CSIP5304 - Fuzzy Logic & Evolutionary Computing
Weekly Exercises 2 - Evolutionary Computing
MSc Artificial Intelligence, 2023-2024

Section I Rosenbrock Function (Benchmark A)

Introduction: Rosenbrock function is one of the several optimization benchmarks used in optimization problems. This report is targeted to the Particle Swarm Optimization problem. It's particularly useful in assessing how well an algorithm can escape local minima and how effectively it can converge to a global minimum in a complex landscape. It is usually symbolized as a parabolic convex graph.

The Particle Swarm Optimization (PSO) Algorithm Code:

The PSO algorithm as shown in the code was used to evaluate the global best, best cost function and convergence of the algorithm, against several parameters as shown below Other parameters will be introduced later in this report.

Parameters	Description	Value
numberVariables	Number of decision variables in the problem	2
maximumIteration	Maximum number of iterations for the algorithm	100
populationSize	This is the size of the population in the swarm	50
inertiaCoefficient	The inertia coefficient is a factor that influences the velocity of each particle in the swarm.	1
wdamp	Parameter that reduces the coefficient of the inertia as it goes through the iteration.	1
tol	determines the acceptable level of accuracy for the solution.	10^-2
velocityControl	controls how drastically particles can change their position in each iteration	0.2

Experiment Setup:

This experiment would be conducted in a **MATLAB** environment, the algorithm will be executed 10 consecutive times and plotted on a graph as a single line chart, the median value will be taken as the accepted optimal result of the benchmark, we would also show convergence on a contour plot for each of our benchmark.

BenchMark A

The benchmark of this algorithm is realized after conducting 10 consecutive trials, the min number of iterations required to meet the acceptable maximum error, the median of these values was recorded, after 10 iterations we got values ranging from **36** - **69** points. The median of this value is seen to be **46**.

Plots:

The **Contour Plot is** shown on **Fig 1.0** We can find the plots of the contour graph as the swarm migrates toward the global best after successive iterations.**Fig 1.2** also shows the linear graph of **10** iterations and the median.

Results: Trials and results.

Table 1.1 showing the benchmark A.

1	2	3	4	5	6	7	8	9	10	Median
39	54	42	36	46	50	51	69	45	41	46

Benchmark B

Effect of parameters: The objective here is to determine the most effective combination by observing patterns through tuning of the parameters involved in the PSO algorithm. In order to reduce inconsistencies in the results, each of these methods was run on the same population, except for the effect of population.

Effect of maxIteration

MaxIt	50	100	150	200	250
Fc	18	26	69	51	47

Table 2.1 shows the effect of several values of Max. Iteration on same population

Effect of population

Pop size	50	100	150	500	1000
Fc	35	38	34	28	6

Table 2.2 shows the effect of population size on the First Convergence point.

Effect of inertia Coeff (Ic)

InCf	-0.5	0.125	0.75	1.375	2
Fc	94	15	14	45	-

Table 2.3 shows the effect of Inertia Coefficient on same population

Effect of personal Acceleration Coefficient (Pac)

Pc	-1	0.25	0.5	1.25	4
Fc	76	16	44	69	14

Table 2.4 shows the effect of Personal acceleration Coefficient.

Effect of social Coeff (Sc)

Sc	-0.5	0.625	1.75	2.875	4
Fc	56	28	24	51	-

Table 2.3 shows the effect of social acceleration Coefficient.

From the results we obtained

1. number of iteration had no consistent effect as we noticed that we had both an increase and decrease in this value,
2. Population, we saw that an increase in population leads to a significant decrease in the first convergence.
3. Inertia coefficient showed its best values within **0.125** and **0.75**
4. Personal coefficient showed **4** to be the best value
5. Social coefficient showed **1.75** to be the best value

New Optimal Parameters

MaxIt	population	Ic	Pac	Sc
50	200	0.75	4	1.75

Table 2.4 best combination of optimal parameters

Plots: Contour Plot

On **Fig 2.0** We can find the plots of the contour graph as the swarm migrates toward the global best, **Fig 2.1** shows the combination of our optimal parameters and the median of these values.

Results: Trials and Result

1	2	3	4	5	6	7	8	9	10	Median
19	32	26	50	41	32	17	12	28	2	27

Table 2.5 median of best combination of optimal parameters

Benchmark C

Effect of Constriction Coefficients:

The constriction coefficients in PSO act as multiplicative factors in updating the velocity equation. The constriction coefficients ensure particles stay within the search space by preventing the explosion of velocity.

Plots: Contour Plot

On **Fig 3.0.** We can find the plots of the contour graph as the swarm migrates toward the global bestFig **3.1** shows the median after 10 iterations.

Results: Trials

1	2	3	4	5	6	7	8	9	10	Median
8	17	17	13	6	6	-	10	37	25	15

Table 3.1 effect of constriction coefficient.

DISCUSSION:

Benchmark A, Showed a moderate efficiency in reaching the acceptable error threshold, with a median of **46** iterations. Standard PSO settings are used for this baseline performance. **Benchmark B** show is slightly decreased Median of **27** indicating that tuning parameters will lead to an increase in performance and then **Benchmark C** was the most efficient in terms of convergence speed, indicating the effectiveness of constriction coefficients in PSO algorithm.

When Comparing the Contour Plots at the 50 iteration of all benchmarks given 4 distinct levels of the plot, it is clear that the visualization in Fig 1.0 and 1.2 suggests a steady convergence of the swarm where by the 50 iteration all particles tend to fall within the second major contour. Although **Benchmark B (Fig 2.2)** shows more population outside the contour, this may be due to the fact that **Benchmark B** was conducted with a larger population Size, For **Benchmark C** at the 50th iteration, there are no particle outside the second prominent contour showing that effect of constriction coefficient of the velocity towards the global minimum.

APPENDIX

Fig1.0 contour plot

The images below show the contour plot of the swarm particle moving towards the global best positioned particle for the Rosenbrock Function in the default parameters.

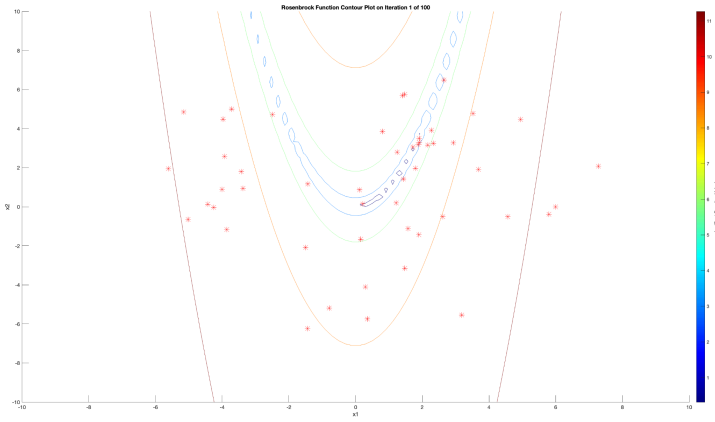

Fig1.a - after 1 iteration

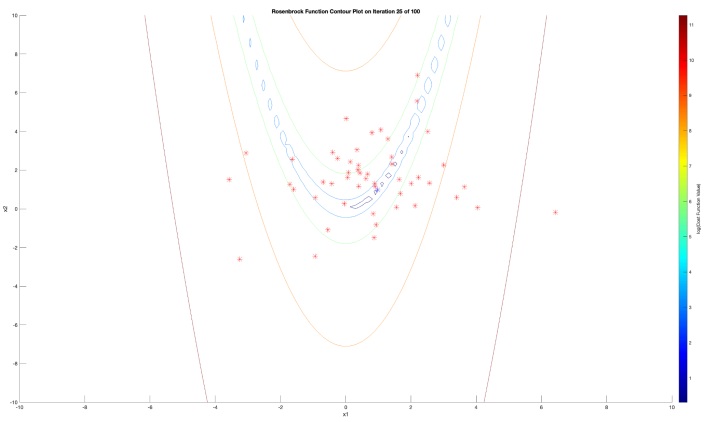

Fig1.b - after 25 iterations

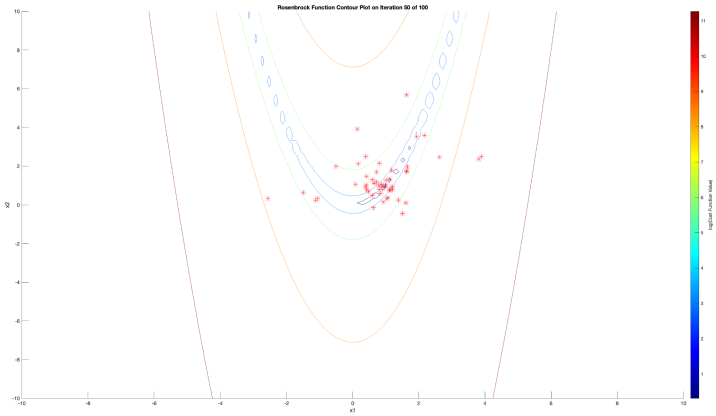

Fig 1.c - after 50 iterations

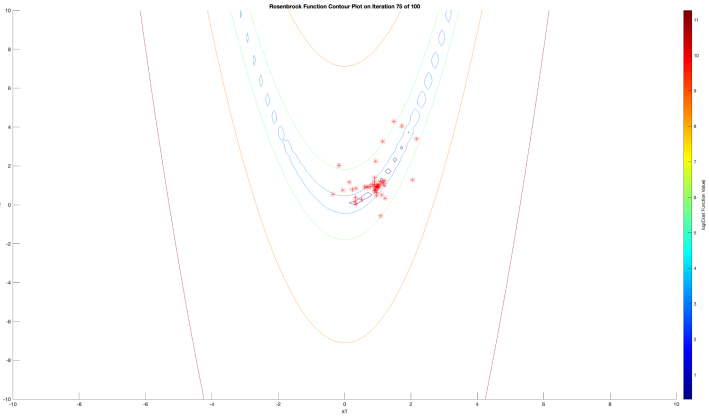

Fig 1.d - after 75 Iterations

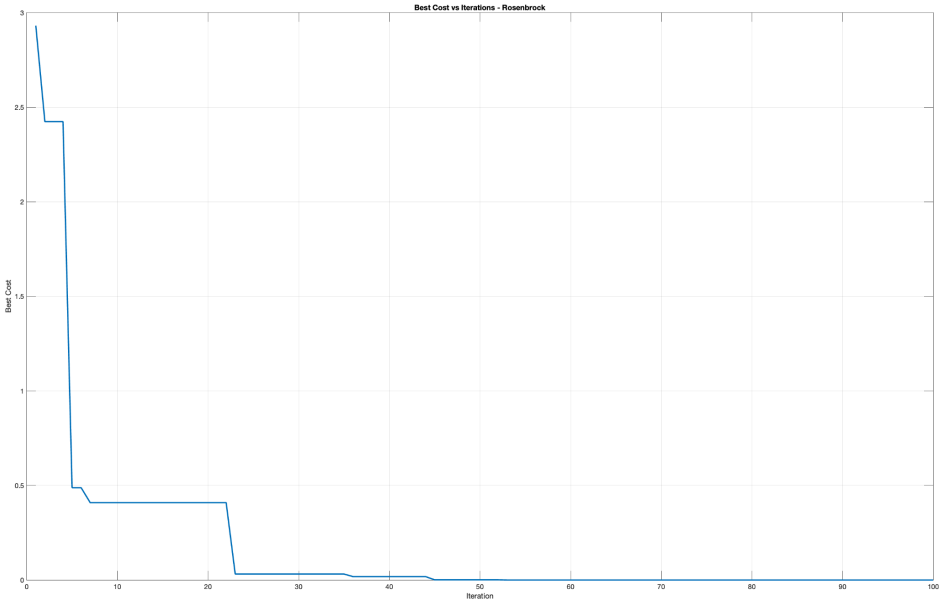

Fig 1.1 Straight line graph showing convergence of the Rosenbrock function

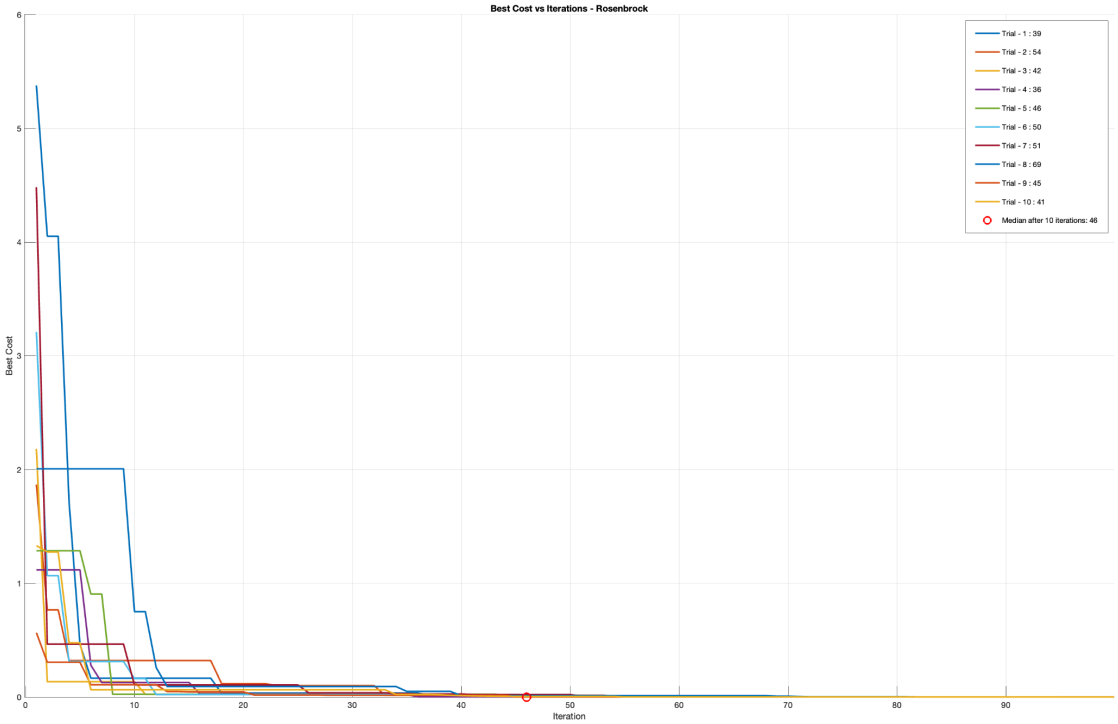

Fig 1.2 Shows the median plot of the Rosenbrock function

Fig 2.0 Shows the effect of parameters on the best cost

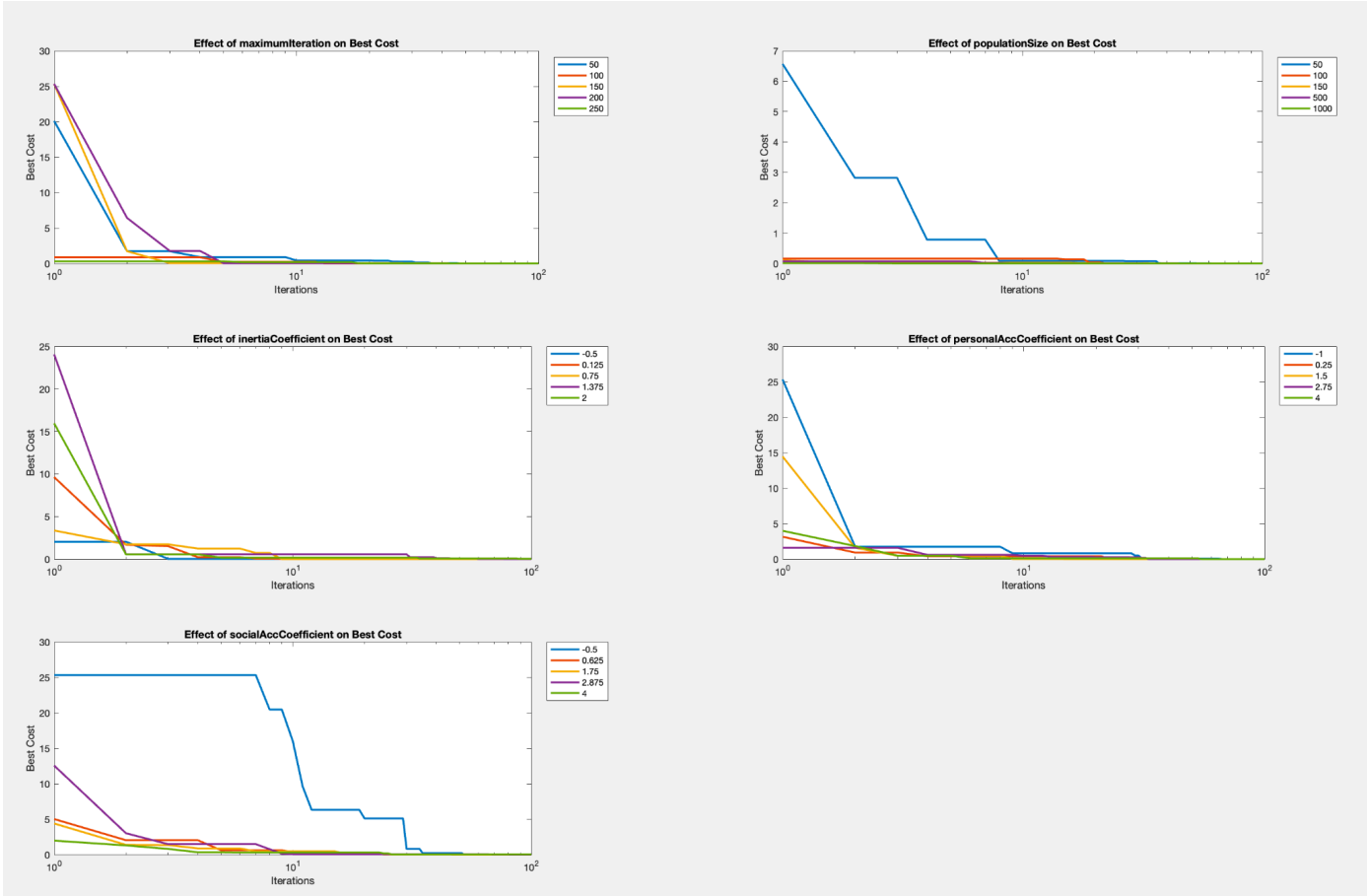

Fig 2.1 Shows the effect of best combination of optimal parameters on the best cost and the median after 10 iterations

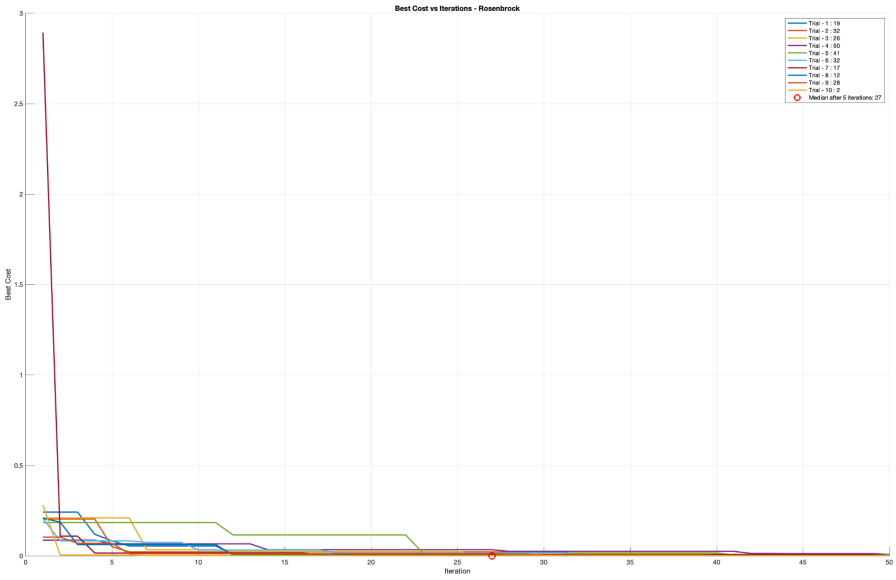

Fig. 2.2a contour plot: after 1 iteration

Fig. 2.2b contour plot: after 20 iterations

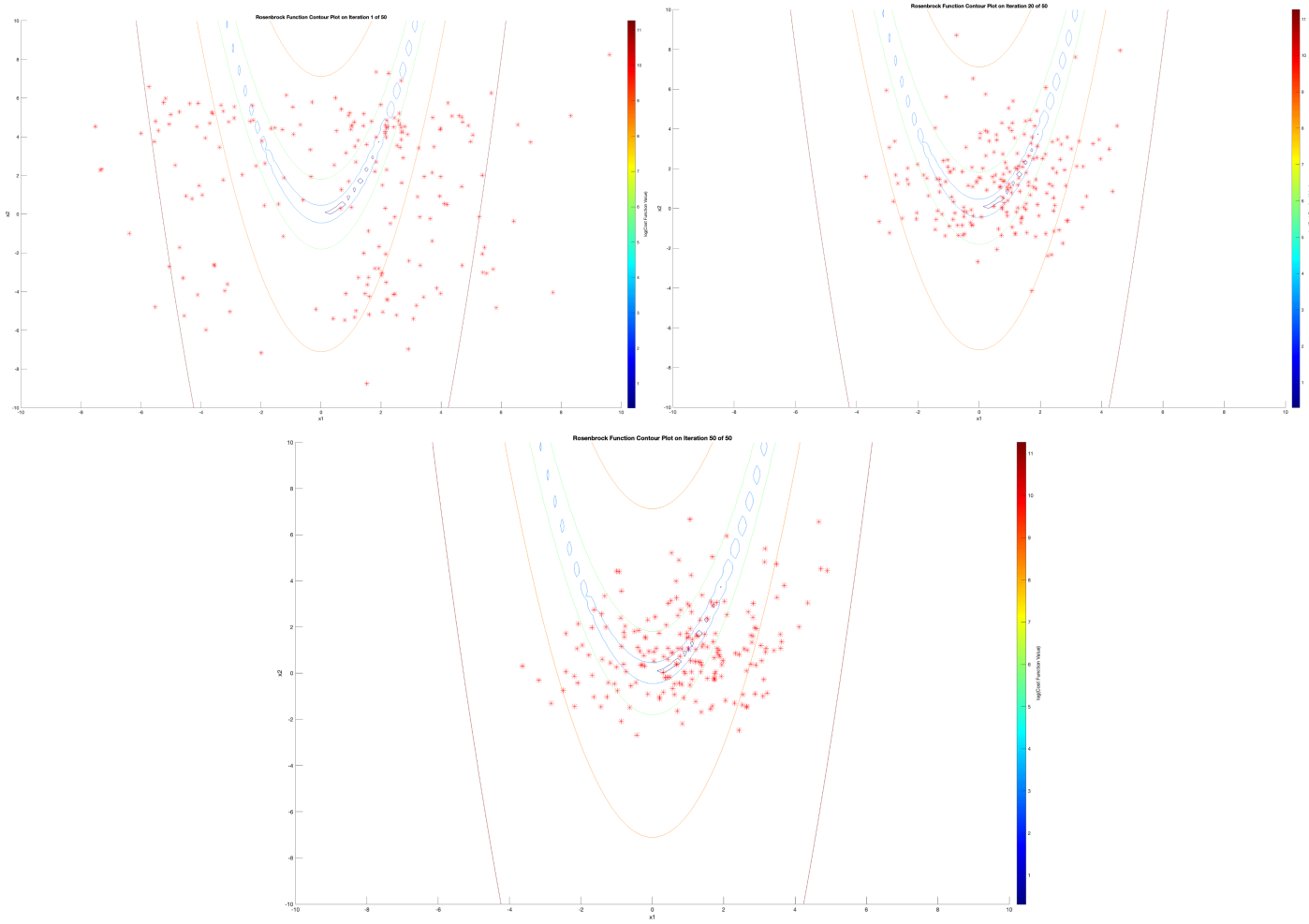

Fig. 2.2c contour plot: after 50 iterations

Fig. 3.0 Contour Plot showing the effect of constriction coefficient on the PSO algorithm:

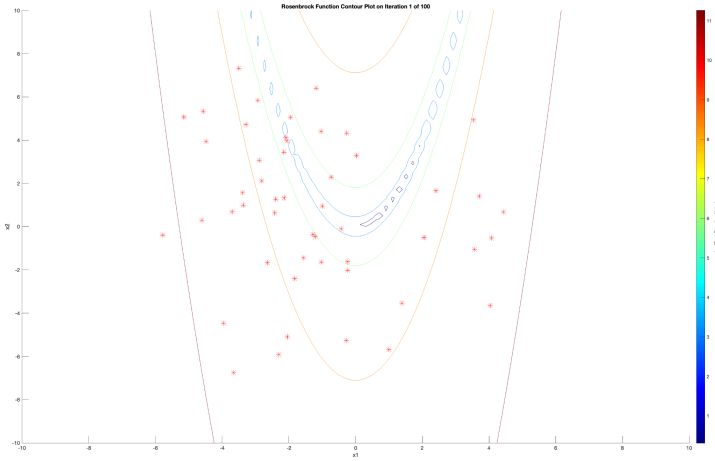

Fig. 3.0a contour plot: after 1 iteration

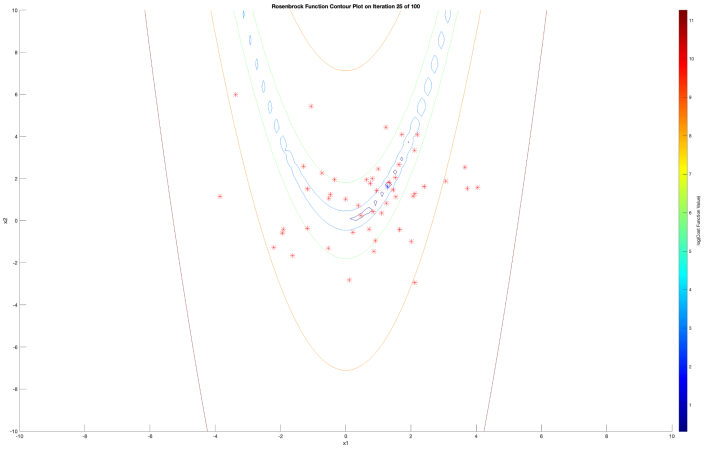

Fig. 3.0b contour plot: after 25 iteration

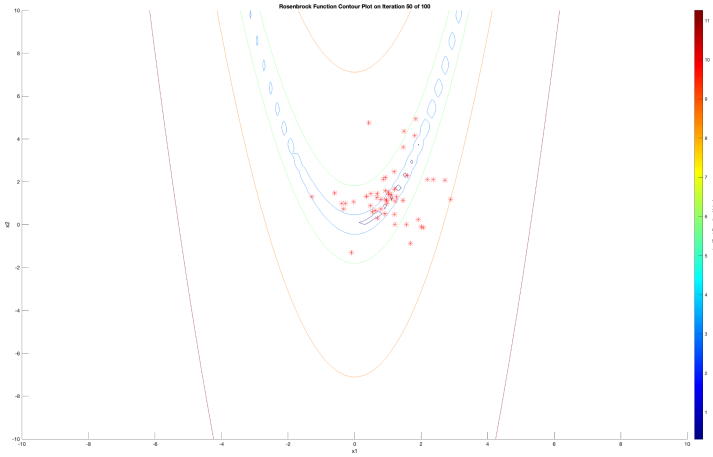

Fig. 3.0c contour plot: after 50 iteration

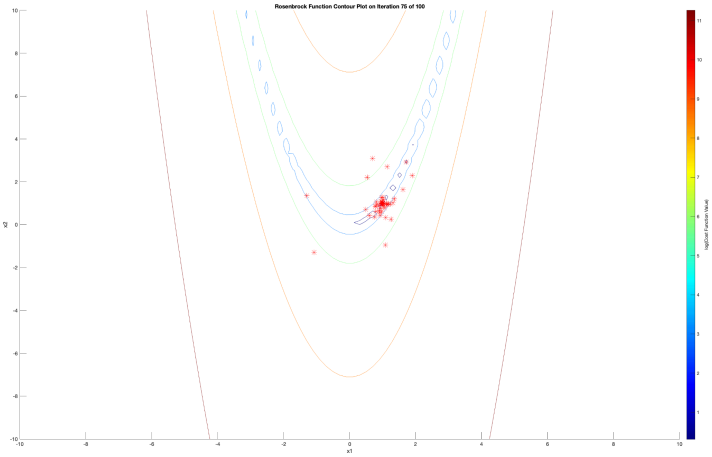

Fig. 3.0d contour plot: after 75 iteration

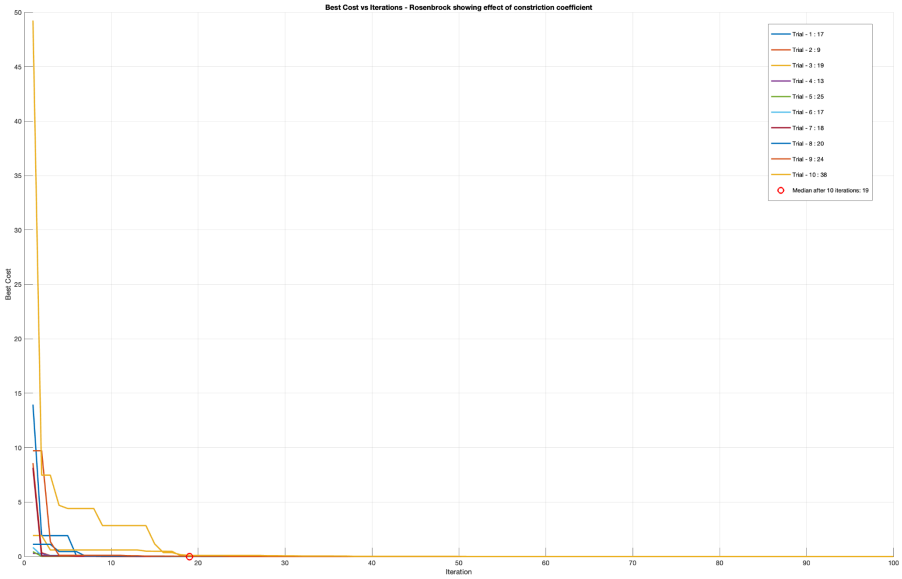

Fig 3.1 shows the benchmark after 10 iterations