as the ability for each pacman to be controlled by different controllers. This functionality in addition to the new game over check and terminal set addition discussed in the BONUS1 section was implemented.

The implementation of this bonus section required more changes to the original codebase than BONUS1, as the ties between the pacman list associated with each world and the single pacman controller were stronger. The main way this dependency was removed was by creating a list of pacman controllers to match the list of pacmen. A pacman list index was then passed along with the game's state to the pacman controllers so that controller had a specific pacman to control. Code also had to be removed that allowed one controller to move all pacmen passed along in the game state, as each pacman now had its own controller.

Because there were multiple controllers, functions such as the bloat controller had to be adjusted to handle multiple controller trees. Additionally, the recombination and mutation functions were updated so that each controller tree was involved in crossover and sub-tree mutation.

To maintain the relationship between pacman and controller, dead pacmen, instead of being removed from the pacman list, were noted in a taboo list. Before moving pacmen, this list would be polled to see if the current pacman being moved was dead. Once the length of

the taboo list equaled the length of the pacman list, all pacmen in the world were known to be dead.

One additional change was made to satisfy this bonus section. The solution file generator was altered to output the controller of both pacmen upon the discovery of a globally optimal score.

Figure 4, depicting the evaluations versus fitness for this bonus assignment with two independently-controlled pacmen per world, demonstrates volatile variances and high outlying score values.

Note that only the small world was used to examine BONUS2.

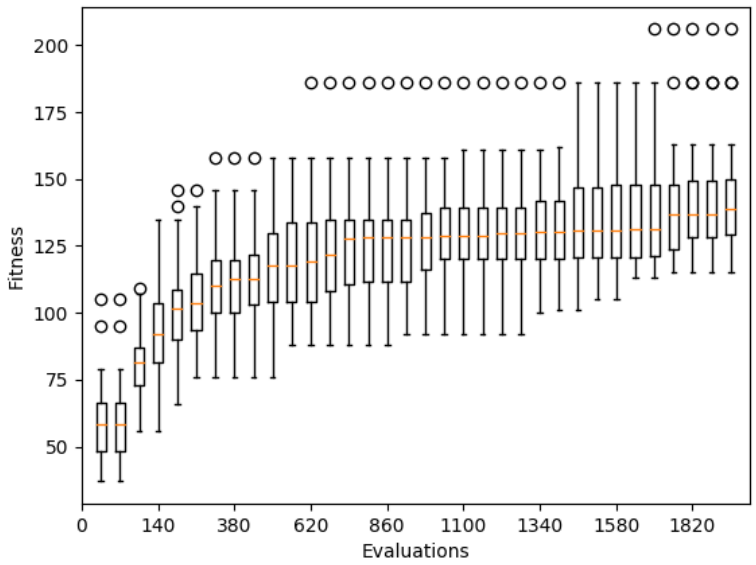

Figure 4: Global Best Fitness versus Fitness Evaluations for the **BONUS2 (Multiple Pacmen Employing Different Controllers) Small**, Randomly Generated World. The figure was generated with data obtained by running the GP with the **BONUS_small_multi_controller.cfg** configuration file.

Analysis of Main Assignment, BONUS1, and BONUS2

Three pairings of statistical analysis were performed on the main assignment GP, BONUS1, and BONUS2. This analysis consisted of an f-test to determine the assumption of equal variances followed by a t-test either assuming equal variances or assuming unequal variances depending on the output of the f-test. The pairings of statistical analysis are as follows:

- BONUS1 Small, Multi-Pacman World versus BONUS2 Small, Multi-Pacman World Employing Multiple Controllers (Table 1)
- BONUS2 Small, Multi-Pacman World Employing Multiple Controllers versus Small, Single-Pacman World (Table 2)
- BONUS1 Small, Multi-Pacman World versus Small, Single-Pacman World (Table 3)

In each analysis it was involved in (Tables 1 and 2), the BONUS2 approach, employing multiple pacmen each with their own controller, proved to be statistically superior on the given problem space. This implies that the pacmen controllers could have evolved in tandem to ensure cooperation between pacmen in getting the highest possible score.

Another interesting observation is that when the standard GP employing a single pacman was compared to BONUS1, employing multiple pacmen and one pacman controller (Table 3), there was no statistical difference between the two approaches. This result showed that more pacmen, all controlled by the same controller, are not necessarily more optimal than one pacman controlled by one controller and that to see the gains of more pacmen in the world, alternate controller approaches (such as using different controllers for each pacman, as seen in BONUS2) may be necessary.

Table 1: Statistical Analysis performed on the BONUS1 Small, Multi-Pacman World versus BONUS2 Small, Multi-Pacman World Employing Multiple Controllers

	BONUS_small_multi_controller	BONUS_small
mean	142.96666666666667	101.1
variance	439.96555555555557	408.8233333333334
standard deviation	20.975355910104494	20.21938014216394
observations	30	30
df	29	29
F	1.0761752563590357	
F critical	0.5373999648406917	
Unequal variances assumed		
observations	30	
df	31	
t Stat	7.738691619777811	
P two-tail	1.694665580406777e-10	
t Critical two-tail	2.0395	
BONUS_small_multi_controller is statistically better than BONUS_small		

Table 2: Statistical Analysis performed on the BONUS2 Small, Multi-Pacman World Employing Multiple Controllers versus Small, Single-Pacman World

	BONUS_small_multi_controller	small
mean	142.96666666666667	101.0
variance	439.96555555555557	494.46666666666664
standard deviation	20.975355910104494	22.23660645572221
observations	30	30
df	29	29
F	0.8897779875061795	
F critical	0.5373999648406917	
Unequal variances assumed		
observations	30	
df	31	
t Stat	7.393150913824469	
P two-tail	6.520299920112773e-10	
t Critical two-tail	2.0395	
BONUS_small_multi_controller is statistically better than small		

Table 3: Statistical Analysis performed on the BONUS1 Small, Multi-Pacman World versus Small, Single-Pacman World

	BONUS_small	small
mean	101.1	101.0
variance	408.8233333333334	494.46666666666664
standard deviation	20.21938014216394	22.23660645572221
observations	30	30
df	29	29
F	0.8267965484697318	
F critical	0.5373999648406917	
Unequal variances assumed		
observations	30	
df	31	
t Stat	0.01791782942177858	
P two-tail	0.9857664534615012	
t Critical two-tail	2.0395	
Nether small nor BONUS_small is statistically better		