# COMP SCI 5401 FS2017 Assignment 1c

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## Self-Adaptive EA Strategy Parameter

The self-adaptive parameter that was chosen for this EA was the mutation rate. The self adaptation that was created for the mutation rate is very simple, it simply changes based on the number of iterations gone between mutations. So if there are too many mutations happening the code will increase the mutation rate by a factor of 0.001 or 0.1

## Investigation

**a.)**

For problem 1, I would say that the self-adaptivity did not have a very large impact on the average fitness, but it very well may have increased the best fitness by quite a lot due to the ability of getting a population out of a local optimum. For problem 2 it seems like the average fitness is extremely low while the best fitness is doing just fine. I believe this is due to the mutation rate getting too high, though it seems to work fine for Problem 1 and Problem 3. Problem 3, much like Problem 1, seems to be doing quite well. The average gets to a certain point on all three problems and steadies out like it should, however for Problem 2 something is holding it back and I am not entirely sure what.

So there is definitely a differing benefit between the problems, with Problem 1 and Problem 3 looking about the same and Problem 2 being underwhelming in terms of average fitness. The average fitness does reach a certain point on all datasets and hover around that point, which is a good thing when it comes to the averaging of populations.

**b.)**

The penalty function coefficient will greatly impact the performance of all three problems. If I was to increase the penalty function coefficient there would be a severe drop in best fitness and average fitness due to how the penalty function currently works, likewise if the penalty function coefficient was decreased the best fitness and average fitness would go up since the penalty function coefficient directly decreases the fitness of a given dataset.

It seems that the penalty coefficient in Problem 1 and Problem 3 could both use a little lower penalty function in order to obtain a better average fitness, but Problem 2 is having a very hard time with a penalty function coefficient of 1. This means that Problem 2 needs to have a smaller penalty function coefficient than Problem 1 and Problem 3, which is mainly due to having double the shapes of Problem 1 and a smaller width of 20 and length while Problem 3 has a larger width of 30 and length to work with.

# Experiment parameters and graphs

# 1 Problem 1

## 1.1 Graphs

### 1.1.1 Result Tables

Problem 1: final results

| Assignment 1c: Problem 1 | | |
|---|---|---|
| Run | Average Fitness | best Fitness |
| 1 | 5.4 | 68 |
| 2 | 4.74 | 77 |
| 3 | 4.67 | 79 |
| 4 | 4.4 | 75 |
| 5 | 4.48 | 77 |
| 6 | 4.23 | 69 |
| 7 | 4.36 | 75 |
| 8 | 4.19 | 71 |
| 9 | 4.16 | 65 |
| 10 | 4.13 | 69 |
| 11 | 4.03 | 77 |
| 12 | 4.11 | 73 |
| 13 | 4.32 | 73 |
| 14 | 4.15 | 80 |
| 15 | 4.02 | 76 |
| 16 | 4.21 | 73 |
| 17 | 4.08 | 77 |
| 18 | 3.99 | 73 |
| 19 | 3.89 | 72 |
| 20 | 3.88 | 74 |
| 21 | 3.84 | 77 |
| 22 | 3.82 | 71 |
| 23 | 4.02 | 74 |
| 24 | 4.01 | 75 |
| 25 | 3.85 | 65 |
| 26 | 3.72 | 70 |
| 27 | 4.01 | 66 |
| 28 | 3.65 | 84 |
| 29 | 3.77 | 72 |
| 30 | 3.86 | 69 |

## 1.2 Statistical Analysis

| Problem 1: Best Fitness | | | | | Problem 1: Average Fitness | | | | |
|---|---|---|---|---|---|---|---|---|---|
| subject # | Fitness 1b | fitness 1c | x-y | (x-y)^2 | subject # | Fitness 1b | fitness 1c | x-y | (x-y)^2 |
| 1 | 15 | 68 | -53 | 2809 | 1 | 5 | 5.4 | -0.4 | 0.16 |
| 2 | 12 | 77 | -65 | 4225 | 2 | 5 | 4.74 | 0.26 | 0.0676 |
| 3 | 6 | 79 | -73 | 5329 | 3 | 0 | 4.67 | -4.67 | 21.8089 |
| 4 | 2 | 75 | -73 | 5329 | 4 | 0 | 4.4 | -4.4 | 19.36 |
| 5 | 20 | 77 | -57 | 3249 | 5 | 9 | 4.48 | 4.52 | 20.4304 |
| 6 | 10 | 69 | -59 | 3481 | 6 | 3 | 4.23 | -1.23 | 1.5129 |
| 7 | 7 | 75 | -68 | 4624 | 7 | 4 | 4.36 | -0.36 | 0.1296 |
| 8 | 11 | 71 | -60 | 3600 | 8 | 1 | 4.19 | -3.19 | 10.1761 |
| 9 | 13 | 65 | -52 | 2704 | 9 | 4 | 4.16 | -0.16 | 0.0256 |
| 10 | 15 | 69 | -54 | 2916 | 10 | 1 | 4.13 | -3.13 | 9.7969 |
| 11 | 13 | 77 | -64 | 4096 | 11 | 7 | 4.03 | 2.97 | 8.8209 |
| 12 | 9 | 73 | -64 | 4096 | 12 | 3 | 4.11 | -1.11 | 1.2321 |
| 13 | 17 | 73 | -56 | 3136 | 13 | 8 | 4.32 | 3.68 | 13.5424 |
| 14 | 16 | 80 | -64 | 4096 | 14 | 6 | 4.15 | 1.85 | 3.4225 |
| 15 | 17 | 76 | -59 | 3481 | 15 | 3 | 4.02 | -1.02 | 1.0404 |
| 16 | 21 | 73 | -52 | 2704 | 16 | 9 | 4.21 | 4.79 | 22.9441 |
| 17 | 8 | 77 | -69 | 4761 | 17 | 5 | 4.08 | 0.92 | 0.8464 |
| 18 | 16 | 73 | -57 | 3249 | 18 | 9 | 3.99 | 5.01 | 25.1001 |
| 19 | 17 | 72 | -55 | 3025 | 19 | 3 | 3.89 | -0.89 | 0.7921 |
| 20 | 14 | 74 | -60 | 3600 | 20 | 6 | 3.88 | 2.12 | 4.4944 |
| 21 | 8 | 77 | -69 | 4761 | 21 | 3 | 3.84 | -0.84 | 0.7056 |
| 22 | 17 | 71 | -54 | 2916 | 22 | 3 | 3.82 | -0.82 | 0.6724 |
| 23 | 12 | 74 | -62 | 3844 | 23 | 6 | 4.02 | 1.98 | 3.9204 |
| 24 | 6 | 75 | -69 | 4761 | 24 | 2 | 4.01 | -2.01 | 4.0401 |
| 25 | 14 | 65 | -51 | 2601 | 25 | 3 | 3.85 | -0.85 | 0.7225 |
| 26 | 16 | 70 | -54 | 2916 | 26 | 6 | 3.72 | 2.28 | 5.1984 |
| 27 | 6 | 66 | -60 | 3600 | 27 | 2 | 4.01 | -2.01 | 4.0401 |
| 28 | 8 | 84 | -76 | 5776 | 28 | 1 | 3.65 | -2.65 | 7.0225 |
| 29 | 13 | 72 | -59 | 3481 | 29 | 6 | 3.77 | 2.23 | 4.9729 |
| 30 | 11 | 69 | -58 | 3364 | 30 | 5 | 3.86 | 1.14 | 1.2996 |
| SUM: | | | -1826 | 112530 | SUM: | | | 4.01 | 198.2979 |
| | | | | | | | | | |
| | t-value: | -1.23094 | | df: 29 | | t-value: | 0.0095054 | | df: 29 |
| | P-Value: | 0.2282 | | t-value: 2.045 | | P-Value: | 0.9925 | | t-value: 2.045 |

So according to the statistical analysis (shown above) the p-value for both best fitness and average fitness is not low enough to say that the results are statistically significant. That means that the t-value of -1.23094 and the t-value of 0.0095054, computed using the tables given, were not far enough apart from the t-value given of 2.045 to make the difference in the fitness values statistically significant.

## 1.3 EA Configurations

If you want to get the same results you have to change the newSeed variable to 0 (Zero) in the configuration file in order to use the previous seed.

```
1  Random = 0
2  EA = 1
3  newSeed = 1
4
```

```
 5  mu: 20
 6  lambda: 10
 7  penalty: 1
 8  runs: 30
 9  mutation_rate: 0.01
10  fitness_evaluations: 10000
11  prob_log_random: logs/prob1_random_log.txt
12  prob_log_EA: logs/prob1_EA_log.txt
13  number_of_evals_till_termination: 5
14  tournament_size_for_parent_selection: 10
15  tournament_size_for_survival_selection: 10
16  n_for_termination_convergence_criterion: 5
17  prob_solution_random: solutions/prob1_random_solution.txt
18  prob_solution_EA: solutions/prob1_EA_solution.txt
19  seed: time.time()
20
21  selfAdaptive: adaptMutation: 1
22
23  Initialization: Uniform_Random: 1
24
25  Parent_Selection: Uniform_random_parent: 0,
        Fitness_Proportional_Selection: 0, k-
        Tournament_Selection_with_replacement: 1
26
27  Survival_Strategy: plus: 0, comma: 1
28
29  Survival_Selection: Uniform_random_survival: 0, Truncation: 0, k-
        Tournament_Selection_without_replacement: 1
30
31  Termination: Number_of_evals: 0,
        no_change_in_average_population_fitness_for_n_generations: 0,
        no_change_in_best_fitness_in_population_for_n_generations: 1
```

# 2 Problem 2

## 2.1 Graphs



### 2.1.1 Result Tables

Problem 2: final results

| Assignment 1c: Problem 2 | | |
|---|---|---|
| Run | Average Fitness | best Fitness |
| 1 | 2.96 | 78 |
| 2 | 1.57 | 77 |
| 3 | 1.3 | 91 |
| 4 | 0.83 | 69 |
| 5 | 0.47 | 71 |
| 6 | 0.63 | 72 |
| 7 | 1.02 | 72 |
| 8 | 0.12 | 70 |
| 9 | 0.57 | 74 |
| 10 | 0.34 | 67 |
| 11 | 0.36 | 75 |
| 12 | 0.06 | 92 |
| 13 | 0.36 | 73 |
| 14 | 0.28 | 74 |
| 15 | 0.08 | 66 |
| 16 | 0.18 | 70 |
| 17 | -0.15 | 65 |
| 18 | -0.04 | 69 |
| 19 | 0 | 69 |
| 20 | 0.1 | 68 |
| 21 | 0.04 | 75 |
| 22 | 0.02 | 78 |
| 23 | -0.25 | 73 |
| 24 | -0.25 | 75 |
| 25 | -0.07 | 83 |
| 26 | -0.03 | 66 |
| 27 | 0.03 | 68 |
| 28 | -0.17 | 68 |
| 29 | -0.12 | 70 |
| 30 | -0.32 | 81 |

## 2.2 Statistical Analysis

| Problem 2: Best Fitness | | | | | Problem 2: Average Fitness | | | | |
|---|---|---|---|---|---|---|---|---|---|
| subject # | Fitness 1b | fitness 1c | x-y | (x-y)^2 | subject # | Fitness 1b | fitness 1c | x-y | (x-y)^2 |
| 1 | 17 | 68 | -51 | 2601 | 1 | 6 | 2.96 | 3.04 | 9.2416 |
| 2 | 16 | 77 | -61 | 3721 | 2 | 8 | 1.57 | 6.43 | 41.3449 |
| 3 | 11 | 79 | -68 | 4624 | 3 | 5 | 1.3 | 3.7 | 13.69 |
| 4 | 15 | 75 | -60 | 3600 | 4 | 5 | 0.83 | 4.17 | 17.3889 |
| 5 | 11 | 77 | -66 | 4356 | 5 | 2 | 0.47 | 1.53 | 2.3409 |
| 6 | 17 | 69 | -52 | 2704 | 6 | 1 | 0.63 | 0.37 | 0.1369 |
| 7 | 8 | 75 | -67 | 4489 | 7 | 3 | 1.02 | 1.98 | 3.9204 |
| 8 | 17 | 71 | -54 | 2916 | 8 | 4 | 0.12 | 3.88 | 15.0544 |
| 9 | 12 | 65 | -53 | 2809 | 9 | 5 | 0.57 | 4.43 | 19.6249 |
| 10 | 9 | 69 | -60 | 3600 | 10 | 4 | 0.34 | 3.66 | 13.3956 |
| 11 | 12 | 77 | -65 | 4225 | 11 | 3 | 0.36 | 2.64 | 6.9696 |
| 12 | 16 | 73 | -57 | 3249 | 12 | 6 | 0.06 | 5.94 | 35.2836 |
| 13 | 6 | 73 | -67 | 4489 | 13 | 2 | 0.36 | 1.64 | 2.6896 |
| 14 | 9 | 80 | -71 | 5041 | 14 | 2 | 0.28 | 1.72 | 2.9584 |
| 15 | 15 | 76 | -61 | 3721 | 15 | 4 | 0.08 | 3.92 | 15.3664 |
| 16 | 30 | 73 | -43 | 1849 | 16 | 5 | 0.18 | 4.82 | 23.2324 |
| 17 | 10 | 77 | -67 | 4489 | 17 | 4 | -0.15 | 4.15 | 17.2225 |
| 18 | 11 | 73 | -62 | 3844 | 18 | 4 | -0.04 | 4.04 | 16.3216 |
| 19 | 7 | 72 | -65 | 4225 | 19 | 2 | 0 | 2 | 4 |
| 20 | 22 | 74 | -52 | 2704 | 20 | 7 | 0.1 | 6.9 | 47.61 |
| 21 | 15 | 77 | -62 | 3844 | 21 | 3 | 0.04 | 2.96 | 8.7616 |
| 22 | 23 | 71 | -48 | 2304 | 22 | 12 | 0.02 | 11.98 | 143.5204 |
| 23 | 17 | 74 | -57 | 3249 | 23 | 6 | -0.25 | 6.25 | 39.0625 |
| 24 | 12 | 75 | -63 | 3969 | 24 | 6 | -0.25 | 6.25 | 39.0625 |
| 25 | 14 | 65 | -51 | 2601 | 25 | 5 | -0.07 | 5.07 | 25.7049 |
| 26 | 17 | 70 | -53 | 2809 | 26 | 5 | -0.03 | 5.03 | 25.3009 |
| 27 | 11 | 66 | -55 | 3025 | 27 | 5 | 0.03 | 4.97 | 24.7009 |
| 28 | 16 | 84 | -68 | 4624 | 28 | 5 | -0.17 | 5.17 | 26.7289 |
| 29 | 11 | 72 | -61 | 3721 | 29 | 7 | -0.12 | 7.12 | 50.6944 |
| 30 | 16 | 69 | -53 | 2809 | 30 | 7 | -0.32 | 7.32 | 53.5824 |
| SUM: | | | -1773 | 106211 | SUM: | | | 133.08 | 744.912 |
| | | | | | | | | | |
| | t-value: | -1.26389 | | df: 29 | | t-value: | 0.382909 | | df: 29 |
| | P-Value: | 0.2163 | | t-value: 2.045 | | P-Value: | 0.7046 | | t-value: 2.045 |

So according to the statistical analysis (shown above) the p-value for both best fitness and average fitness is not low enough to say that the results are statistically significant. That means that the t-value of -1.26389 and the t-value of 0.382909, computed using the tables given, were not far enough apart from the t-value given of 2.045 to make the difference in the fitness values statistically significant.

## 2.3 EA Configurations

If you want to get the same results you have to change the newSeed variable to 0 (Zero) in the configuration file in order to use the previous seed.

```
1  Random = 0
2  EA = 1
3  newSeed = 1
4
```

```
 5  mu: 20
 6  lambda: 10
 7  penalty: 1
 8  runs: 30
 9  mutation_rate: 0.01
10  fitness_evaluations: 10000
11  prob_log_random: logs/prob2_random_log.txt
12  prob_log_EA: logs/prob2_EA_log.txt
13  number_of_evals_till_termination: 5
14  tournament_size_for_parent_selection: 10
15  tournament_size_for_survival_selection: 10
16  n_for_termination_convergence_criterion: 5
17  prob_solution_random: solutions/prob2_random_solution.txt
18  prob_solution_EA: solutions/prob2_EA_solution.txt
19  seed: time.time()
20
21  selfAdaptive: adaptMutation: 1
22
23  Initialization: Uniform_Random: 1
24
25  Parent_Selection: Uniform_random_parent: 0,
        Fitness_Proportional_Selection: 0, k-
        Tournament_Selection_with_replacement: 1
26
27  Survival_Strategy: plus: 0, comma: 1
28
29  Survival_Selection: Uniform_random_survival: 0, Truncation: 1, k-
        Tournament_Selection_without_replacement: 0
30
31  Termination: Number_of_evals: 0,
        no_change_in_average_population_fitness_for_n_generations: 0,
        no_change_in_best_fitness_in_population_for_n_generations: 1
```

# 3  Problem 3

## 3.1  Graphs



Problem 3: Evaluations vs Fitness
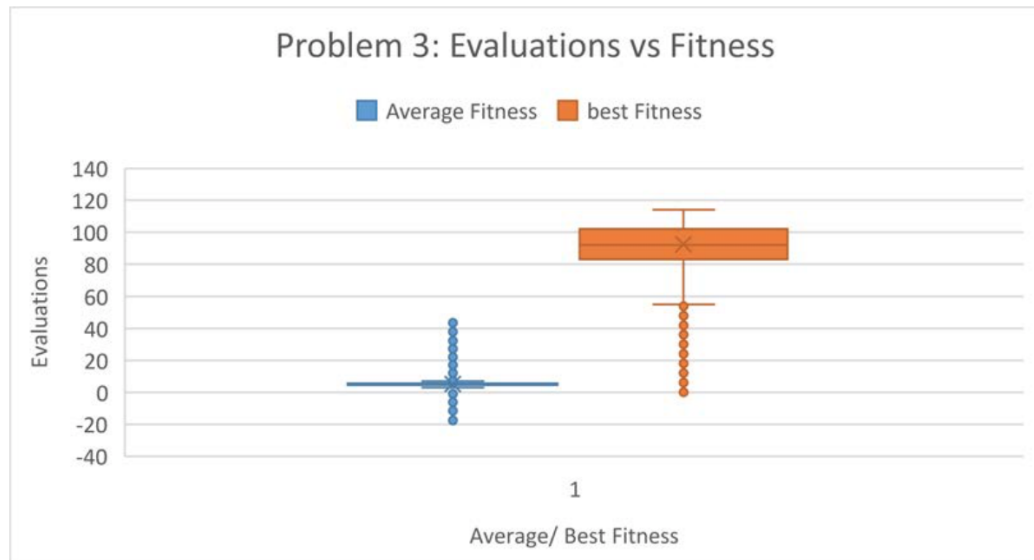
### 3.1.1  Result Tables

Problem 3: final results

| Assignment 1c: Problem 3 | | |
| --- | --- | --- |
| Run | Average Fitness | best Fitness |
| 1 | 7.42 | 89 |
| 2 | 6.66 | 91 |
| 3 | 5.69 | 90 |
| 4 | 6.1 | 92 |
| 5 | 5.59 | 101 |
| 6 | 5.64 | 90 |
| 7 | 5.3 | 102 |
| 8 | 5.42 | 99 |
| 9 | 5.23 | 106 |
| 10 | 5.48 | 108 |
| 11 | 4.51 | 94 |
| 12 | 4.54 | 98 |
| 13 | 4.75 | 102 |
| 14 | 5.04 | 95 |
| 15 | 5.19 | 113 |
| 16 | 5.04 | 114 |
| 17 | 4.64 | 92 |
| 18 | 5.41 | 93 |
| 19 | 4.18 | 113 |
| 20 | 4.41 | 106 |
| 21 | 4.71 | 108 |
| 22 | 5.01 | 92 |
| 23 | 4.76 | 82 |
| 24 | 5.06 | 106 |
| 25 | 4.58 | 113 |
| 26 | 4.45 | 111 |
| 27 | 4.54 | 112 |
| 28 | 4.67 | 112 |
| 29 | 4.49 | 106 |
| 30 | 4.39 | 95 |

## 3.2 Statistical Analysis

| | Problem 3: Best Fitness | | | | | Problem 3: Average Fitness | | | |
|---|---|---|---|---|---|---|---|---|---|
| subject # | Fitness 1b | fitness 1c | x-y | (x-y)^2 | subject # | Fitness 1b | fitness 1c | x-y | (x-y)^2 |
| 1 | 50 | 68 | -18 | 324 | 1 | 16 | 7.42 | 8.58 | 73.6164 |
| 2 | 28 | 77 | -49 | 2401 | 2 | 5 | 6.66 | -1.66 | 2.7556 |
| 3 | 31 | 79 | -48 | 2304 | 3 | 4 | 5.69 | -1.69 | 2.8561 |
| 4 | 43 | 75 | -32 | 1024 | 4 | 15 | 6.1 | 8.9 | 79.21 |
| 5 | 41 | 77 | -36 | 1296 | 5 | 13 | 5.59 | 7.41 | 54.9081 |
| 6 | 34 | 69 | -35 | 1225 | 6 | 14 | 5.64 | 8.36 | 69.8896 |
| 7 | 34 | 75 | -41 | 1681 | 7 | 21 | 5.3 | 15.7 | 246.49 |
| 8 | 25 | 71 | -46 | 2116 | 8 | 6 | 5.42 | 0.58 | 0.3364 |
| 9 | 32 | 65 | -33 | 1089 | 9 | 14 | 5.23 | 8.77 | 76.9129 |
| 10 | 35 | 69 | -34 | 1156 | 10 | 14 | 5.48 | 8.52 | 72.5904 |
| 11 | 19 | 77 | -58 | 3364 | 11 | 5 | 4.51 | 0.49 | 0.2401 |
| 12 | 23 | 73 | -50 | 2500 | 12 | 7 | 4.54 | 2.46 | 6.0516 |
| 13 | 50 | 73 | -23 | 529 | 13 | 16 | 4.75 | 11.25 | 126.5625 |
| 14 | 19 | 80 | -61 | 3721 | 14 | 6 | 5.04 | 0.96 | 0.9216 |
| 15 | 30 | 76 | -46 | 2116 | 15 | 4 | 5.19 | -1.19 | 1.4161 |
| 16 | 36 | 73 | -37 | 1369 | 16 | 10 | 5.04 | 4.96 | 24.6016 |
| 17 | 30 | 77 | -47 | 2209 | 17 | 15 | 4.64 | 10.36 | 107.3296 |
| 18 | 30 | 73 | -43 | 1849 | 18 | 4 | 5.41 | -1.41 | 1.9881 |
| 19 | 43 | 72 | -29 | 841 | 19 | 5 | 4.18 | 0.82 | 0.6724 |
| 20 | 36 | 74 | -38 | 1444 | 20 | 16 | 4.41 | 11.59 | 134.3281 |
| 21 | 27 | 77 | -50 | 2500 | 21 | 6 | 4.71 | 1.29 | 1.6641 |
| 22 | 22 | 71 | -49 | 2401 | 22 | 12 | 5.01 | 6.99 | 48.8601 |
| 23 | 29 | 74 | -45 | 2025 | 23 | 7 | 4.76 | 2.24 | 5.0176 |
| 24 | 55 | 75 | -20 | 400 | 24 | 20 | 5.06 | 14.94 | 223.2036 |
| 25 | 41 | 65 | -24 | 576 | 25 | 7 | 4.58 | 2.42 | 5.8564 |
| 26 | 51 | 70 | -19 | 361 | 26 | 15 | 4.45 | 10.55 | 111.3025 |
| 27 | 28 | 66 | -38 | 1444 | 27 | 5 | 4.54 | 0.46 | 0.2116 |
| 28 | 40 | 84 | -44 | 1936 | 28 | 15 | 4.67 | 10.33 | 106.7089 |
| 29 | 55 | 72 | -17 | 289 | 29 | 19 | 4.49 | 14.51 | 210.5401 |
| 30 | 29 | 69 | -40 | 1600 | 30 | 12 | 4.39 | 7.61 | 57.9121 |
| SUM: | | | -1150 | 48090 | SUM: | | | 175.1 | 1854.9542 |
| | | | | | | | | | |
| | t-value: | -0.76874 | | df: 29 | | t-value: | 0.206653 | | df: 29 |
| | P-Value: | 0.4483 | | t-value: 2.045 | | P-Value: | 0.8377 | | t-value: 2.045 |

So according to the statistical analysis (shown above) the p-value for both best fitness and average fitness is not low enough to say that the results are statistically significant. That means that the t-value of -0.76874 and the t-value of 0.206653, computed using the tables given, were not far enough apart from the t-value given of 2.045 to make the difference in the fitness values statistically significant.

## 3.3 EA Configurations

If you want to get the same results you have to change the newSeed variable to 0 (Zero) in the configuration file in order to use the previous seed.

```
1  Random = 0
2  EA = 1
3  newSeed = 1
4
```

```
 5  mu: 20
 6  lambda: 10
 7  penalty: 1
 8  runs: 30
 9  mutation_rate: 0.01
10  fitness_evaluations: 10000
11  prob_log_random: logs/prob3_random_log.txt
12  prob_log_EA: logs/prob3_EA_log.txt
13  number_of_evals_till_termination: 5
14  tournament_size_for_parent_selection: 10
15  tournament_size_for_survival_selection: 10
16  n_for_termination_convergence_criterion: 5
17  prob_solution_random: solutions/prob3_random_solution.txt
18  prob_solution_EA: solutions/prob3_EA_solution.txt
19  seed: time.time()
20
21  selfAdaptive: adaptMutation: 1
22
23  Initialization: Uniform_Random: 1
24
25  Parent_Selection: Uniform_random_parent: 1,
        Fitness_Proportional_Selection: 0, k-
        Tournament_Selection_with_replacement: 0
26
27  Survival_Strategy: plus: 0, comma: 1
28
29  Survival_Selection: Uniform_random_survival: 1, Truncation: 0, k-
        Tournament_Selection_without_replacement: 0
30
31  Termination: Number_of_evals: 0,
        no_change_in_average_population_fitness_for_n_generations: 0,
        no_change_in_best_fitness_in_population_for_n_generations: 1
```

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