COMP 5560 Fall 2022 Assignment 1c

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1. Constraint Satisfaction

In this assignment, two evolutionary algorithms handling constraint satisfaction are implemented and compared against each other. The first, making use of penalized fitness measures (parameterized in configs/green1c0_penalty_config.txt), has the best bridge 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 penalized fitness measure was 11,000,000. The second, making use of ignoring constraints (parameterized in configs/green1c0_ignore_config.txt), has the best bridge 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 ignoring constraints was 3,500,000.

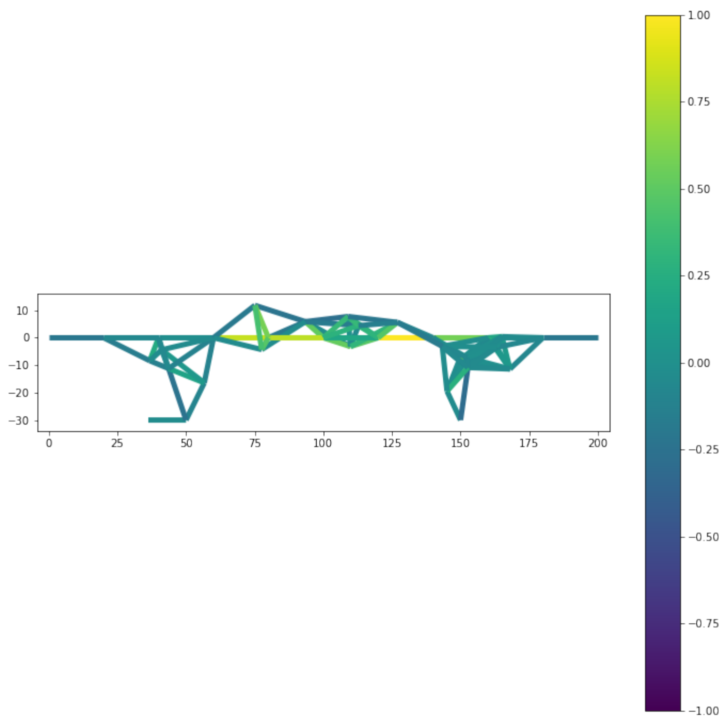

Figure 1: Bridge Plot of the Best Run with Penalized Fitness

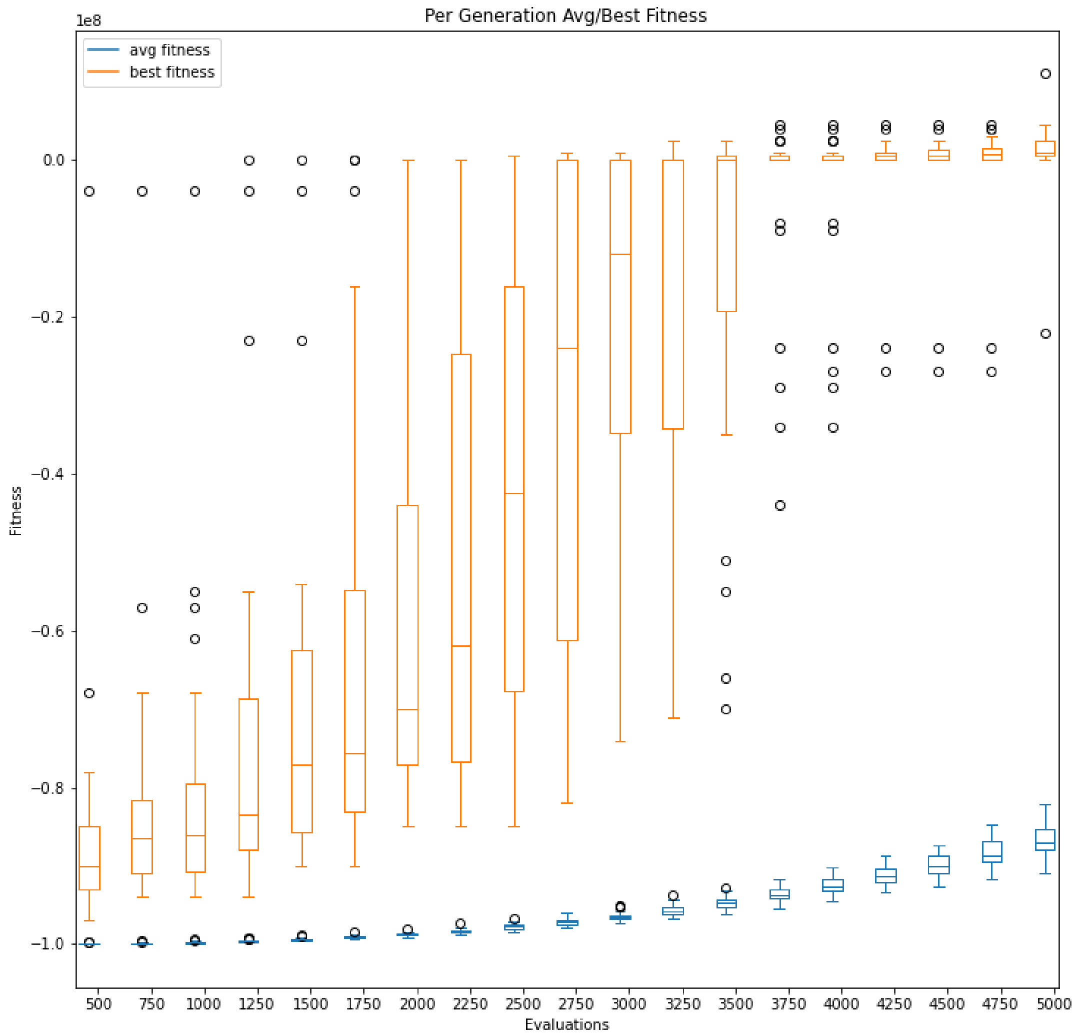

Figure 2: Box Plots of the Averaged Per Generation Avg/Best Fitness with Penalized Fitness

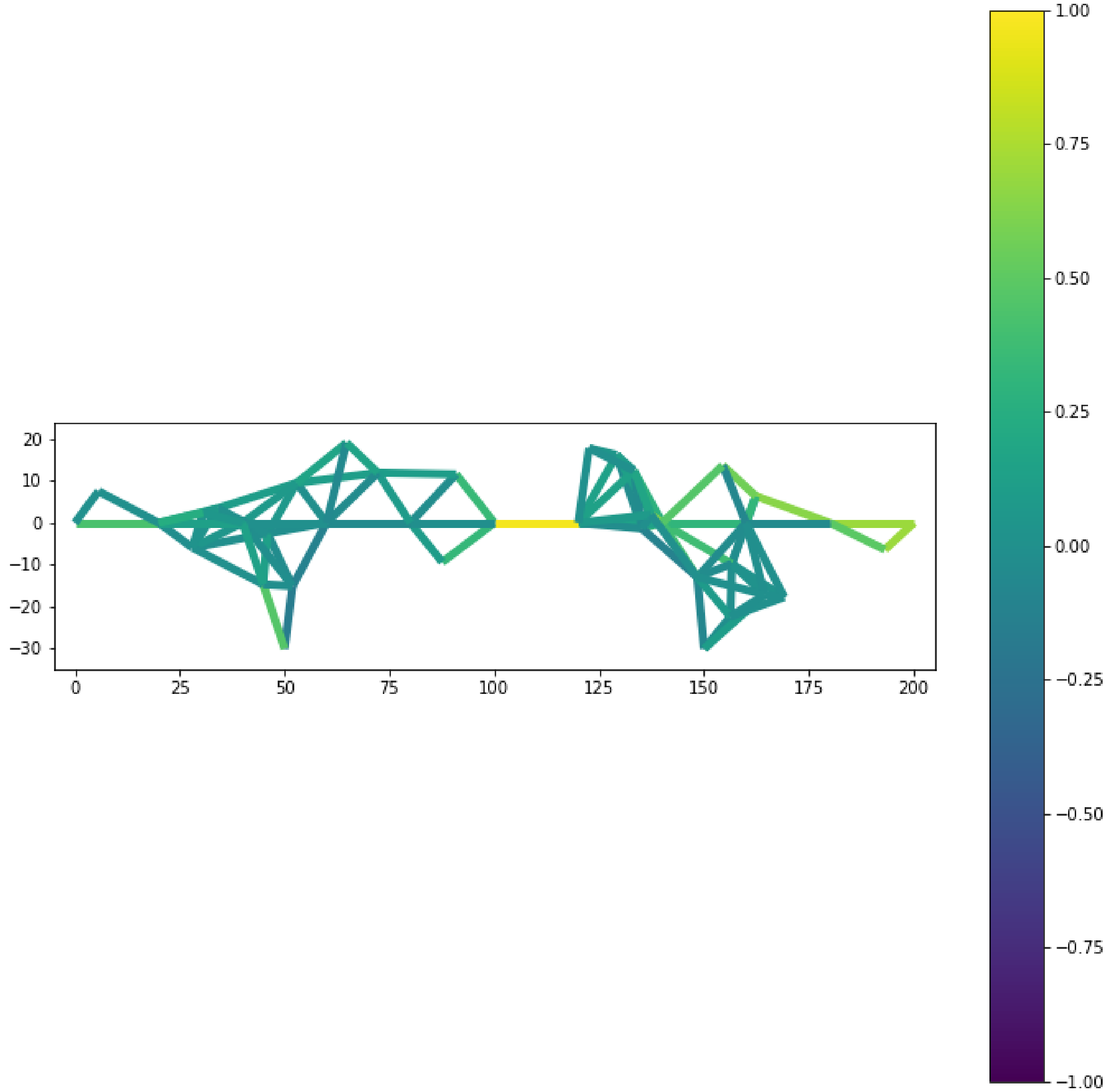

Figure 3: Bridge Plot of the Best Run with Ignore Constraints

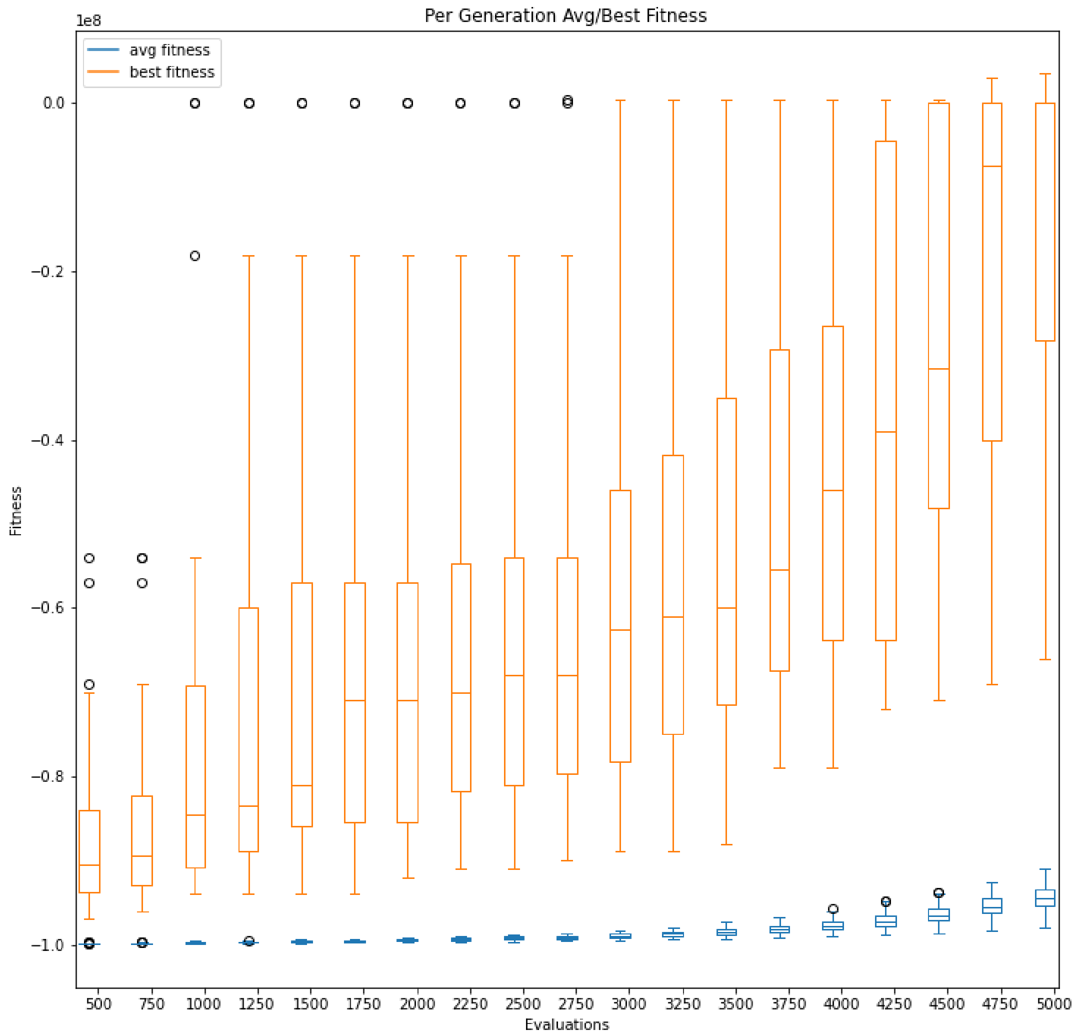

Figure 4: Box Plots of the Averaged Per Generation Avg/Best Fitness with Ignore Constraints

2. Constraint Satisfaction Analysis using F-Test and t-Test

A two-sample F-Test for equality of variances is used to determine if the variances of the penalized fitness algorithm (data/green1c0_penalty/results.txt) and the ignore constraints algorithm (data/green1c0_ignore/results.txt) are equal. Given that $F < 1$ and $F < F$ *Critical one-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	penalty	ignore
Mean	966666.6667	-14050000
Variance	2.34299E+13	4.4842E+14
Observations	30	30
df	29	29
α	**0.025**	
F	0.052249886	
P(F<=f) one-tail	2.5635E-12	
F Critical one-tail	0.475964774	

Table 1: F-Test of Penalized Fitness and Ignore Constraints Algorithms

A two-sample t-Test is used to determine if the means of the penalized fitness algorithm (data/green1c0_penalty/results.txt) and the ignore constraints algorithm (data/green1c0_ignore/results.txt) 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 penalized fitness algorithm can be assumed to perform better than the ignore constraints algorithm.

t-Test: Two-Sample Assuming Unequal Variances	penalty	ignore
Mean	966666.6667	-14050000
Variance	2.34299E+13	4.4842E+14
Observations	30	30
Hypothesized Mean Difference	0	
df	32	
α	**0.05**	
t Stat	3.786450821	
P(T<=t) one-tail	0.000317791	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	0.000635583	
t Critical two-tail	2.036933343	

Table 2: t-Test of Penalized Fitness and Ignore Constraints Algorithms

3. Multi-Objective

In this assignment, a multi-objective evolutionary algorithm is implemented to design bridges optimizing for both weight supported and minimal material used. The full experiment (parameterized in configs/green1c1_config.txt) has two plots displaying the by generation improvement of weight supported and minimal material used (Figure 5 & Figure 6 respectively). Following this, the best Pareto Front is plotted (Figure 7) as well as the plots of the individual bridges (figures 8-14).

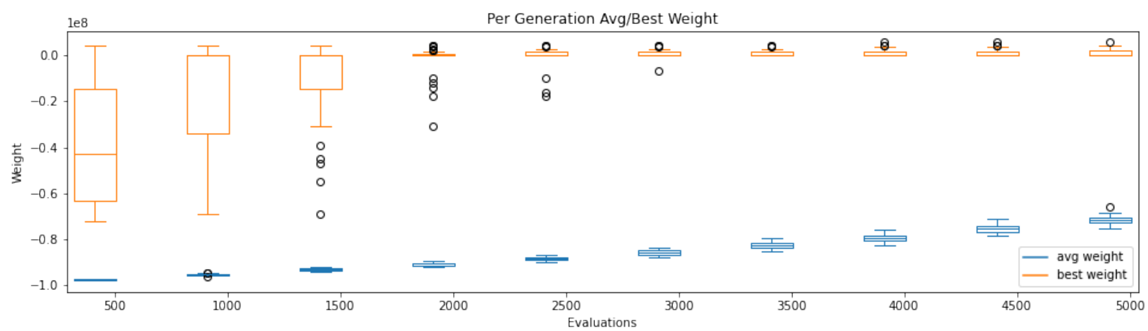

Figure 5: Box Plots of the Averaged Per Generation Avg/Best Weight

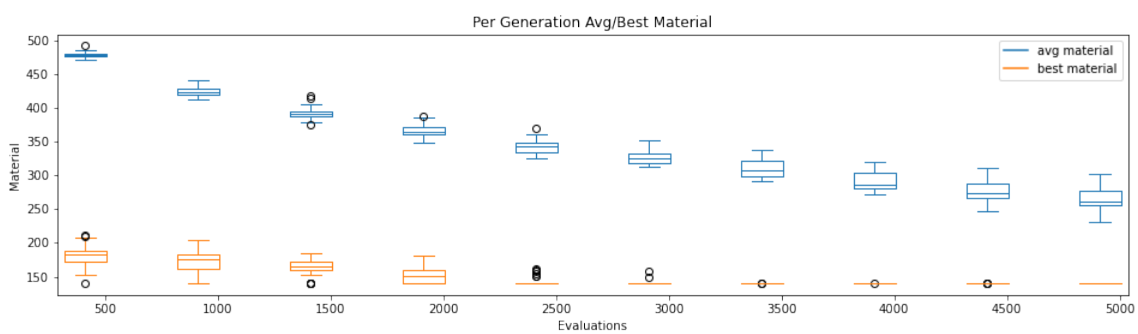

Figure 6: Box Plots of the Averaged Per Generation Avg/Best Material (Less is Better)

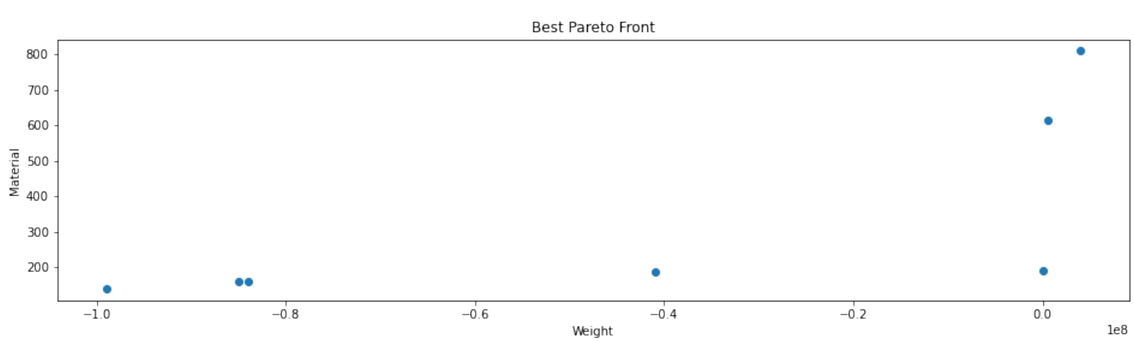

Figure 7: Best Pareto Front

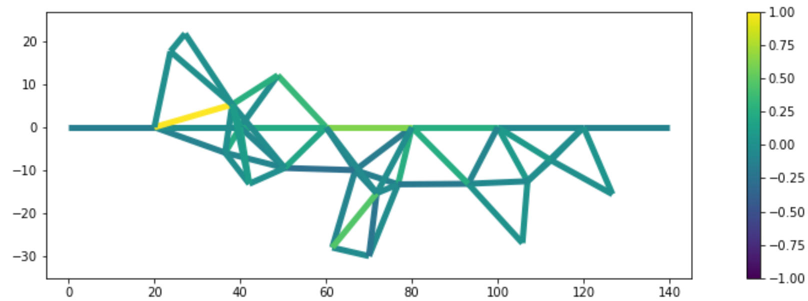

Figure 8: Bridge Plot of the 1st Member in the Pareto Front

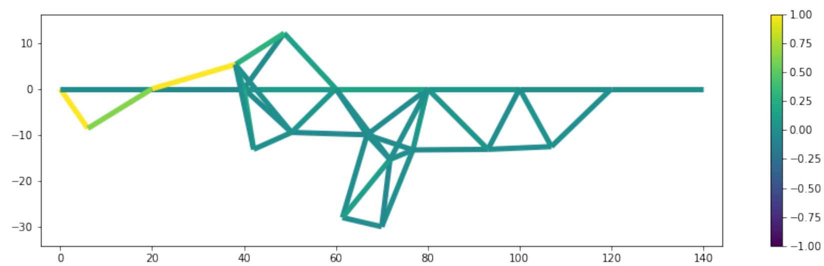

Figure 9: Bridge Plot of the 2nd Member in the Pareto Front

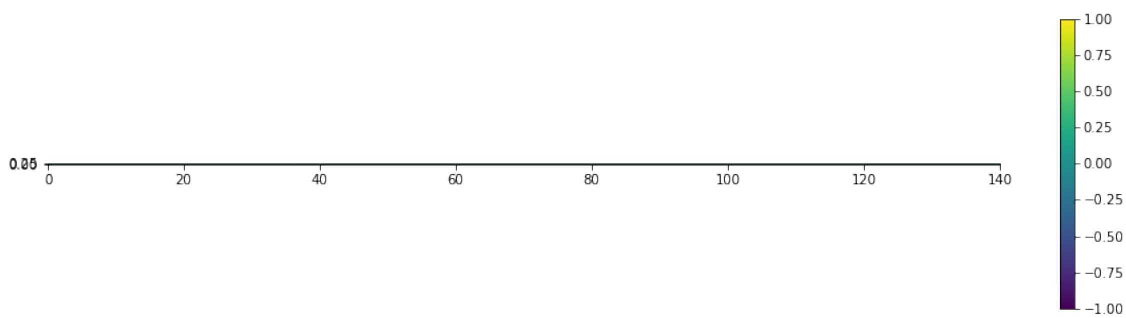

Figure 10: Bridge Plot of the 3rd Member in the Pareto Front

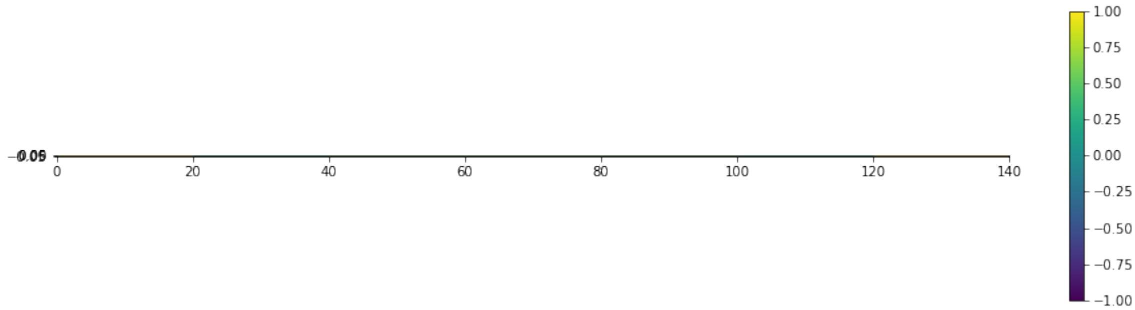

Figure 11: Bridge Plot of the 4th Member in the Pareto Front

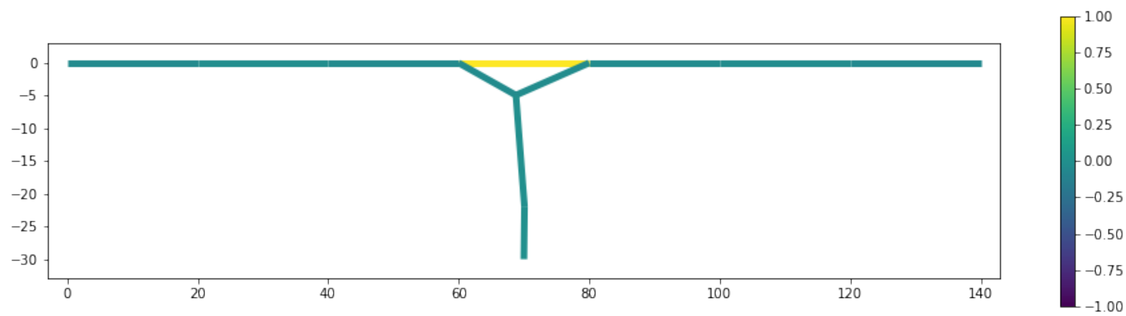

Figure 12: Bridge Plot of the 5th Member in the Pareto Front

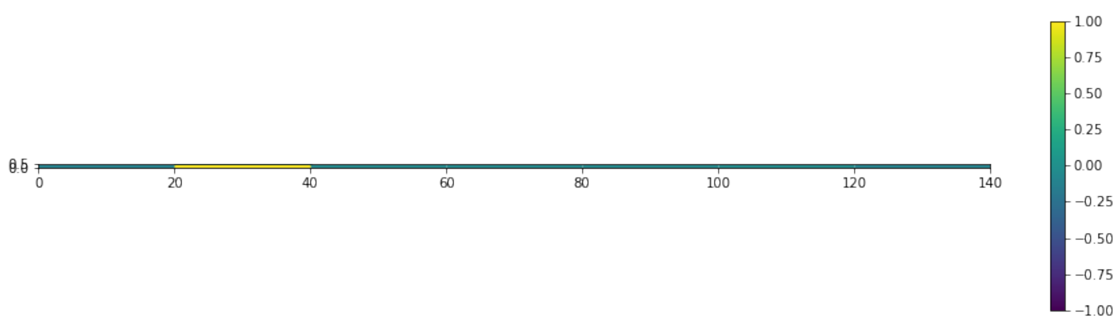

Figure 13: Bridge Plot of the 6th Member in the Pareto Front

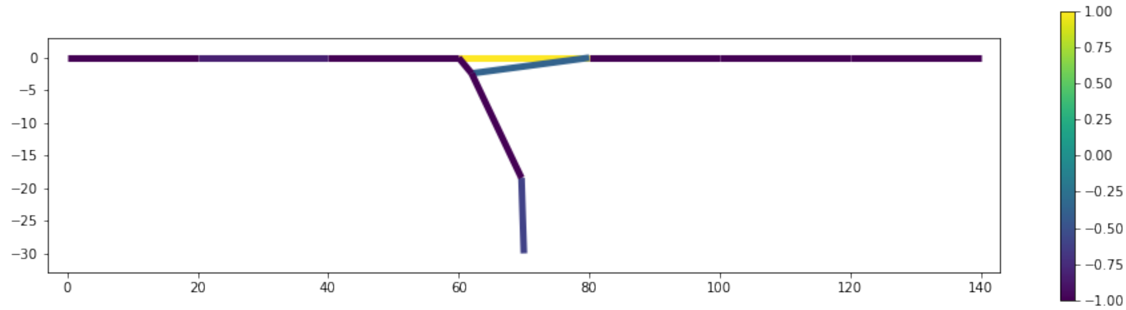

Figure 14: Bridge Plot of the 7th Member in the Pareto Front

4. Multi-Objective Analysis

Of the seven members of the Pareto Front, three bridges (Figure 10, Figure 11, & Figure 13) distributed their points in such a way to remove all connections except the road enforced in the parameters, thus finding the absolute minimum material needed given the problem constraints. In a slightly less egregious example of this pattern, two bridges (Figure 12 & Figure 14) have no added connections bar a central pillar, thus near minimizing the material used and adding a bit more weight support. Lastly, two bridges (Figure 8 & Figure 9) were structurally sound (> 0 weight supported) but also made use of the point distribution trick to lessen the number of points involved in making connections, thus also lowering the material used. Every bridge, in some way, gamed the simulation to create inactive points and lessen the overall number of connections but varied in the weight support trade-off to accomplish this.