COMP 5660 Fall 2023 Assignment 1c

Matthew Freestone
maf0083@auburn.edu

1 October 2023

1 Green Penalty Deliverables

1.1 EA Parameters

See Table 1 for Green Penalty EA Parameters.

Parameter Name	Value
μ	600
λ	500
Mutation Rate	0.50
Penalty Coefficient	1.2
Parent Selection Method	Fitness Proportionate
Survival Selection	K-Tournament Without Replacement ($k = 5$)
Recombination Method	Uniform Crossover
Mutation Expected Loci Changed	3
Mutation Creep Normal Distribution σ	5

Table 1: Green Penalty EA Parameter Values

1.2 Results

See Figure 1 for an Evals vs Population Mean {Base, Penalty} fitness and Population Max {Base, Penalty} fitness. As the plot shows, the mean and max penalized fitness stay relatively close for the run, with the mean base fitness and proportion of valid solutions increasing at the end of the run.

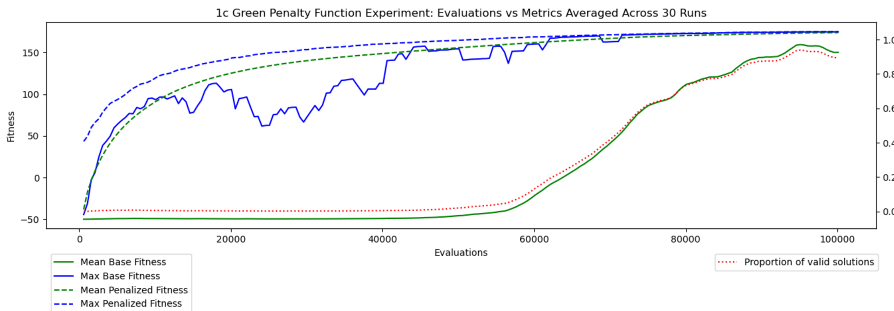

Figure 1: Green Penalty Evals vs Fitness

See Figure 2 for the optimal solution generated by the Green Penalty parameters. This solution came from run 4 and had fitness 181.

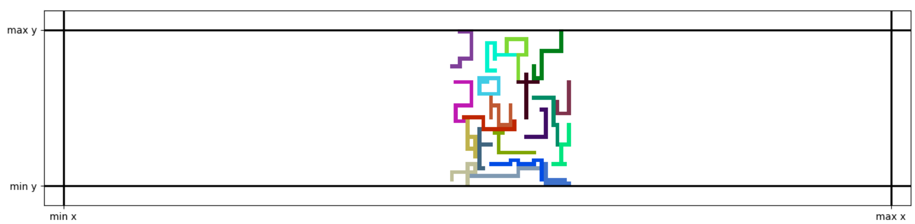

Figure 2: Best Solution from Green Penalty

1.3 Statistical Analysis

In this section, the data from a run of the 1b EA on the problem is compared to the EA with a penalty coefficient implemented in this report.
The statistics for each dataset are shown in Table 2.

1c penalty data mean:	174.66666666666666
1c penalty data stdv:	2.880772565599833
1b data mean:	92.7
1b data stdv:	10.269304781223273

Table 2: Green Penalty Statistical Data

After performing a Welch's T-test, a p value was found of $1.298702079 \cdot 10^{-30}$. With $\alpha = 0.05/3$, the null hypothesis of the methods yielding the same results can be firmly rejected, as $\alpha >> p$.
Based on the means of the fitnesses from each dataset, the results from the positive penalty coefficient EA are clearly better.

2 Green Ignore Deliverables

2.1 EA Parameters

See Table 3 for Green EA Parameters.

Parameter Name	Value
μ	5000
λ	5000
Mutation Rate	0.50
Penalty Coefficient	0
Parent Selection Method	Fitness Proportionate
Survival Selection	K-Tournament Without Replacement ($k = 5$)
Recombination Method	One-Point Crossover
Mutation Expected Loci Changed	5
Mutation Creep Normal Distribution σ	10

Table 3: Green Ignore EA Parameter Values

2.2 Results

See Figure 3 for an Evals vs Population Mean {Base, Penalty} fitness and Population Max {Base, Penalty} fitness.
When invalid solutions are treated as equally fit to valid solutions, we see the number of valid solutions drop dramatically as the run progresses. The best results are found early, when the large genetic variety in the population is still around.

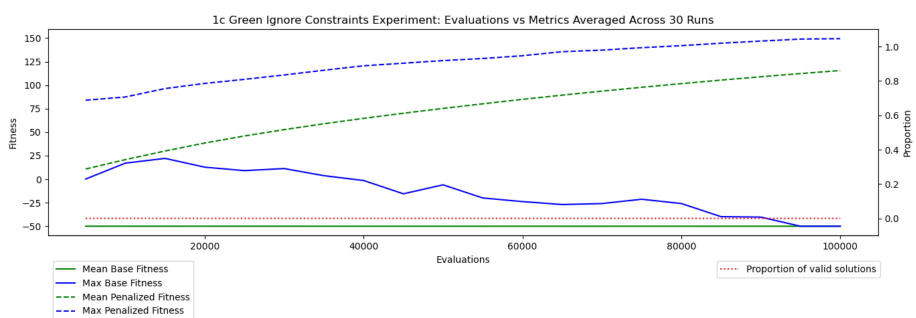

Figure 3: Green Ignore Evals vs Fitness

See Figure 4 for the optimal solution generated by the Green Penalty parameters. This solution came from run 7 and had fitness 111.

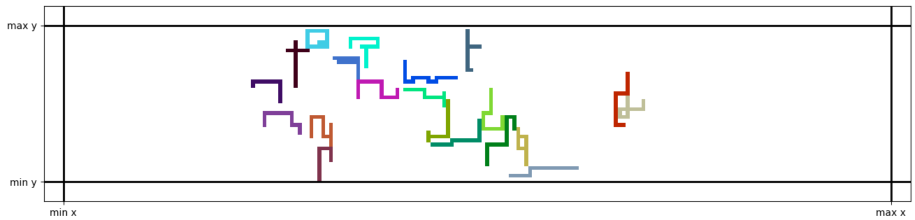

Figure 4: Best Solution from Green Ignore

2.3 Statistical Analysis

In this section, the data from a run of the 1b EA on the problem is compared to the EA with a 0 penalty coefficient implemented in this report.
The statistics for each dataset are shown in Table 4.

1c ignore data mean:	66.6
1c ignore data stdv:	23.420592177206675
1b data mean:	92.7
1b data stdv:	10.269304781223273

Table 4: Green Ignore Statistical Data

After performing a Welch's T-test, a p value was found of $1.8131463 \cdot 10^{-6}$. With $\alpha = 0.05/3$, the null hypothesis of the methods yielding the same results can be firmly rejected, as $\alpha >> p$.
Based on the means of the fitnesses from each dataset, the results from the sample data is significantly better. The zero-value penalty coefficient lead to poor results.

3 Yellow Deliverables

3.1 EA Parameters

See Table 5 for Yellow EA Parameters.

Parameter Name	Value
μ	600
λ	500
Mutation Rate	0.50
Adaptive Penalty Coefficient	1/12
Parent Selection Method	K-Tournament with Replacement ($k = 5$)
Survival Selection	K-Tournament Without Replacement ($k = 7$)
Recombination Method	N-Point Crossover (n=3)
Mutation Expected Loci Changed	3
Mutation Creep Normal Distribution σ	5

Table 5: Yellow EA Parameter Values

3.1.1 Adaptive Penalty Coefficient

The penalty coefficient was set using an adaptive parameter control strategy. In this scheme, the parameter is set using some value from the population.
The strategy used in this paper adjusts the coefficient based on the standard deviation of fitnesses in the current population. When variance is high, the penalty coefficient is also high, pressuring the population toward selecting valid individuals over those that are more fit but invalid. When the variance is low, we are likely further into the run, where shapes are closely grouped and invalid solutions are very close to high-fitness valid ones. Therefore, we set the penalty coefficient to be low to encourage exploration of these invalid solutions.
In order to keep the value more stable, the value of this penalty coefficient is set using the average of the last 5 values of fitness standard deviation. Additionally, in order to have reasonable values, an additional parameter, "Adaptive Penalty Coefficient," was introduced to scale up or down the fitness standard deviation. There was also an arbitrary cap of 2 set on the penalty coefficient to prevent a single large standard distribution from increasing the penalty coefficient too high and ruining the run's population.

3.2 Results

See Figure 5 for an Evals vs Population Mean {Base, Penalty} fitness and Population Max {Base, Penalty} fitness. Here, the number of valid solutions is higher at the start of the run, but the EA is also permitted to explore invalid solutions late in the run, resulting in better results.

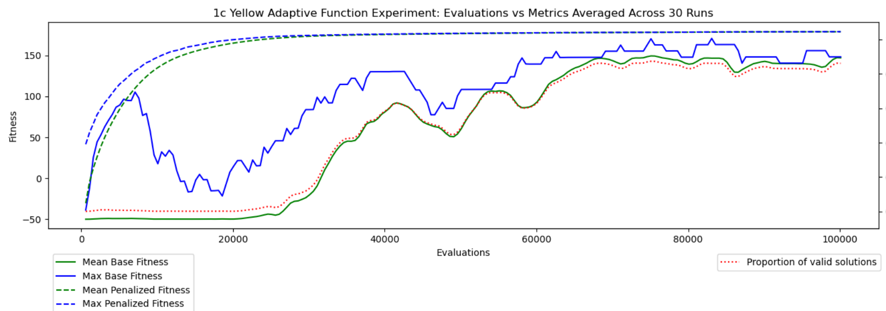

Figure 5: Yellow Evals vs Fitness

See Figure 6 for the optimal solution generated by the Yellow parameters. This solution came from run 13 and had fitness 184.

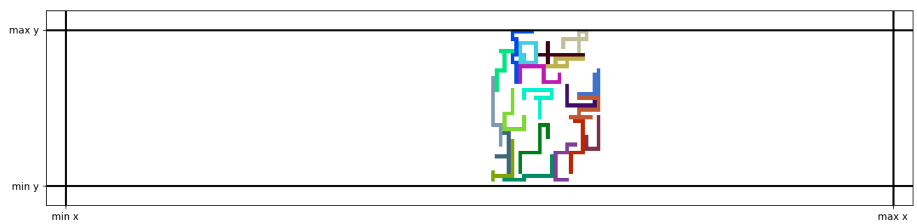

Figure 6: Best Solution from Yellow

3.3 Statistical Analysis

In this second, the data from the Green penalty section of the report is compared to the Yellow version with an adaptive penalty coefficient.
The statistics for each dataset are shown in Table 6.

yellow data mean:	178.6
yellow data stdv:	2.4858218650634614
green penalty data mean:	174.66666666666666
green penalty data stdv:	2.880772565599833

Table 6: Yellow Statistical Data

After performing a Welch's T-test, a p value was found of $5.1631263 \cdot 10^{-7}$. With $\alpha = 0.05/3$, the null hypothesis of the methods yielding the same results can be firmly rejected, as $\alpha >> p$.
Based on the means of the fitnesses from each dataset, the results from the yellow adaptive penalty coefficient EA is significantly better.

4 Red Deliverables

It proved challenging to determine an algorithm to repair invalid solutions in a way that is computationally efficient and also produces the nearest valid solution. The uncomplete code is currently present in the unconstrained_population_evaluation function of stock_population_evaluation.py.