COMP 5560 Fall 2022 Assignment 1d

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1. Island Topologies

In this assignment, four evolutionary algorithms utilizing different island topologies are implemented and compared against each other, these topologies being uni-circle, bi-circle, all-to-all, and toroid.

(a) Uni-Circle

The evolutionary algorithm using a uni-circle topology (parameterized in configs/green1d_uni_circle_config.txt), had an island system where each island would send migrants in one direction around the group. Its best bridge is depicted (Figure 1) as well as the plot comparing evaluations against fitness per generation of all runs in the experiment (Figure 2). Overall, the highest fitness recorded by the uni-circle topology was 93,000,000.

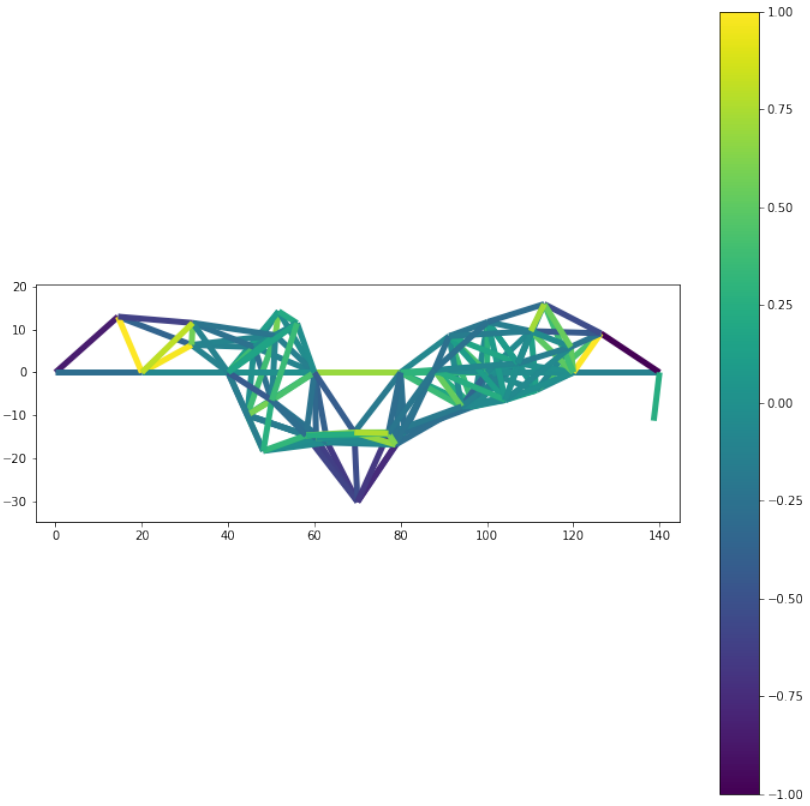

Figure 1: Bridge Plot of the Best Run using a Uni-Circle Topology

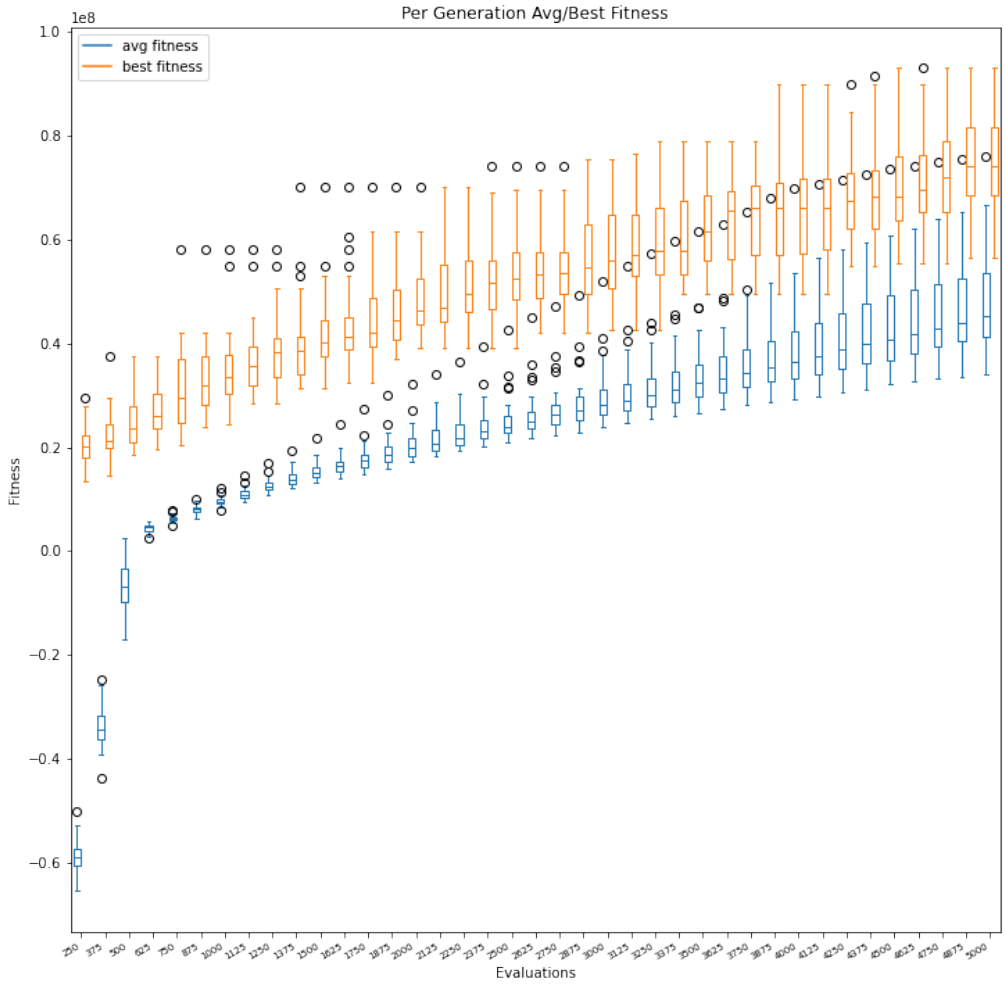

Figure 2: Averaged Per Generation Avg/Best Fitness using a Uni-Circle Topology

(b) Bi-Circle

The evolutionary algorithm using a bi-circle topology (parameterized in configs/green1d_bi_circle_config.txt), had an island system where each island would send migrants in bi-directionally around the group. Its best bridge is depicted (Figure 3) as well as the plot comparing evaluations against fitness per generation of all runs in the experiment (Figure 4). Overall, the highest fitness recorded by the bi-circle topology was 100,500,000.

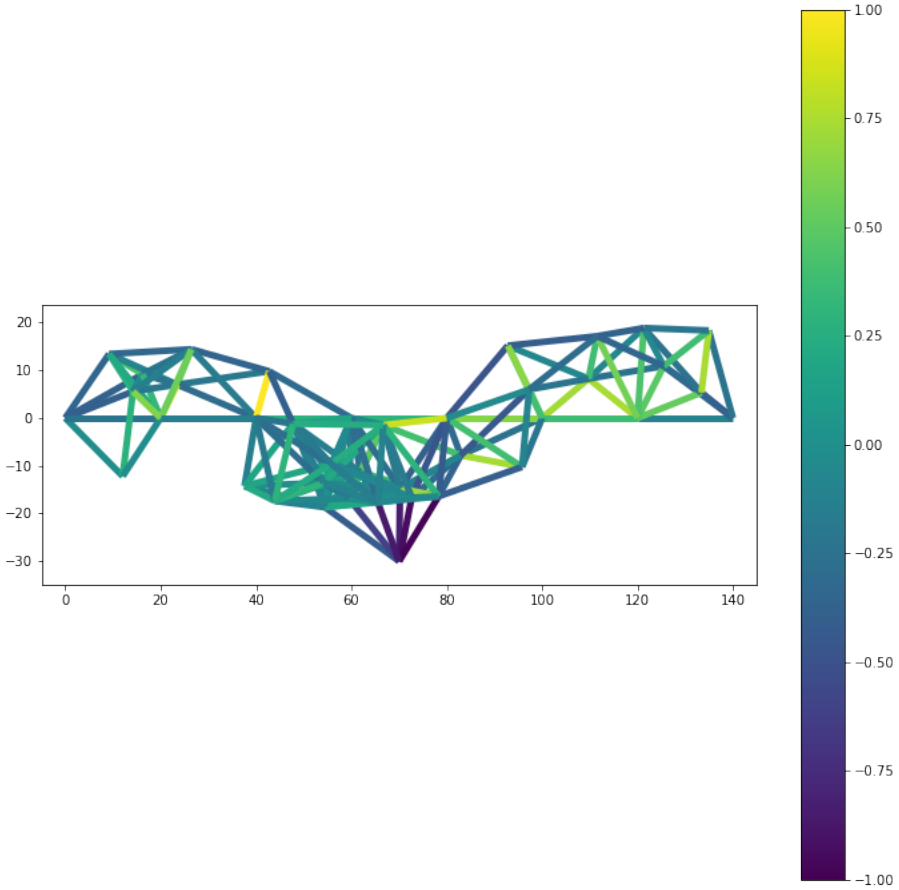

Figure 3: Bridge Plot of the Best Run using a Bi-Circle Topology

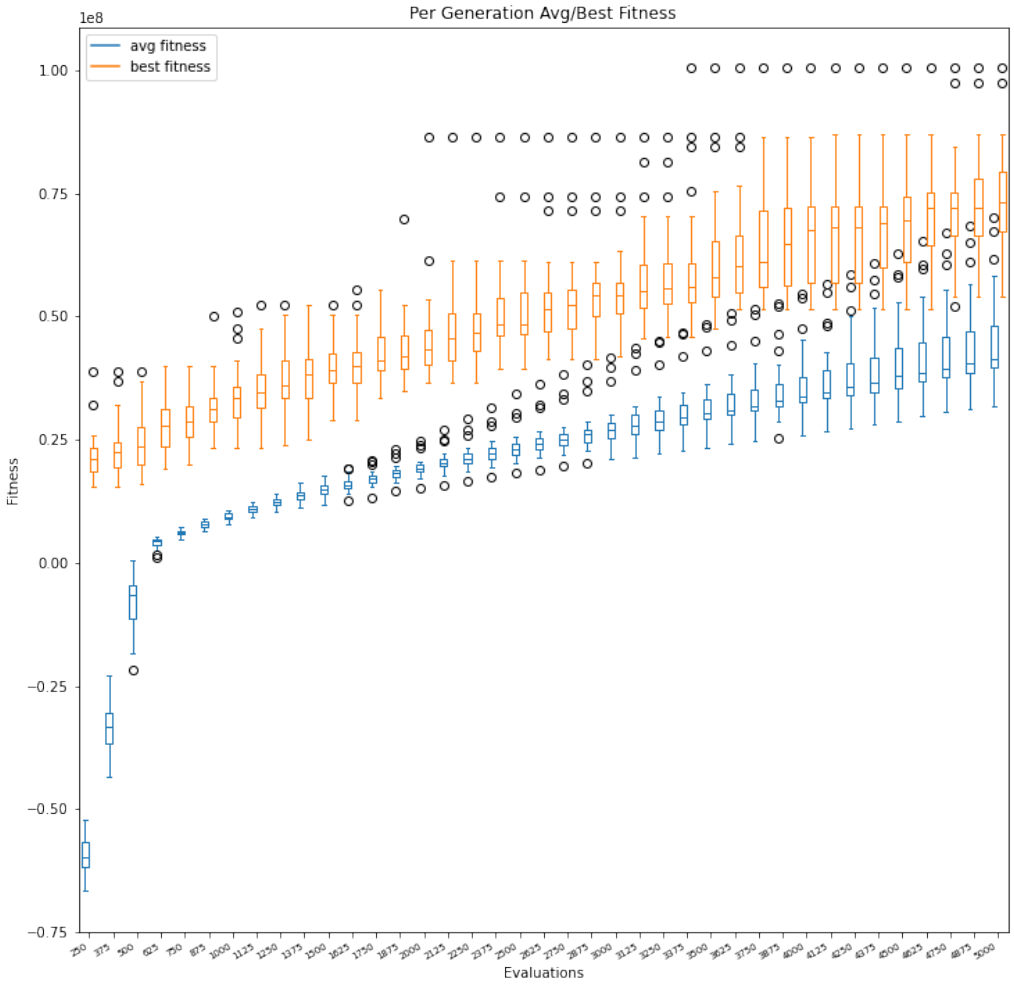

Figure 4: Averaged Per Generation Avg/Best Fitness using a Bi-Circle Topology

(c) All-to-All

The evolutionary algorithm using an all-to-all topology (parameterized in configs/green1d_all_to_all_config.txt), had an island system where each island would send migrants to every other island in the group. Its best bridge is depicted (Figure 5) as well as the plot comparing evaluations against fitness per generation of all runs in the experiment (Figure 6). Overall, the highest fitness recorded by the all-to-all topology was 94,000,000.

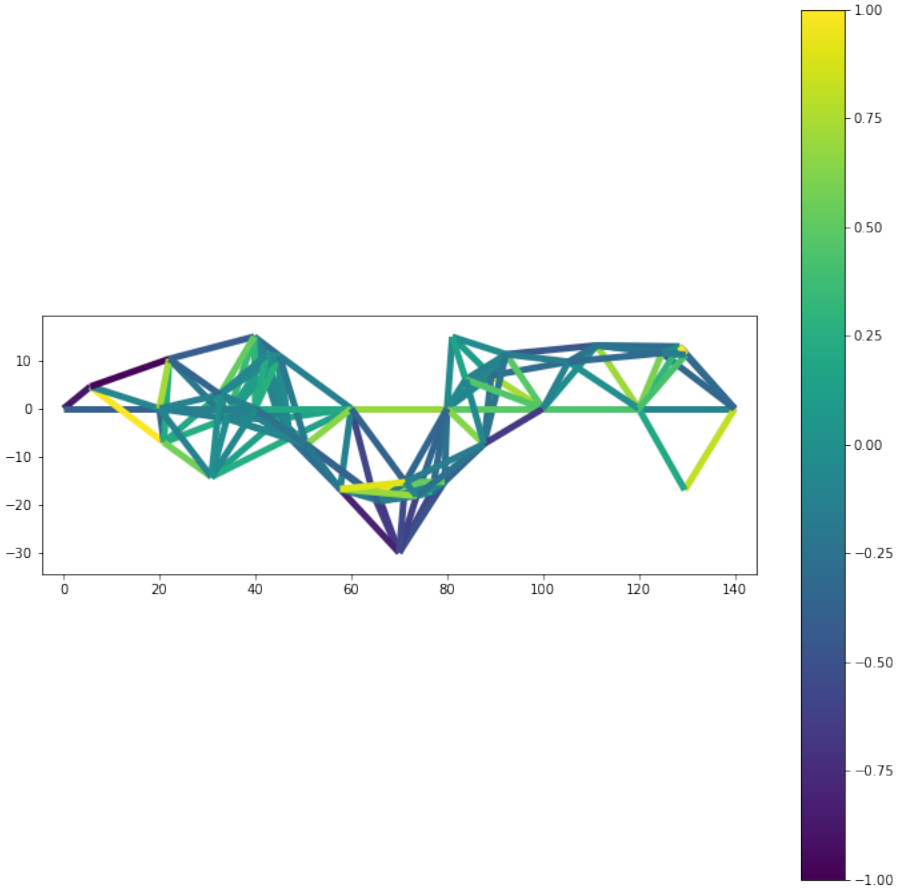

Figure 5: Bridge Plot of the Best Run using an All-to-All Topology

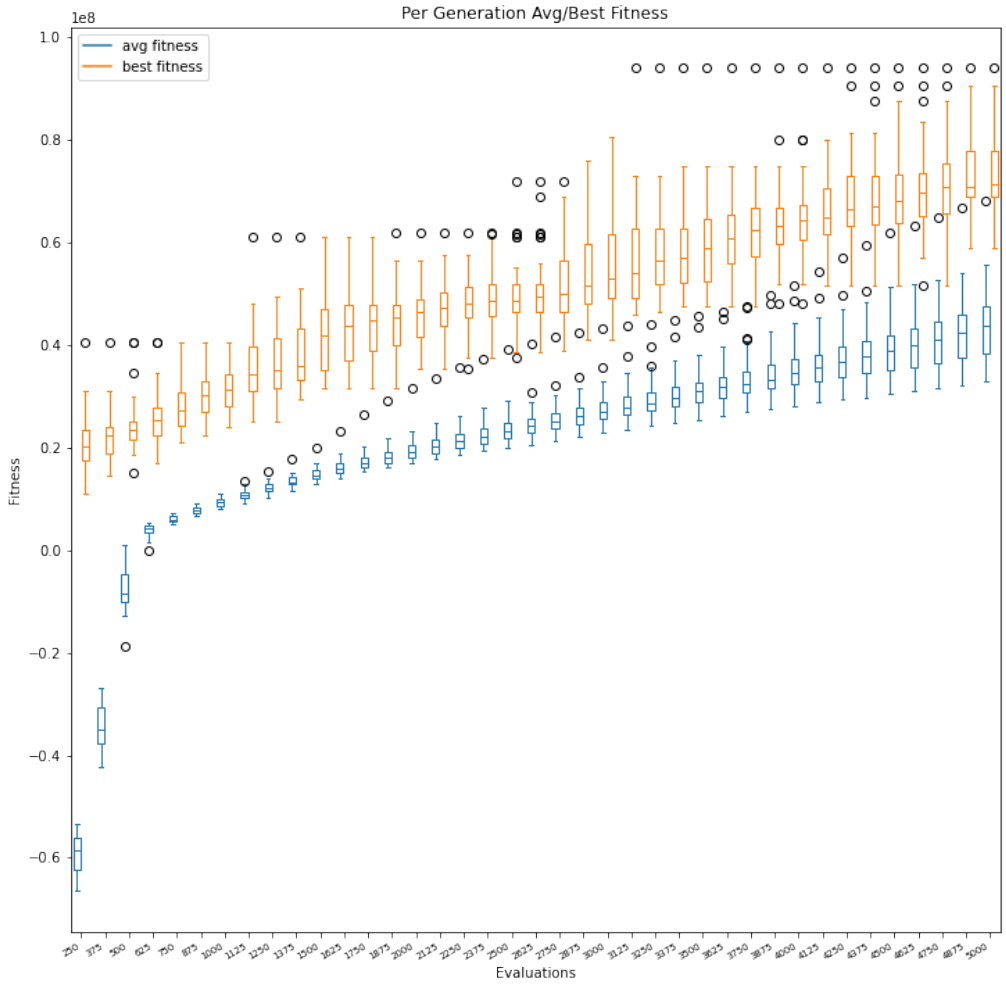

Figure 6: Averaged Per Generation Avg/Best Fitness using an All-to-All Topology

(d) Toroid

The evolutionary algorithm using a toroid topology (parameterized in configs/green1d_toroid_config.txt), had an island system where each island would send migrants up, down, left, or right with respect to its position in the island rectangle layout. Its best bridge is depicted (Figure 7) as well as the plot comparing evaluations against fitness per generation of all runs in the experiment (Figure 8). Overall, the highest fitness recorded by the toroid topology was 75,500,000.

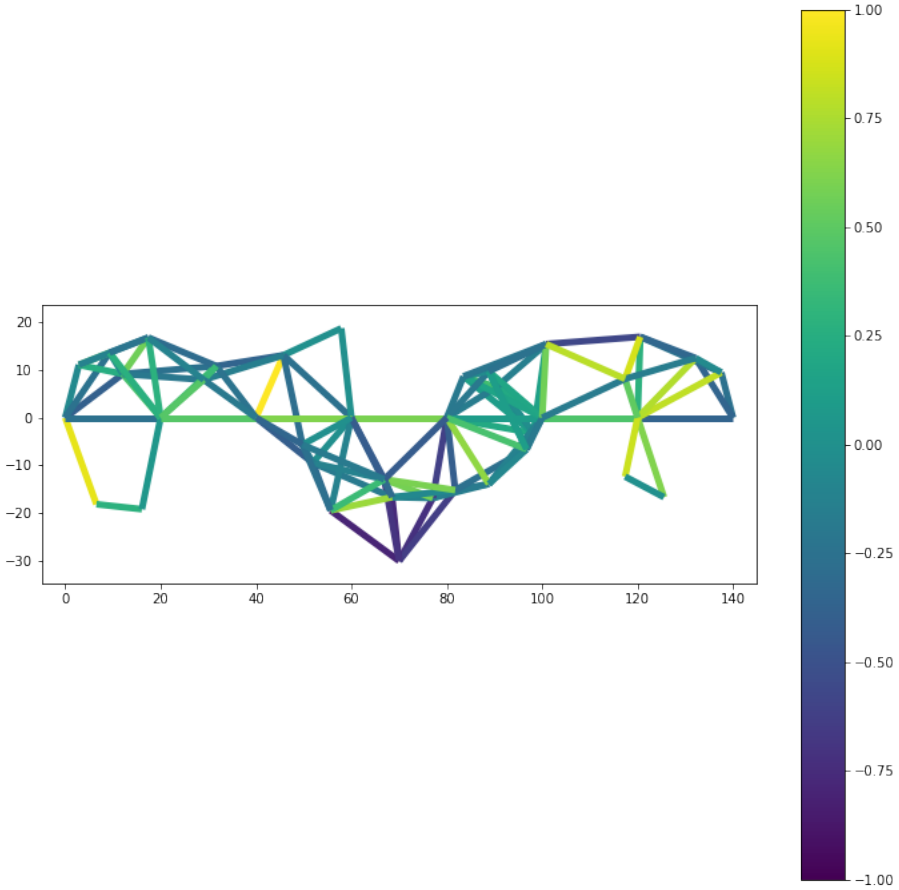

Figure 7: Bridge Plot of the Best Run using a Toroid Topology

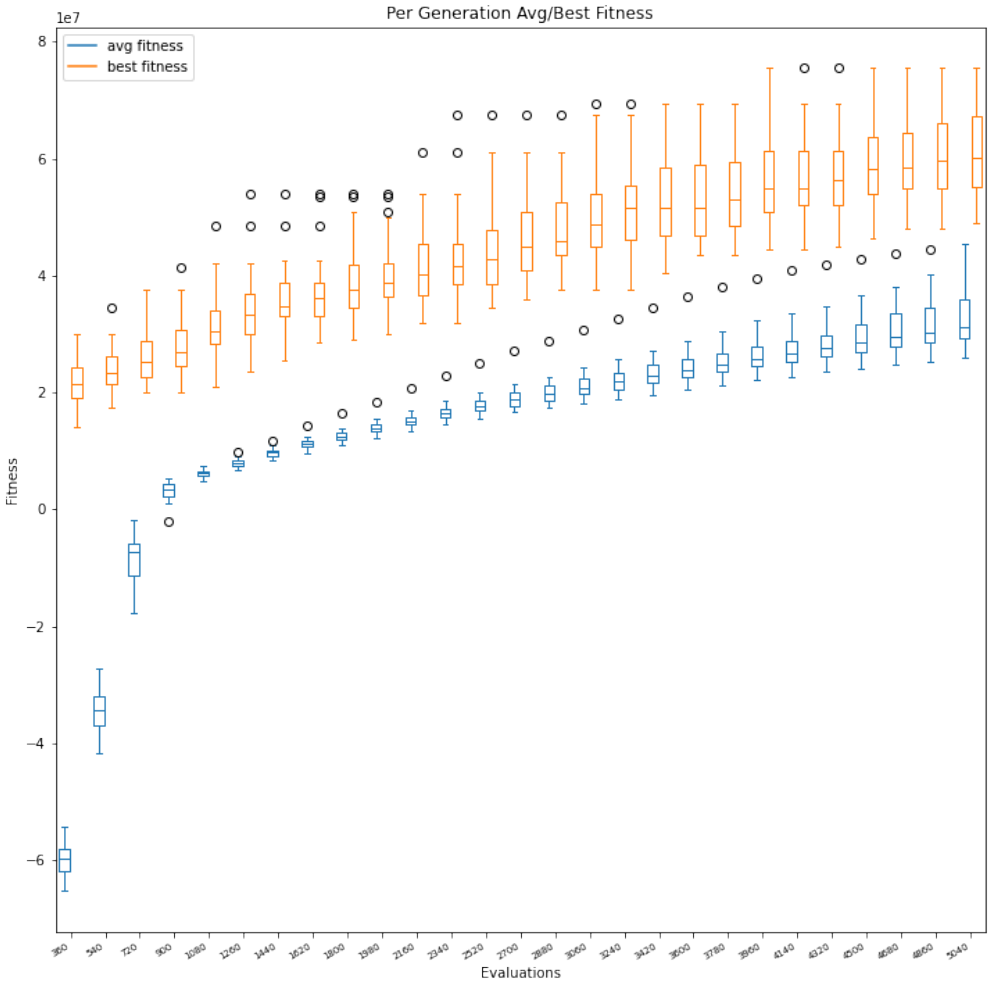

Figure 8: Averaged Per Generation Avg/Best Fitness using a Toroid Topology

2. Island Topologies Analysis using F-Test and t-Test

For each pair of island topologies, statistical analysis is performed to determine the effect each island topology has on the performance of the evolutionary algorithm.

(a) Uni-Circle v. Bi-Circle

A two-sample F-Test for equality of variances is used to determine if the variances of the uni-circle topology (data/green1d_uni_circle/results.txt) and the bi-circle topology (data/green1d_bi_circle/results.txt) algorithms are equal.

Given that $F < 1$ but $F > F\ Critical\ one\text{-}tail$, the null hypothesis of equal variances is failed to be rejected and it is determined that the two populations do not have significantly unequal variances. This prompts the use of a two-sample t-Test assuming equal variances.

F-Test Two-Sample for Variances	uni-circle	bi-circle
Mean	74833333.33	73916666.67
Variance	8.6523E+13	1.22484E+14
α	**0.025**	
Observations	30	30
df	29	29
F	0.706401248	
P(F<=f) one-tail	0.177343788	
F Critical one-tail	0.475964774	

Table 1: F-Test of Uni-Circle and Bi-Circle Algorithms

A two-sample t-Test is used to determine if the means of the uni-circle topology (data/green1d_uni_circle/results.txt) and the bi-circle topology (data/green1d_bi_circle/results.txt) algorithms are equal.

Given that $t\ Stat > 0$ but $t\ Stat < t\ Critical\ two\text{-}tail$, the null hypothesis of equal means is failed to be rejected and it is determined that the two populations do not have significantly unequal means. Neither algorithm can be assumed to perform better than the other.

t-Test: Two-Sample Assuming Equal Variances	uni-circle	bi-circle
Mean	74833333.33	73916666.67
Variance	8.6523E+13	1.22484E+14
Observations	30	30
Pooled Variance	1.04504E+14	
Hypothesized Mean Difference	0	
df	58	
α	**0.05**	
t Stat	0.347289345	
P(T<=t) one-tail	0.364815511	
t Critical one-tail	1.671552762	
P(T<=t) two-tail	0.729631021	
t Critical two-tail	2.001717484	

Table 2: t-Test of Uni-Circle and Bi-Circle Algorithms

(b) Uni-Circle v. All-to-All

A two-sample F-Test for equality of variances is used to determine if the variances of the uni-circle topology (data/green1d_uni_circle/results.txt) and the all-to-all topology (data/green1d_all_to_all/results.txt) algorithms are equal.

Given that $F > 1$ but $F < F\ Critical\ one\text{-}tail$, the null hypothesis of equal variances is failed to be rejected and it is determined that the two populations do not have significantly unequal variances. This prompts the use of a two-sample t-Test assuming equal variances.

F-Test Two-Sample for Variances	uni-circle	all-to-all
Mean	74833333.33	73550000
Variance	8.6523E+13	6.73853E+13
α	**0.025**	
Observations	30	30
df	29	29
F	1.284003053	
P(F<=f) one-tail	0.252557269	
F Critical one-tail	2.100995817	

Table 3: F-Test of Uni-Circle and All-to-All Algorithms

A two-sample t-Test is used to determine if the means of the uni-circle topology (data/green1d_uni_circle/results.txt) and the all-to-all topology (data/green1d_all_to_all/results.txt) algorithms are equal.

Given that *t Stat* > 0 but *t Stat* $<$ *t Critical two-tail*, the null hypothesis of equal means is failed to be rejected and it is determined that the two populations do not have significantly unequal means. Neither algorithm can be assumed to perform better than the other.

t-Test: Two-Sample Assuming Equal Variances	uni-circle	all-to-all
Mean	74833333.33	73550000
Variance	8.6523E+13	6.73853E+13
Observations	30	30
Pooled Variance	7.69542E+13	
Hypothesized Mean Difference	0	
df	58	
α	**0.05**	
t Stat	0.566590169	
P(T<=t) one-tail	0.28658938	
t Critical one-tail	1.671552762	
P(T<=t) two-tail	0.57317876	
t Critical two-tail	2.001717484	

Table 4: t-Test of Uni-Circle and All-to-All Algorithms

(c) Uni-Circle v. Toroid

A two-sample F-Test for equality of variances is used to determine if the variances of the uni-circle topology (data/green1d_uni_circle/results.txt) and the toroid topology (data/green1d_toroid/results.txt) algorithms are equal.

Given that $F > 1$ but $F <$ *F Critical one-tail*, the null hypothesis of equal variances is failed to be rejected and it is determined that the two populations do not have significantly unequal variances. This prompts the use of a two-sample t-Test assuming equal variances.

F-Test Two-Sample for Variances	uni-circle	toroid
Mean	74833333.33	60466666.67
Variance	8.6523E+13	5.44989E+13
α	**0.025**	
Observations	30	30
df	29	29
F	1.587611254	
P(F<=f) one-tail	0.109623487	
F Critical one-tail	2.100995817	

Table 5: F-Test of Uni-Circle and Toroid Algorithms

A two-sample t-Test is used to determine if the means of the
uni-circle topology (data/green1d_uni_circle/results.txt) and the toroid topology
(data/green1d_toroid/results.txt) algorithms are equal.

Given that *t Stat* > 0 and *t Stat* $>$ *t Critical two-tail*, the null hypothesis of equal means is rejected and it is determined that the two populations have significantly unequal means. The uni-circle algorithm can be assumed to perform better than the toroid algorithm.

t-Test: Two-Sample Assuming Equal Variances	uni-circle	toroid
Mean	74833333.33	60466666.67
Variance	8.6523E+13	5.44989E+13
Observations	30	30
Pooled Variance	7.05109E+13	
Hypothesized Mean Difference	0	
df	58	
α	**0.05**	
t Stat	6.626336031	
P(T<=t) one-tail	6.19992E-09	
t Critical one-tail	1.671552762	
P(T<=t) two-tail	1.23998E-08	
t Critical two-tail	2.001717484	

Table 6: t-Test of Uni-Circle and Toroid Algorithms

(d) Bi-Circle v. All-to-All

A two-sample F-Test for equality of variances is used to determine if the variances of the
bi-circle topology (data/green1d_bi_circle/results.txt) and the all-to-all topology
(data/green1d_all_to_all/results.txt) algorithms are equal.

Given that $F > 1$ but $F <$ *F Critical one-tail*, the null hypothesis of equal variances is failed to be rejected and it is determined that the two populations do not have significantly unequal variances. This prompts the use of a two-sample t-Test assuming equal variances.

F-Test Two-Sample for Variances	bi-circle	all-to-all
Mean	73916666.67	73550000
Variance	1.22484E+14	6.73853E+13
α	**0.025**	
Observations	30	30
df	29	29
F	1.817668155	
P(F<=f) one-tail	0.056639594	
F Critical one-tail	2.100995817	

Table 7: F-Test of Bi-Circle and All-to-All Algorithms

A two-sample t-Test is used to determine if the means of the
bi-circle topology (data/green1d_bi_circle/results.txt) and the all-to-all topology
(data/green1d_all_to_all/results.txt) algorithms are equal.

Given that *t Stat* > 0 but *t Stat* $<$ *t Critical two-tail*, the null hypothesis of equal means is failed to be rejected and it is determined that the two populations do not have significantly unequal means. Neither algorithm can be assumed to perform better than the other.

t-Test: Two-Sample Assuming Equal Variances	bi-circle	all-to-all
Mean	73916666.67	73550000
Variance	1.22484E+14	6.73853E+13
Observations	30	30
Pooled Variance	9.49348E+13	
Hypothesized Mean Difference	0	
df	58	
α	**0.05**	
t Stat	0.145748606	
P(T<=t) one-tail	0.442312605	
t Critical one-tail	1.671552762	
P(T<=t) two-tail	0.884625211	
t Critical two-tail	2.001717484	

Table 8: t-Test of Bi-Circle and All-to-All Algorithms

(e) Bi-Circle v. Toroid

A two-sample F-Test for equality of variances is used to determine if the variances of the bi-circle topology data/green1d_bi_circle/results.txt) and the toroid topology (data/green1d_toroid/results.txt) algorithms are equal.

Given that $F > 1$ and $F > F\ Critical\ one\text{-}tail$, the null hypothesis of equal variances is rejected and it is determined that the two populations have significantly unequal variances. This prompts the use of a two-sample t-Test assuming unequal variances.

F-Test Two-Sample for Variances	bi-circle	toroid
Mean	73916666.67	60466666.67
Variance	1.22484E+14	5.44989E+13
α	**0.025**	
Observations	30	30
df	29	29
F	2.247463829	
P(F<=f) one-tail	0.016441695	
F Critical one-tail	2.100995817	

Table 9: F-Test of Bi-Circle and Toroid Algorithms

A two-sample t-Test is used to determine if the means of the
bi-circle topology data/green1d_bi_circle/results.txt) and the toroid topology
(data/green1d_toroid/results.txt) algorithms are equal.

Given that $t\ Stat > 0$ and $t\ Stat > t\ Critical\ two\text{-}tail$, the null hypothesis of equal means is rejected and it is determined that the two populations have significantly unequal means. The bi-circle algorithm can be assumed to perform better than the toroid algorithm.

t-Test: Two-Sample Assuming Unequal Variances	bi-circle	toroid
Mean	73916666.67	60466666.67
Variance	1.22484E+14	5.44989E+13
Observations	30	30
Hypothesized Mean Difference	0	
df	51	
α	**0.05**	
t Stat	5.537542585	
P(T<=t) one-tail	5.38485E-07	
t Critical one-tail	1.67528495	
P(T<=t) two-tail	1.07697E-06	
t Critical two-tail	2.00758377	

Table 10: t-Test of Bi-Circle and Toroid Algorithms

(f) All-to-All v. Toroid

A two-sample F-Test for equality of variances is used to determine if the variances of the all-to-all topology (data/green1d_all_to_all/results.txt) and the toroid topology (data/green1d_toroid/results.txt) algorithms are equal.

Given that $F > 1$ but $F < F\ Critical\ one\text{-}tail$, the null hypothesis of equal variances is failed to be rejected and it is determined that the two populations do not have significantly unequal variances. This prompts the use of a two-sample t-Test assuming equal variances.

F-Test Two-Sample for Variances	all-to-all	toroid
Mean	73550000	60466666.67
Variance	6.73853E+13	5.44989E+13
α	**0.025**	
Observations	30	30
df	29	29
F	1.236454423	
P(F<=f) one-tail	0.285674872	
F Critical one-tail	2.100995817	

Table 11: F-Test of All-to-All and Toroid Algorithms

A two-sample t-Test is used to determine if the means of the all-to-all topology (data/green1d_all_to_all/results.txt) and the toroid topology (data/green1d_toroid/results.txt) algorithms are equal.

Given that $t\ Stat > 0$ and $t\ Stat > t\ Critical\ two\text{-}tail$, the null hypothesis of equal means is rejected and it is determined that the two populations have significantly unequal means. The all-to-all algorithm can be assumed to perform better than the toroid algorithm.

t-Test: Two-Sample Assuming Equal Variances	all-to-all	toroid
Mean	73550000	60466666.67
Variance	6.73853E+13	5.44989E+13
Observations	30	30
Pooled Variance	6.09421E+13	
Hypothesized Mean Difference	0	
df	58	
α	**0.05**	
t Stat	6.490906247	
P(T<=t) one-tail	1.04389E-08	
t Critical one-tail	1.671552762	
P(T<=t) two-tail	2.08778E-08	
t Critical two-tail	2.001717484	

Table 12: t-Test of All-to-All and Toroid Algorithms

(g) Summary

The uni-circle, bi-circle, and all-to-all topologies were all found to not perform better than each other, however, every one of those topologies performed better than the toroid topology. The highest fitness value discovered across all experiments was 100,500,000 by the bi-circle topology.