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Optimization of nonlinear functions using novel optimization algorithms

A project report submitted for the course

Engineering Optimization (EEE1020)

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Abstract

The optimization is the current need of an hour. Whether it may be the efficient engine model for an automobile, or increasing efficiency in the supply chain network. But, as uncomplicated as these problems appear, there are far too many constraints and the limitations these problems possess. For instance, take the example of a photovoltaic model. A perfectly good linear theoretical model, turns out to be not that efficient for a real life situation. Thus, these issues need to be addressed and researched upon from a very fundamental level. The most significant issue which occurs is the adaptation of any optimization algorithm in order to optimize the given situation across these practical “non-linearities”. Thus, in this project we are going to explore various recently developed algorithms and compare their preciseness in determining such non-linearities. All these non-linearities are stimulated via the means of various test functions, and the models consisting of various algorithms are trained accordingly to fit those functions. These test functions used are highly non-linear, and typically a combination of trigonometric and polynomial variants. Our aim is to explore all these algorithms and try to get the best algorithm to replace the typical gradient based models which works the best for the so called “theoretical” models.

Contents

Introduction

So, let us start with the question, what is optimization? Well, according to the Oxford diction, the process of finding the best possible solution to a problem, is termed as optimization. In mathematics, this often consists of maximizing or minimizing the value of a certain function, perhaps subject to given constraints [1]. The subject grew from a realization that quantitative problems in manifestly different disciplines have important mathematical elements in common. Because of this commonality, many problems can be formulated and solved by using the unified set of ideas and methods that make up the field of optimization [2]. So, now that we know about what optimization is and why it is needed, let us review the current scenario of the same. Most local optimization algorithms are gradient-based. Gradient-based algorithms are widely used for solving a variety of optimization problems in engineering. These techniques are popular because they are efficient (in terms of the number of function evaluations required to find the optimum), they can solve problems with large numbers of design variables, and they typically require little problem-specific parameter tuning. These algorithms, however, also have several drawbacks which include that they can only locate a local optimum, they have difficulty solving discrete optimization problems, they are complex algorithms that are difficult to implement efficiently, and they may be susceptible to numerical noise [3]. So, our aim of the paper is to explore some of the non-gradient based methods, which will be able to get around these drawbacks of solving such complex nonlinear problem functions.

Literature Survey

Reference	Name Of The Paper	Author	Description	Year of publication
[4]	Genetic Algorithm Optimization Problems	S. N. Sivanandam and S. N. Deepa	The paper proposes the various problem statements for which the genetic algorithm can be applied.	2008
[5]	Particle swarm optimization - An overview	R. Polli, J. Kennedy and T. Blackwell	The paper discusses the history and developments that have occurred since the PSO was implemented.	2007
[6]	Simulated annealing	K. A. Downsland and J. Thompson	The paper explains about the use of simulated annealing in innovative fields	2012
[7]	A particle swarm pattern search method for bound constrained global optimization	A. Ismael, F. Vaz and L. Vicente	The paper implements the pattern search optimization for global optimization problems.	2007

[8]	Recent advances in surrogate-based optimization	A. I. J. Forester and A. J. Keane	The paper proposes the recent developments in the surrogate based optimization technique.	2009
[9]	Test problems in optimization	X. S. Yang	The paper proposes various problem statements to check whether the algorithm works fine.	2010
[10]	On test functions for evolutionary algorithms.	T. Okabe, Y. Jin, M. Olhofer and B. Sendhoff	The paper proposes the various test functions which can be used to assess the performance of various evolutionary algorithms.	2004
[11]	Nonlinear optimization using MADS algorithm	S. L. Digabel	The paper proposes a software which implements the pattern search based mesh optimization algorithm.	2010

Background

The paper proposes on comparing five different optimization algorithms on five different test functions. Here is a brief description about the algorithms implemented in this paper, while the test functions will be covered later in this paper.

a) Genetic Algorithm

A genetic algorithm is a search heuristic that is inspired by Charles Darwin's theory of natural evolution. This algorithm reflects the process of natural selection where the fittest individuals are selected for reproduction in order to produce offspring of the next generation. The process of natural selection starts with the selection of fittest individuals from a population. They produce offspring which inherit the characteristics of the parents and will be added to the next generation. If parents have better fitness, their offspring will be better than parents and have a better chance at surviving. This process keeps on iterating and at the end, a generation with the fittest individuals will be found. This notion can be applied for a search problem. We consider a set of solutions for a problem and select the set of best ones out of them. There are five phases considered in the genetic algorithm -

1. Initial population:

The process begins with a set of individuals which is called a Population. Each individual is a solution to the problem you want to solve. An individual is characterized by a set of parameters (variables) known as Genes. Genes are joined into a string to form a Chromosome (solution).
In a genetic algorithm, the set of genes of an individual is represented using a string, in terms of an alphabet. Usually, binary values are used (string of 1s and 0s). We say that we encode the genes in a chromosome.

2. Fitness function:

The fitness function determines how fit an individual is (the ability of an individual to compete with other individuals). It gives a fitness score to each individual. The probability that an individual will be selected for reproduction is based on its fitness score.

3. Selection:

The idea of the selection phase is to select the fittest individuals and let them pass their genes to the next generation. Two pairs of individuals (parents) are selected based on their fitness scores. Individuals with high fitness have more chances to be selected for reproduction.

4. Crossover:

Crossover is the most significant phase in a genetic algorithm. For each pair of parents to be mated, a crossover point is chosen at random from within the genes. Offspring are created by exchanging the genes of parents among themselves until the crossover point is reached. The new offspring are added to the population.

5. Mutation:

In certain new offspring formed, some of their genes can be subjected to a mutation with a low random probability. This implies that some of the bits in the bit string can be flipped. In certain new offspring formed, some of their genes can be subjected to a mutation with a low random probability. This implies that some of the bits in the bit string can be flipped. Mutation occurs to maintain diversity within the population and prevent premature convergence.

Termination:

The algorithm terminates if the population has converged (does not produce offspring which are significantly different from the previous generation). Then it is said that the genetic algorithm has provided a set of solutions to our problem.

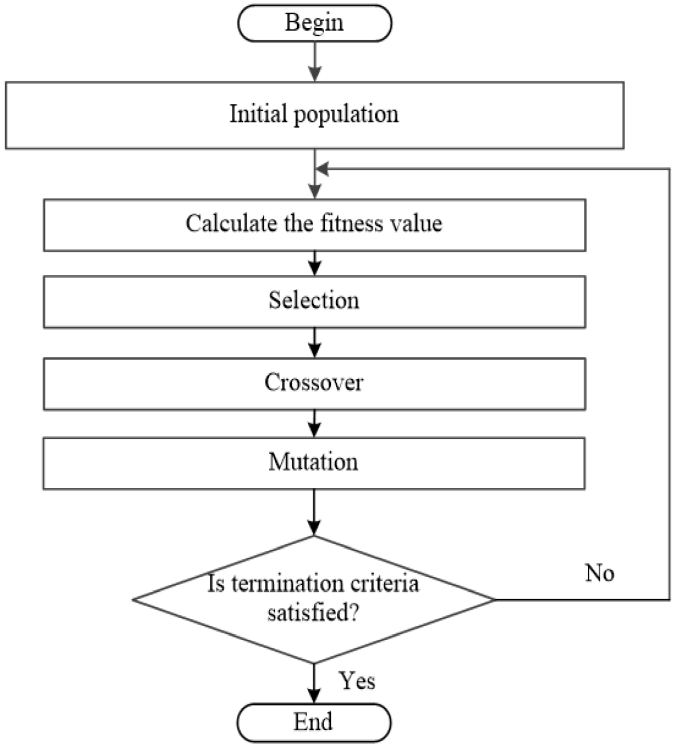

Figure 1 - Flowchart of genetic optimization algorithm

b) Particle Swarm Optimization

In computational science, particle swarm optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. It solves a problem by having a population of candidate solutions, here dubbed particles, and moving these particles around in the search-space according to a simple mathematical formula over the particle's position and velocity. Each particle's movement is influenced by its local best known position, but is also guided toward the best known positions in the search-space, which are updated as better positions are found by other particles. This is expected to move the swarm toward the best solutions. PSO is a metaheuristic as it makes few or no assumptions about the problem being optimized and can search very large spaces of candidate solutions. Also, PSO does not use the gradient of the problem being optimized, which means PSO does not require that the optimization problem be differentiable as is required by classic optimization methods such as gradient descent and quasi-newton methods. A basic variant of the PSO algorithm works by having a population (called a swarm) of candidate solutions (called

particles). These particles are moved around in the search-space according to a few simple formulae. The movements of the particles are guided by their own best-known position in the search-space as well as the entire swarm's best-known position. When improved positions are being discovered these will then come to guide the movements of the swarm. The process is repeated and by doing so it is hoped, but not guaranteed, that a satisfactory solution will eventually be discovered.

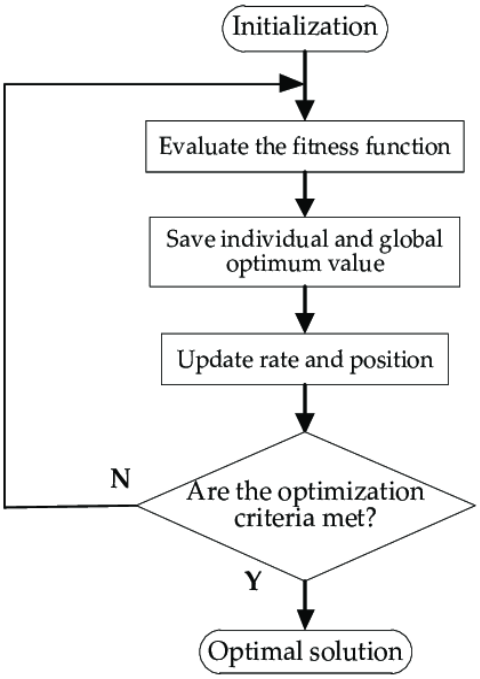

Figure 2 - Flowchart of particle swarm optimization algorithm

c) Simulated Annealing

The Simulated Annealing algorithm is based upon Physical Annealing in real life. Physical Annealing is the process of heating up a material until it reaches an annealing temperature and then it will be cooled down slowly in order to change the material to a desired structure. When the material is hot, the molecular structure is weaker and is more susceptible to change. When the material cools down, the molecular structure is harder and is less susceptible to change.

Simulated Annealing (SA) mimics the Physical Annealing process but is used for optimizing parameters in a model. This process is very useful for situations where there are a lot of local minima such that algorithms like Gradient Descent would be stuck at.

Step 1:

We first start with an initial solution $s = S_0$. This can be any solution that fits the criteria for an acceptable solution. We also start with an initial temperature $t = t_0$.

Step 2:

Setup a temperature reduction function *alpha*. There are usually 3 main types of temperature reduction rules:

1. Linear Reduction Rule: $t = t - \alpha$
2. Geometric Reduction Rule: $t = t * \alpha$
3. Slow-Decrease Rule: $t = \frac{t}{1+\beta t}$

Each reduction rule reduces the temperature at a different rate and each method is better at optimizing a different type of model. For the 3rd rule, *beta* is an arbitrary constant.

Step 3:

Starting at the initial temperature, loop through n iterations of Step 4 and then decrease the temperature according to alpha. Stop this loop until the termination conditions are reached. The termination conditions could be reaching some end temperature, reaching some acceptable threshold of performance for a given set of parameters, etc. The mapping of time to temperature and how fast the temperature decreases is called the Annealing Schedule.

Step 4:

Given the neighbourhood of solutions *N(s)*, pick one of the solutions and calculate the difference in cost between the old solution and the new neighbour solution. The neighbourhood of a solution are all solutions that are close to the solution. For example, the neighbourhood of a set of 5 parameters might be if we were to change one of the five parameters but kept the remaining four the same.

Step 5:

If the difference in cost between the old and new solution is greater than 0 (the new solution is better), then accept the new solution. If the difference in cost is less than 0 (the old solution is better), then generate a random number between 0 and 1 and accept it if it's under the value calculated from the constraint equation.

d) Pattern Search Optimization

Pattern search (also known as direct search, derivative-free search, or black-box search) is a family of numerical optimization methods that does not require a gradient. As a result, it can be used on functions that are not continuous or differentiable. Optimization attempts to find the best match (the solution that has the lowest error value) in a multidimensional analysis space of possibilities. Convergence is a pattern search method proposed by Yu, who proved that it converges using the theory of positive bases. Later, Torczon, Lagarias and co-authors used positive-basis techniques to prove the convergence of another pattern-search method on specific classes of functions. Outside of such classes, pattern search is a heuristic that can provide useful approximate solutions for some issues, but can fail on others. Outside of such classes, pattern search is not an iterative method that converges to a solution; indeed, pattern-search methods can converge to non-stationary points on some relatively tame problems. The mesh based convergence is based on the same concept. The mesh is basically a grid of coordinates, where the search of optimization takes place. Whenever a mesh contains an optimum point, the mesh size decreases in order to increase the resolution and preciseness to the solution. If not, then the mesh size is either moved or the mesh size is increased.

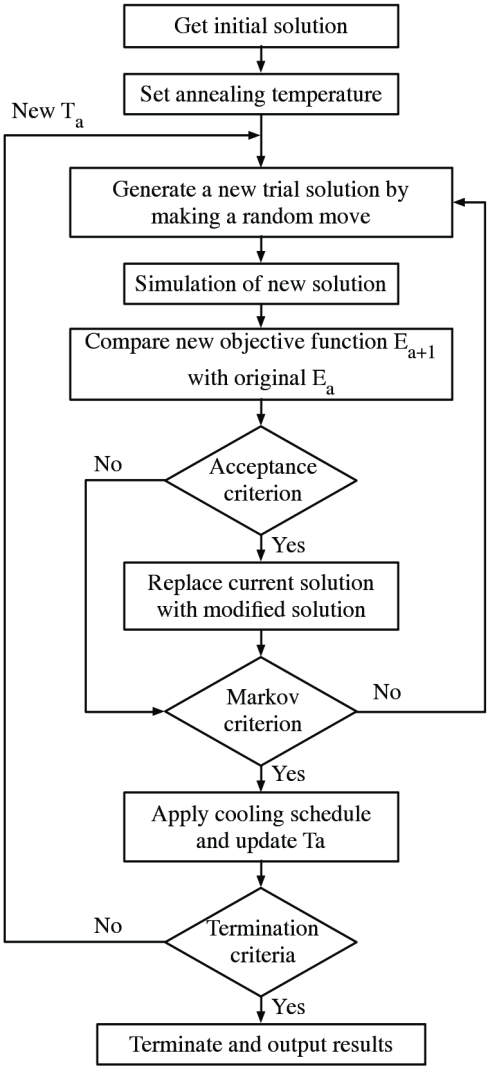

Figure 3 - Flowchart for simulated annealing algorithm

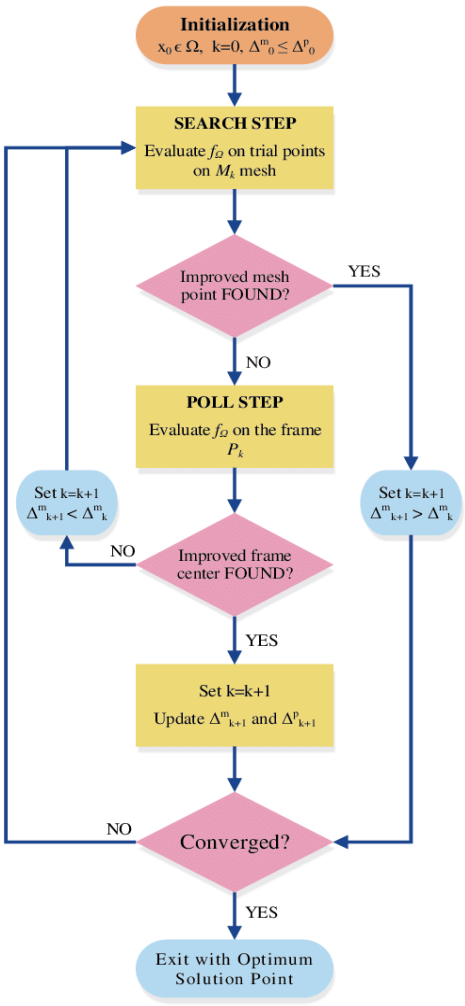

Figure 4 - Flowchart for mesh algorithm

e) Surrogate Based Optimization

Since calling computer simulations really slows down the optimization process, why not replace expensive simulations with a pre-trained statistical model to accurately approximate the objective function, given the same design parameters? Would that help gain optimization efficiency? That's exactly the basic idea of the surrogate optimization strategy. In the engineering domain, that statistical model is formally known as the surrogate model. Essentially, a surrogate model is a statistical model that can accurately approximate a function's output given the inputs. In general, a single evaluation of the surrogate model is much faster than a single evaluation of the original expensive computer simulation. As a result, performing hundreds and thousands of

output evaluations given various combinations of design parameters would no longer be a problem. This feature enables us to freely explore the "landscape" of the objective function, therefore significantly accelerating the optimization speed. Surrogate optimization cannot be achieved without a surrogate model. Training a surrogate model usually follows these steps:

Step 1:

First of all, we need to collect labeled training data. Toward that end, we probe the objective function at several intelligently selected locations in the design parameter space. At each of these locations, a full simulation is conducted to calculate the corresponding objective values. Later, we assemble the pairs of inputs (design parameters) and their outputs (objective values) into a training dataset.

Step 2:

Second, we need to select the model type. Popular choices include polynomial regressions, support vector machines, Gaussian Processes, neural networks, etc. Here, we could follow the established model selection practices in supervised machine learning.

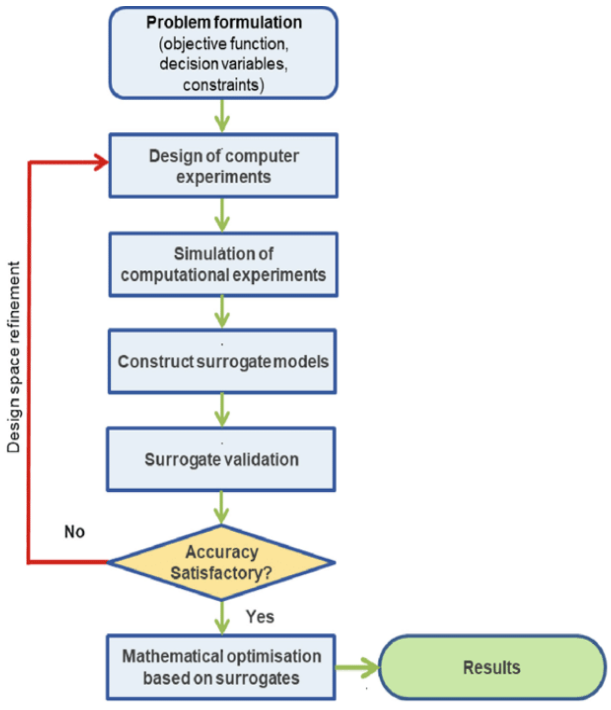

Figure 5 - Flowchart for surrogate optimization algorithm

SIMULATIONS

The above-mentioned algorithms were simulated on the MATLAB R2021b version. The algorithms were tested on five different test functions. The test functions and their domains are summarised in the tabular chart mentioned below -

Table 1 - Summary of test functions			
Sr. No.	**Name of the function**	**Search Domain**	**Minima (x1, x2)**
1.	Ackley	[-35, 35]	(0,0)
2.	Booth	[-35, 35]	(1,3)
3.	Egg Holder	[-35, 35]	(-35,35)
4.	Leon	[-35, 35]	(1,1)
5.	Trigonometric	[-35, 35]	(±2n**π**,±2n**π**)

$$f(\mathbf{x}) = -a\exp\left(-b\sqrt{\frac{1}{d}\sum_{i=1}^{d}x_i^2}\right) - \exp\left(\frac{1}{d}\sum_{i=1}^{d}\cos(cx_i)\right) + a + \exp(1)$$

Figure 6 - Ackley Function

$$f(x,y) = (x+2y-7)^2 + (2x+y-5)^2$$

Figure 7 - Booth Function

$$f(x,y) = -(y+47)\cdot sin\sqrt{\left|\frac{x}{2}+(y+47)\right|} - x\cdot sin\sqrt{|x-(y+47)|}$$

Figure 8 - Egg Holder Function for domain (-47,47)

$$f(x,y) = 100(y-x^3)^2 + (1-x)^2$$

Figure 9 - Leon Function

The summary of the simulated results is mentioned below -

Table 2 - Summary of simulations: obtained global minima						
Sr. No.	**Algorithm**	**Ackley**	**Booth**	**Egg Holder**	**Leon**	**Trigonometric**
1.	**Genetic**	(6e-6, 5e-5)	(1,3)	(-35,35)	(0.88,0.68)	(-24.88,-11.95)
2.	**PSO**	(-4e-13, 1e-12)	(0.9997,3)	(-35,35)	(-18.63,27.9)	(12.57,18.84)
3.	**Simulated Annealing**	(-4e-7, 9e-7)	(0.99,3.02)	(-34.999,35)	(1.01,1.05)	(-18.6,-30.8)
4.	**Pattern Search**	(0,0)	(1,3)	(8.46, 15.65)	(0.74,0.4)	(31.42,31.42)
5.	**Surrogate**	(0,0)	(-1.09,3.82)	(-35,35)	(0,0)	(0,0)

CONCLUSION

The following conclusions were drawn from the observations:

1. The evolutionary algorithms, such as genetic and particle swarm optimization tend to give more precise minimum function values, especially when the function is sinusoidal in nature.

2. The simulated annealing algorithm took a lot of time to obtain the minima, as the process of annealing took about 1000+ iterations on an average, yet able to perform as precisely as the evolutionary algorithms.

3. The pattern search algorithm worked the best for exponential and almost linear functions. The duration taken to determine the minima of such functions was quite less as compared to the other algorithms, moreover giving the most optimum function value as compared to others. Although, the function fails to deliver if the extent of nonlinearity increases, or the function is sinusoidal.

4. The surrogate algorithm turns out to be the worst performing algorithm, which is because of the fact that it is as slow as the simulated annealing procedure and still unable to deliver the results which were expected. The major reason for the failure comes back to how adaptive the surrogate parent is. Thus, the performance can be improved if the surrogate is a highly efficient neural network or optimization algorithm.

Thus, we conclude that the evolutionary algorithms are the far the best algorithms which can be applied to all the real world scenarios.

The only problem lacking in the implementation is the lack of availability of technology which may be able to integrate such efficient algorithms at a mass scale without compromising the time performance of the algorithm. To achieve that, firm hardware and system requirements need to be fulfilled and while those requirements are achieved, the basic architecture of the processing units need to be optimised in such a way that it effectively balances out the performance and the affordability of the product. Thus, the future scope of the project will be the research for the best solutions which are able to satisfy all the requirements mentioned before.

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```
nvar = 2
```

```
nvar = 2
```

```
fun = @
```

```
fun = function_handle with value:
    @ackley
```

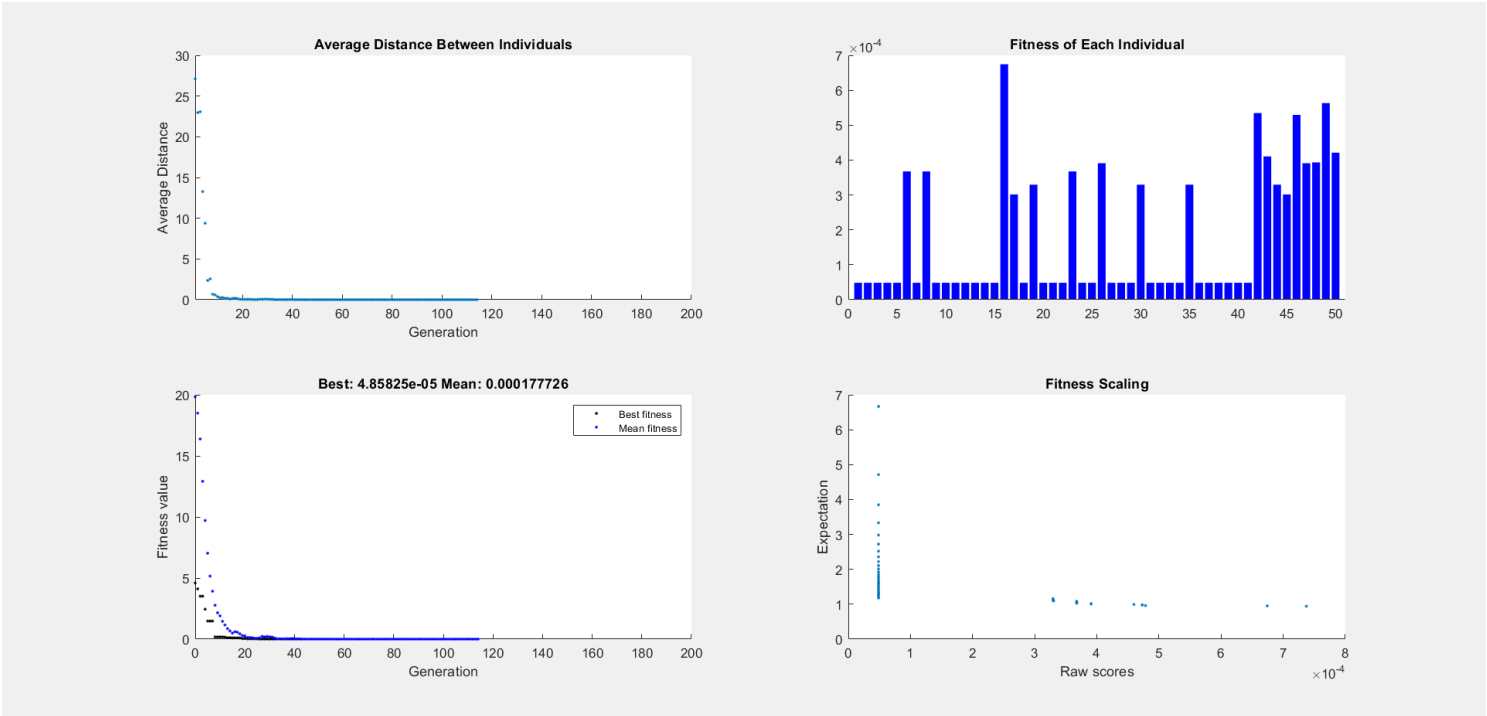
```
% Set nondefault solver options
options = optimoptions("ga","Display","iter","PlotFcn",["gaplotdistance",...
    "gaplotscores","gaplotbestf","gaplotexpectation"]);

% Solve
[solution,objectiveValue] = ga(fun,nvar,[],[],[],[],repmat(-35,nvar,1),...
    repmat(35,nvar,1),[],[],options);
```

```
Single objective optimization:
2 Variable(s)

Options:
CreationFcn:       @gacreationuniform
CrossoverFcn:      @crossoverscattered
SelectionFcn:      @selectionstochunif
MutationFcn:       @mutationadaptfeasible

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
    1              100           4.112           18.5        0
    2              147           3.513          16.38        0
    3              194           3.513          12.92        1
    4              241           2.447           9.71        0
    5              288           1.479          7.032        0
    6              335           1.479          5.157        1
    7              382           1.479          3.916        2
    8              429          0.1784          2.771        0
    9              476          0.1784          2.158        1
   10              523          0.1784          1.902        2
   11              570          0.1784          1.459        3
   12              617           0.162          1.161        0
   13              664          0.1128         0.8597        0
   14              711          0.1128          0.669        1
   15              758          0.1022         0.4898        0
   16              805          0.1022         0.6064        1
   17              852          0.1022         0.5562        2
   18              899          0.1022         0.4348        3
   19              946         0.04714         0.2925        0
   20              993         0.04714         0.2445        1
   21             1040         0.02644         0.1363        0
   22             1087         0.02644          0.139        1
   23             1134         0.02644         0.1157        2
   24             1181         0.01937        0.07566        0
   25             1228         0.01849        0.06549        0
   26             1275        0.009089         0.1066        0
   27             1322        0.009089         0.2274        1
   28             1369        0.007235         0.1839        0
   29             1416        0.007235         0.2135        1
   30             1463        0.007235         0.1889        2

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
```

31	1510	0.007235	0.1641	3
32	1557	0.007235	0.08397	4
33	1604	0.007235	0.02909	5
34	1651	0.007203	0.02534	0
35	1698	0.006353	0.02576	0
36	1745	0.004703	0.02488	0
37	1792	0.004703	0.0349	1
38	1839	0.003769	0.03748	0
39	1886	0.003769	0.04806	1
40	1933	0.003769	0.04786	2
41	1980	0.003769	0.02484	3
42	2027	0.003769	0.01784	4
43	2074	0.001926	0.0119	0
44	2121	0.001926	0.007491	1
45	2168	0.00192	0.005803	0
46	2215	0.00192	0.005428	1
47	2262	0.00192	0.004119	2
48	2309	0.001067	0.003607	0
49	2356	0.001057	0.003141	0
50	2403	0.001057	0.004223	1
51	2450	0.001057	0.003352	2
52	2497	0.001057	0.002679	3
53	2544	0.000469	0.001947	0
54	2591	0.000469	0.002049	1
55	2638	0.0004612	0.001343	0
56	2685	0.0004612	0.001284	1
57	2732	0.0003945	0.001062	0
58	2779	0.0003945	0.001196	1
59	2826	0.0003488	0.0009886	0
60	2873	0.0003161	0.001231	0

Generation	Func-count	Best f(x)	Mean f(x)	Stall Generations
61	2920	0.0003161	0.001952	1
62	2967	0.0003161	0.001647	2
63	3014	0.0003161	0.001143	3
64	3061	4.858e-05	0.0007279	0
65	3108	4.858e-05	0.0007085	1
66	3155	4.858e-05	0.0006227	2
67	3202	4.858e-05	0.0004558	3
68	3249	4.858e-05	0.000298	4
69	3296	4.858e-05	0.0002681	5
70	3343	4.858e-05	0.0002346	6
71	3390	4.858e-05	0.0002215	7
72	3437	4.858e-05	0.0001763	8
73	3484	4.858e-05	0.0001939	9
74	3531	4.858e-05	0.0001654	10
75	3578	4.858e-05	0.0001785	11
76	3625	4.858e-05	0.0001819	12
77	3672	4.858e-05	0.0001761	13
78	3719	4.858e-05	0.0001549	14
79	3766	4.858e-05	0.0001386	15
80	3813	4.858e-05	0.0001492	16
81	3860	4.858e-05	0.0001582	17
82	3907	4.858e-05	0.0001679	18
83	3954	4.858e-05	0.0001914	19
84	4001	4.858e-05	0.0002037	20
85	4048	4.858e-05	0.0002069	21
86	4095	4.858e-05	0.0002074	22
87	4142	4.858e-05	0.0002051	23
88	4189	4.858e-05	0.0001683	24
89	4236	4.858e-05	0.0001616	25
90	4283	4.858e-05	0.000162	26

```
                                Best          Mean      Stall
Generation      Func-count       f(x)          f(x)    Generations
    91            4330       4.858e-05      0.0001817      27
    92            4377       4.858e-05      0.0001641      28
    93            4424       4.858e-05      0.0001487      29
    94            4471       4.858e-05      0.0001433      30
    95            4518       4.858e-05      0.0001541      31
    96            4565       4.858e-05      0.0001599      32
    97            4612       4.858e-05      0.0001534      33
    98            4659       4.858e-05      0.0001563      34
    99            4706       4.858e-05      0.0001418      35
   100            4753       4.858e-05      0.0001492      36
   101            4800       4.858e-05      0.0001655      37
   102            4847       4.858e-05      0.0001843      38
   103            4894       4.858e-05      0.0001793      39
   104            4941       4.858e-05      0.0001875      40
   105            4988       4.858e-05      0.0001518      41
   106            5035       4.858e-05      0.0001499      42
   107            5082       4.858e-05      0.0001577      43
   108            5129       4.858e-05      0.0001632      44
   109            5176       4.858e-05      0.0001782      45
   110            5223       4.858e-05      0.0001864      46
   111            5270       4.858e-05       0.000196      47
   112            5317       4.858e-05      0.0001757      48
   113            5364       4.858e-05      0.0001824      49
   114            5411       4.858e-05      0.0001777      50
Optimization terminated: average change in the fitness value less than options.FunctionTolerance.
```




```
% Clear variables
clearvars options
```

```
disp(['Solution = ',num2str(solution)])
```

```
Solution = 6.7649e-06  1.5785e-05
```

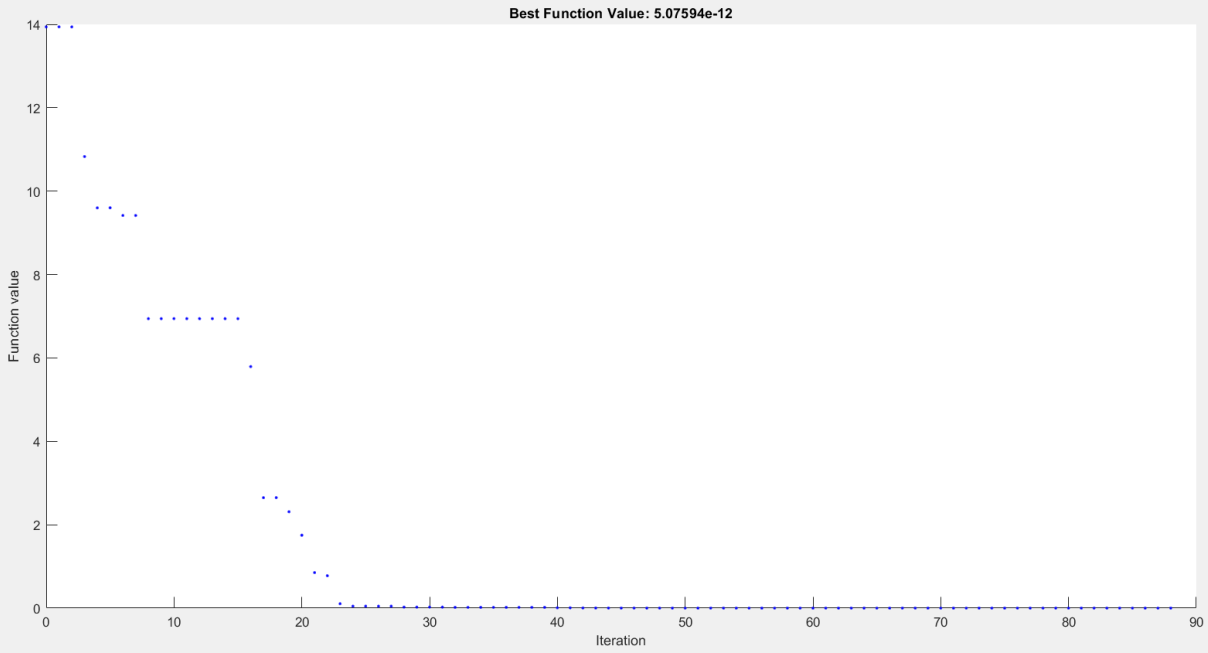
```
disp(['Function value = ', num2str(objectiveValue)])
```

```
Function value = 4.8583e-05
```

```
% Set nondefault solver options
options3 = optimoptions("particleswarm","Display","iter","PlotFcn",...
    "pswplotbestf");

% Solve
[solution2,objectiveValue2] = particleswarm(fun,nvar,repmat(-35,nvar,1),...
    repmat(35,nvar,1),options3);
```

```
                              Best           Mean     Stall
Iteration     f-count          f(x)           f(x)    Iterations
    0             20          13.94           20.5        0
    1             40          13.94          20.17        0
    2             60          13.94          19.93        1
    3             80          10.83          20.02        0
    4            100          9.599          20.19        0
    5            120          9.599          20.78        1
    6            140          9.416          19.61        0
    7            160          9.416           20.7        1
    8            180          6.942          19.73        0
    9            200          6.942          20.49        1
   10            220          6.942          20.05        2
   11            240          6.942          20.41        3
   12            260          6.942          19.89        4
   13            280          6.942           20.1        5
   14            300          6.942          20.08        6
   15            320          6.942           20.3        7
   16            340          5.792          16.29        0
   17            360          2.649          13.73        0
   18            380          2.649          10.36        1
   19            400          2.311          7.571        0
   20            420          1.749          5.068        0
   21            440         0.8513          3.531        0
   22            460          0.777          2.658        0
   23            480         0.1053          1.732        0
   24            500        0.04668           1.29        0
   25            520        0.04668          1.034        1
   26            540          0.046         0.9306        0
   27            560          0.046          1.127        1
   28            580        0.02486           1.15        0
   29            600        0.02486          1.178        1
   30            620        0.02486          1.577        2

                              Best           Mean     Stall
Iteration     f-count          f(x)           f(x)    Iterations
   31            640        0.02486          1.704        3
   32            660        0.01802          1.617        0
   33            680        0.01802          1.789        1
   34            700        0.01802          1.859        2
   35            720        0.01802          2.349        3
   36            740        0.01802          2.114        4
   37            760        0.01802          2.022        5
   38            780        0.01802          1.438        6
   39            800        0.01802         0.6297        7
   40            820       0.008393         0.5131        0
   41            840       0.007095           0.39        0
   42            860       0.004796          0.139        0
   43            880       0.002667        0.06652        0
```

```
   44            900        0.002667         0.02808        1
   45            920        0.001659         0.01552        0
   46            940        0.001659        0.008616        1
   47            960        0.001036        0.005633        0
   48            980       0.0008339         0.00278        0
   49           1000       0.0003043        0.001935        0
   50           1020       0.0002087        0.001288        0
   51           1040       0.0001447       0.0008099        0
   52           1060       0.0001145       0.0005135        0
   53           1080       7.309e-05       0.0003449        0
   54           1100        5.12e-05       0.0004495        0
   55           1120       1.011e-05       0.0003437        0
   56           1140       1.011e-05       0.0005096        1
   57           1160       1.011e-05       0.0004396        2
   58           1180       1.011e-05       0.0006164        3
   59           1200       1.011e-05       0.0005545        4
   60           1220       1.011e-05       0.0007114        5

                              Best            Mean     Stall
Iteration     f-count          f(x)            f(x)    Iterations
   61            1240       1.011e-05       0.0007046        6
   62            1260       5.444e-06       0.0005017        0
   63            1280       5.444e-06       0.0004332        1
   64            1300       5.444e-06       0.0003082        2
   65            1320       5.444e-06       0.0001383        3
   66            1340       5.444e-06       9.967e-05        4
   67            1360       3.313e-06       4.528e-05        0
   68            1380       2.818e-06       2.466e-05        0
   69            1400       8.871e-07       1.524e-05        0
   70            1420       8.871e-07       7.401e-06        1
   71            1440       6.792e-07       3.959e-06        0
   72            1460       4.077e-07       2.564e-06        0
   73            1480        2.03e-07       1.585e-06        0
   74            1500       3.198e-08        8.64e-07        0
   75            1520       3.198e-08       4.704e-07        1
   76            1540       1.769e-08       2.637e-07        0
   77            1560       1.769e-08       1.246e-07        1
   78            1580       5.385e-09       5.335e-08        0
   79            1600       5.385e-09       3.116e-08        1
   80            1620       1.899e-09       1.586e-08        0
   81            1640       9.054e-10       9.324e-09        0
   82            1660       1.763e-10       4.517e-09        0
   83            1680       1.763e-10       3.668e-09        1
   84            1700       1.763e-10       2.076e-09        2
   85            1720       1.763e-10       1.535e-09        3
   86            1740        4.49e-11        8.32e-10        0
   87            1760        4.49e-11          4.8e-10       1
   88            1780       5.076e-12       2.247e-10        0
Optimization ended: relative change in the objective value
over the last OPTIONS.MaxStallIterations iterations is less than OPTIONS.FunctionTolerance.
```




```
% Clear variables
clearvars options3
```

```
disp(['Solution = ',num2str(solution2)])
```

```
Solution = -4.1747e-13  1.7458e-12
```

```
disp(['Function value = ', num2str(objectiveValue2)])
```

```
Function value = 5.0759e-12
```

```
x0 = [-0.5, -0.5]
```

```
x0 = 1×2
   -0.5000   -0.5000
```

```
% Set nondefault solver options
options4 = optimoptions("simulannealbnd","Display","iter","PlotFcn",...
    ["saplotbestf","saplotbestx","saplotf","saplottemperature"]);

% Solve
[solution3,objectiveValue3] = simulannealbnd(fun,x0,repmat(-35,size(x0)),...
    repmat(35,size(x0)),options4);
```

```
                          Best        Current           Mean
Iteration    f-count       f(x)         f(x)        temperature
     0          1        4.25365       4.25365           100
    10         11        3.27413       20.1472          56.88
    20         21        3.27413        21.731         34.0562
    30         31        3.27413       20.2143         20.3907
```

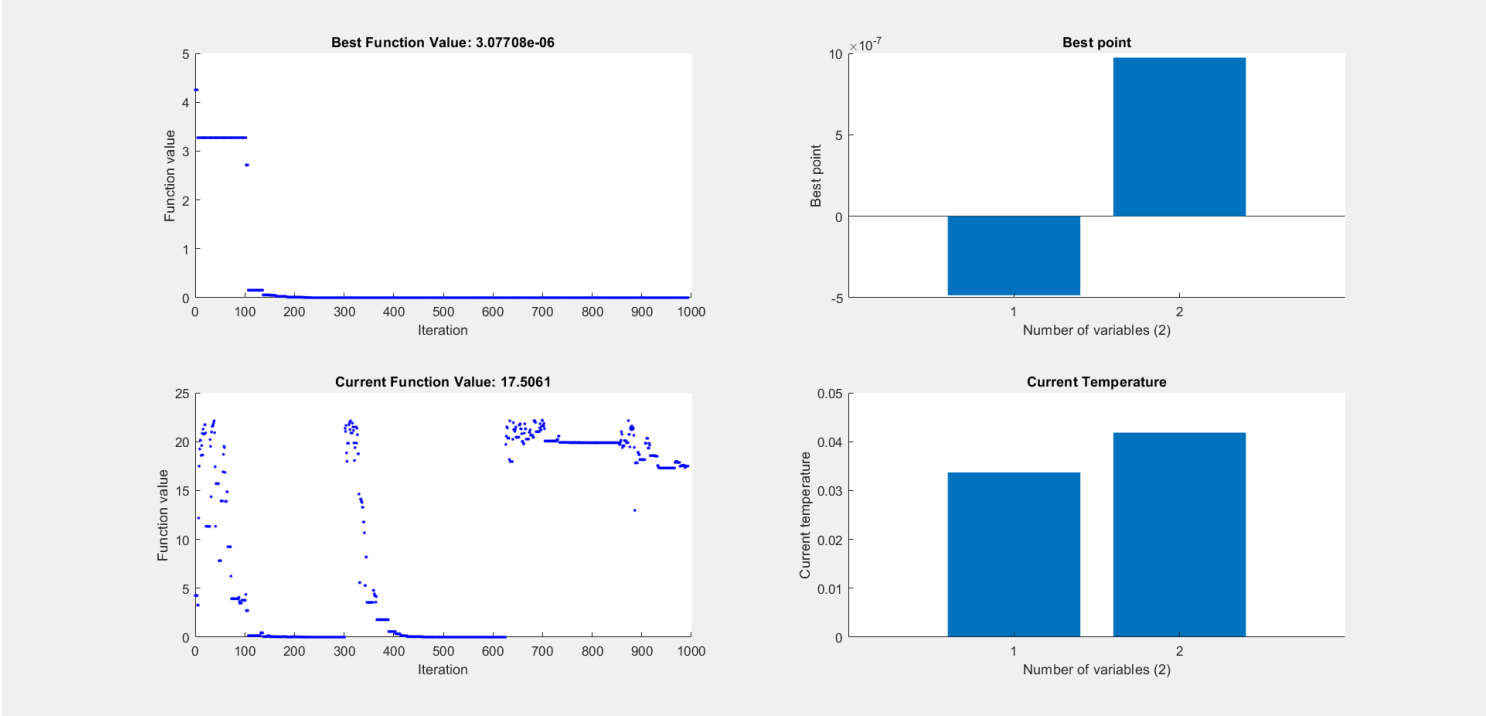
40	41	3.27413	17.4336	12.2087
50	51	3.27413	7.81866	7.30977
60	61	3.27413	16.858	4.37663
70	71	3.27413	9.24289	2.62045
80	81	3.27413	3.92853	1.56896
90	91	3.27413	3.44939	0.939395
100	101	3.27413	3.77072	0.56245
110	111	0.152808	0.152808	0.33676
120	121	0.152808	0.152808	0.201631
130	131	0.152808	0.152808	0.120724
140	141	0.0566163	0.0566163	0.0722817
150	151	0.0566163	0.138321	0.0432777
160	161	0.0484329	0.0484329	0.025912
170	171	0.0269049	0.0314376	0.0155145
180	181	0.0269049	0.0648147	0.00928908
190	191	0.0104534	0.0106641	0.00556171
200	201	0.0104534	0.0309466	0.00333
210	211	0.0104534	0.0192697	0.0019938
220	221	0.00374899	0.00374899	0.00119376
230	231	0.00127003	0.00235327	0.000714748
240	241	0.000166722	0.00144305	0.000427946
250	251	0.000166722	0.000484671	0.000256227
260	261	0.000166722	0.000484671	0.000153413
270	271	0.00010286	0.00010286	9.18538e-05
280	281	0.00010286	0.000208953	5.49963e-05
290	291	0.00010286	0.000281361	3.29283e-05
* 294	297	0.00010286	0.00027003	46.5945
300	303	0.00010286	0.00027003	34.2512

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
310	313	0.00010286	21.7355	20.5075
320	323	0.00010286	19.8743	12.2786
330	333	0.00010286	14.6343	7.35165
340	343	0.00010286	11.7864	4.4017
350	353	0.00010286	3.55318	2.63546
360	363	0.00010286	4.78365	1.57795
370	373	0.00010286	1.78768	0.944776
380	383	0.00010286	1.78768	0.565672
390	393	0.00010286	0.5669	0.338689
400	403	0.00010286	0.5669	0.202786
410	413	0.00010286	0.335106	0.121415
420	423	0.00010286	0.145308	0.0726958
430	433	0.00010286	0.0532531	0.0435256
440	443	0.00010286	0.0484497	0.0260604
450	453	0.00010286	0.0664346	0.0156033
460	463	0.00010286	0.0283902	0.00934229
470	473	0.00010286	0.00236932	0.00559357
480	483	0.00010286	0.00924985	0.00334908
490	493	0.00010286	0.00603684	0.00200522
500	503	0.00010286	0.0021313	0.0012006
510	513	0.00010286	0.000765247	0.000718842
520	523	0.00010286	0.000890502	0.000430397
530	533	0.00010286	0.000501465	0.000257695
540	543	0.00010286	0.000395306	0.000154291
550	553	0.00010286	0.000145894	9.238e-05
560	563	3.62637e-05	3.62637e-05	5.53113e-05
570	573	3.62637e-05	3.62637e-05	3.31169e-05
580	583	3.62637e-05	4.62227e-05	1.98283e-05
590	593	1.85071e-05	1.85071e-05	1.18719e-05
600	603	9.72074e-06	9.72074e-06	7.10817e-06

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature

	610	613	4.61312e-06	4.61312e-06	4.25593e-06
	620	623	4.61312e-06	1.63344e-05	2.54818e-06
*	624	629	3.07708e-06	3.07708e-06	40.4583
	630	635	3.07708e-06	20.36	29.7405
	640	645	3.07708e-06	20.2452	17.8068
	650	655	3.07708e-06	20.4551	10.6616
	660	665	3.07708e-06	20.0211	6.38347
	670	675	3.07708e-06	20.2576	3.82202
	680	685	3.07708e-06	20.6667	2.28839
	690	695	3.07708e-06	21.0174	1.37014
	700	705	3.07708e-06	22.1383	0.820354
	710	715	3.07708e-06	20.0671	0.491176
	720	725	3.07708e-06	20.0671	0.294085
	730	735	3.07708e-06	20.2141	0.17608
	740	745	3.07708e-06	19.9225	0.105425
	750	755	3.07708e-06	19.9225	0.0631221
	760	765	3.07708e-06	19.9074	0.0377935
	770	775	3.07708e-06	19.8919	0.0226284
	780	785	3.07708e-06	19.8904	0.0135485
	790	795	3.07708e-06	19.8922	0.00811196
	800	805	3.07708e-06	19.8916	0.00485693
	810	815	3.07708e-06	19.892	0.00290802
	820	825	3.07708e-06	19.8897	0.00174114
	830	835	3.07708e-06	19.8898	0.00104249
	840	845	3.07708e-06	19.8898	0.000624175
	850	855	3.07708e-06	19.8897	0.000373716
*	854	861	3.07708e-06	19.8897	47.1717
	860	867	3.07708e-06	20.7535	34.6756
	870	877	3.07708e-06	19.8966	20.7615
	880	887	3.07708e-06	21.5995	12.4307
	890	897	3.07708e-06	17.8294	7.44272
	900	907	3.07708e-06	18.159	4.45623

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
910	917	3.07708e-06	20.3442	2.66811
920	927	3.07708e-06	18.5742	1.5975
930	937	3.07708e-06	18.5067	0.95648
940	947	3.07708e-06	17.3085	0.57268
950	957	3.07708e-06	17.3085	0.342884
960	967	3.07708e-06	17.3085	0.205298
970	977	3.07708e-06	17.9776	0.122919
980	987	3.07708e-06	17.5614	0.0735963
990	997	3.07708e-06	17.4798	0.0440648




```
Stop requested.
```

```
% Clear variables
clearvars options4
```

```
disp(['Solution = ',num2str(solution3)])
```

```
Solution = -4.8531e-07  9.7365e-07
```

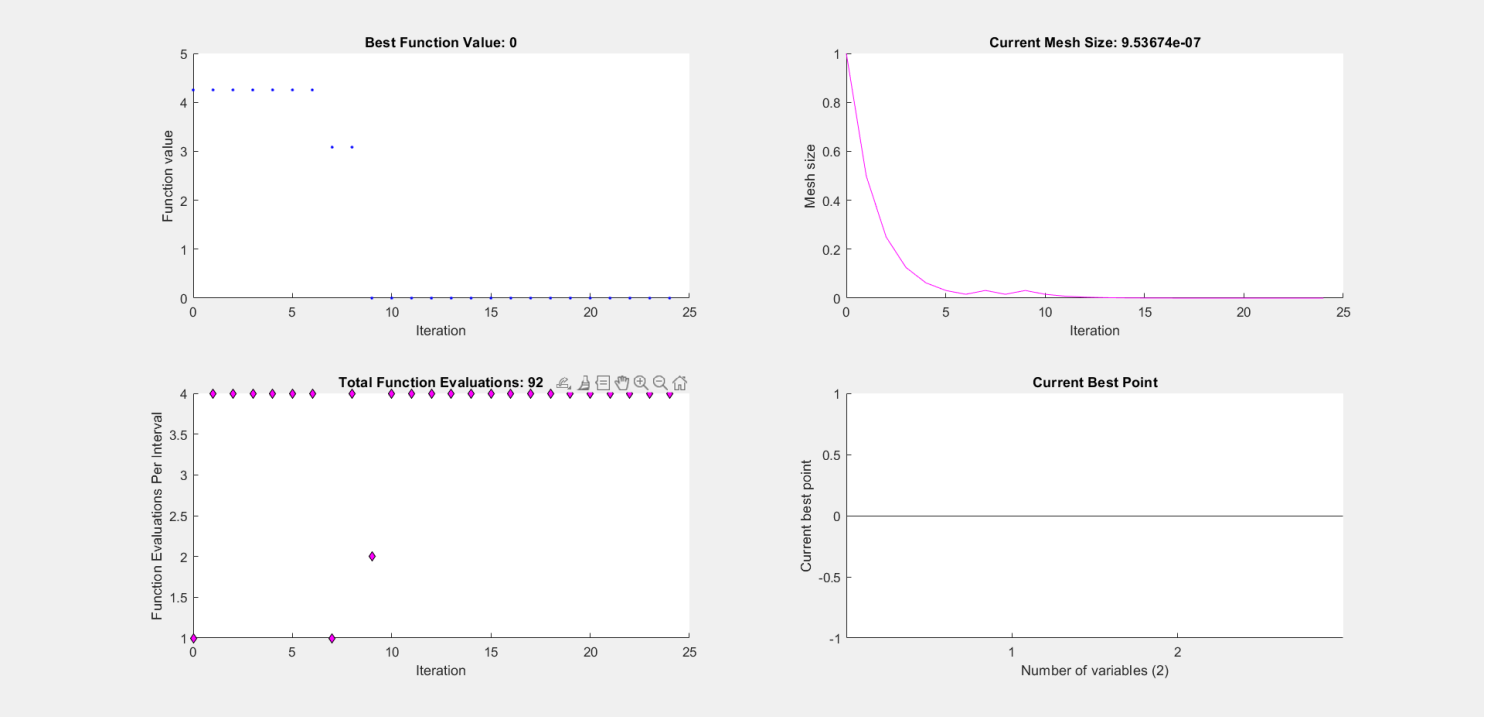
```
disp(['Function value = ', num2str(objectiveValue3)])
```

```
Function value = 3.0771e-06
```

```
% Set nondefault solver options
options5 = optimoptions("patternsearch","Display","iter","PlotFcn",...
    ["psplotbestf","psplotmeshsize","psplotfuncount","psplotbestx"]);

% Solve
[solution4,objectiveValue4] = patternsearch(fun,x0,[],[],[],[],repmat(-35,...
    size(x0)),repmat(35,size(x0)),[],options5);
```

```
Iter     Func-count       f(x)      MeshSize     Method
    0           1        4.25365           1
    1           5        4.25365         0.5     Refine Mesh
    2           9        4.25365        0.25     Refine Mesh
    3          13        4.25365       0.125     Refine Mesh
    4          17        4.25365      0.0625     Refine Mesh
    5          21        4.25365     0.03125     Refine Mesh
    6          25        4.25365     0.01562     Refine Mesh
    7          26        3.08365     0.03125     Successful Poll
    8          30        3.08365     0.01562     Refine Mesh
    9          32              0     0.03125     Successful Poll
```

```
   10          36              0       0.01562     Refine Mesh
   11          40              0      0.007812     Refine Mesh
   12          44              0      0.003906     Refine Mesh
   13          48              0      0.001953     Refine Mesh
   14          52              0     0.0009766     Refine Mesh
   15          56              0     0.0004883     Refine Mesh
   16          60              0     0.0002441     Refine Mesh
   17          64              0     0.0001221     Refine Mesh
   18          68              0     6.104e-05     Refine Mesh
   19          72              0     3.052e-05     Refine Mesh
   20          76              0     1.526e-05     Refine Mesh
   21          80              0     7.629e-06     Refine Mesh
   22          84              0     3.815e-06     Refine Mesh
   23          88              0     1.907e-06     Refine Mesh
   24          92              0     9.537e-07     Refine Mesh
Optimization terminated: mesh size less than options.MeshTolerance.
```




```
% Clear variables
clearvars options5
```

```
disp(['Solution = ',num2str(solution4)])
```

```
Solution = 0  0
```

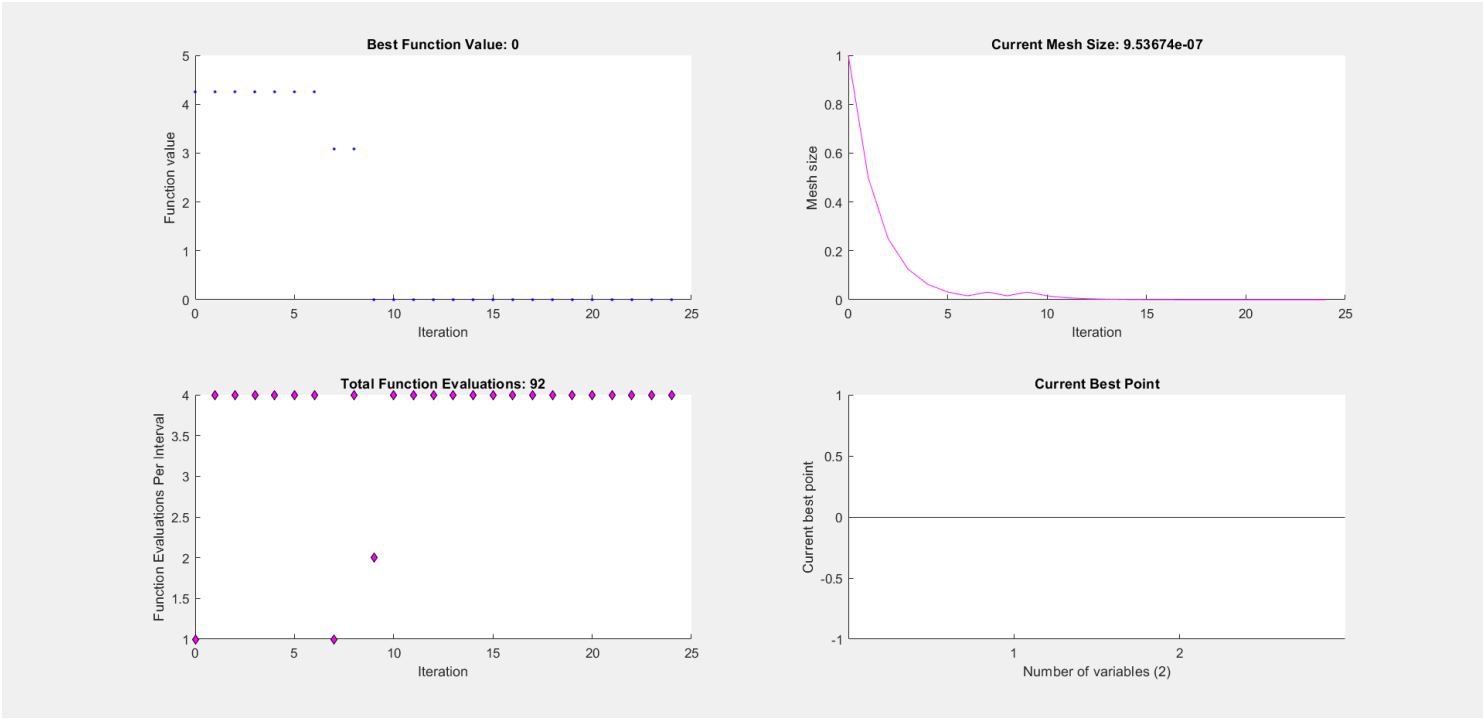
```
disp(['Function value = ', num2str(objectiveValue4)])
```

```
Function value = 0
```

```
% Set nondefault solver options
options6 = optimoptions("surrogateopt","Display","iter","PlotFcn",...
    ["surrogateoptplot","optimplotfvalconstr","optimplotfval","optimplotx"]);

% Solve
```

```
[solution5,objectiveValue5] = surrogateopt(fun,repmat(-35,nvar,1),repmat(35,...
    nvar,1),[],[],[],[],[],options6);
```

```
Scalar objective function
Number of variables: 2
Number of integer constraints: 0
Number of linear inequality constraints: 0
Number of linear equality constraints: 0
Number of nonlinear inequality constraints: 0

F-count       Time        Best          Current         Trial
             (seconds)    Fval          Fval            type
   1         0.53       1.9982e+01      1.9982e+01   random
```




```
   2         1.00       0.0000e+00      0.0000e+00   random
   3         1.27       0.0000e+00      2.1746e+01   random
   4         1.47       0.0000e+00      2.1746e+01   random
   5         1.65       0.0000e+00      1.8243e+01   random
   6         1.85       0.0000e+00      2.1613e+01   random
   7         2.15       0.0000e+00      2.1613e+01   random
   8         2.40       0.0000e+00      1.8243e+01   random
   9         2.57       0.0000e+00      2.1539e+01   random
  10         2.81       0.0000e+00      2.0865e+01   random
  11         3.03       0.0000e+00      2.1539e+01   random
  12         3.45       0.0000e+00      2.0865e+01   random
  13         3.64       0.0000e+00      2.0148e+01   random
  14         3.85       0.0000e+00      2.0148e+01   random
  15         4.06       0.0000e+00      2.1973e+01   random
  16         4.33       0.0000e+00      2.1973e+01   random
  17         4.62       0.0000e+00      8.3391e+00   random
  18         4.82       0.0000e+00      2.1224e+01   random
  19         5.02       0.0000e+00      2.1646e+01   random
  20         5.20       0.0000e+00      2.1101e+01   random
  21         5.42       0.0000e+00      2.1407e+01   adaptive
  22         5.66       0.0000e+00      1.8109e+01   adaptive
  23         5.87       0.0000e+00      9.1718e+00   adaptive
  24         6.09       0.0000e+00      7.7475e+00   adaptive
  25         6.30       0.0000e+00      1.9956e+01   adaptive
  26         6.48       0.0000e+00      1.1295e+01   adaptive
  27         6.69       0.0000e+00      4.2212e+00   adaptive
```

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
28	6.89	0.0000e+00	3.8035e+00	adaptive
29	7.13	0.0000e+00	1.9488e+01	adaptive
30	7.34	0.0000e+00	1.9276e+01	adaptive
31	7.59	0.0000e+00	2.9035e+00	adaptive
32	7.81	0.0000e+00	1.9080e+00	adaptive
33	8.05	0.0000e+00	1.7552e+01	adaptive
34	8.25	0.0000e+00	1.8083e+01	adaptive
35	8.54	0.0000e+00	1.2265e+00	adaptive
36	8.75	0.0000e+00	3.4959e-01	adaptive
37	9.05	0.0000e+00	1.3044e+01	adaptive
38	9.32	0.0000e+00	1.3823e+01	adaptive
39	9.54	0.0000e+00	6.5347e-01	adaptive
40	9.73	0.0000e+00	8.3850e-01	adaptive
41	10.06	0.0000e+00	2.1615e+01	random
42	10.30	0.0000e+00	1.8425e+01	random
43	10.52	0.0000e+00	1.8425e+01	random
44	10.74	0.0000e+00	2.1615e+01	random
45	10.96	0.0000e+00	2.0140e+01	random
46	11.15	0.0000e+00	2.0646e+01	random
47	11.36	0.0000e+00	2.1135e+01	random
48	11.55	0.0000e+00	2.1990e+01	random
49	11.78	0.0000e+00	2.1053e+01	random
50	11.97	0.0000e+00	2.0580e+01	random
51	12.19	0.0000e+00	2.1779e+01	random
52	12.39	0.0000e+00	2.1601e+01	random
53	12.61	0.0000e+00	2.1063e+01	random
54	12.80	0.0000e+00	2.1603e+01	random
55	13.03	0.0000e+00	2.1316e+01	random
56	13.21	0.0000e+00	9.0806e+00	random
57	13.43	0.0000e+00	2.1827e+01	random
58	13.61	0.0000e+00	1.7842e+01	random
59	13.83	0.0000e+00	1.8820e+01	random
60	14.02	0.0000e+00	2.1353e+01	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
61	14.24	0.0000e+00	2.0882e+01	adaptive
62	14.43	0.0000e+00	1.3637e+01	adaptive
63	14.65	0.0000e+00	8.5109e+00	adaptive
64	14.84	0.0000e+00	3.1943e+00	adaptive
65	15.07	0.0000e+00	2.0441e+01	adaptive
66	15.31	0.0000e+00	2.0996e+01	adaptive
67	15.54	0.0000e+00	4.7610e+00	adaptive
68	15.74	0.0000e+00	4.0116e+00	adaptive
69	15.96	0.0000e+00	2.1659e+01	adaptive
70	16.16	0.0000e+00	1.6161e+01	adaptive
71	16.38	0.0000e+00	2.0656e+00	adaptive
72	16.57	0.0000e+00	4.0359e+00	adaptive
73	16.85	0.0000e+00	1.9854e+01	adaptive
74	17.08	0.0000e+00	1.9232e+01	adaptive
75	17.34	0.0000e+00	1.4420e+00	adaptive
76	17.57	0.0000e+00	3.3891e+00	adaptive
77	17.81	0.0000e+00	2.0759e+01	adaptive
78	18.00	0.0000e+00	1.8926e+01	adaptive
79	18.22	0.0000e+00	3.1321e+00	adaptive
80	18.41	0.0000e+00	8.8829e-01	adaptive
81	18.63	0.0000e+00	2.1350e+01	adaptive
82	18.82	0.0000e+00	1.4716e+01	adaptive
83	19.05	0.0000e+00	3.1971e+00	adaptive
84	19.24	0.0000e+00	1.4633e+00	adaptive
85	19.47	0.0000e+00	2.0245e+01	adaptive

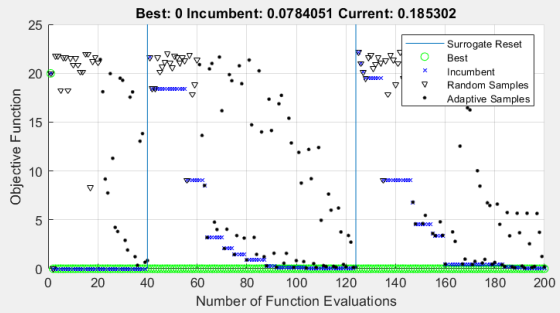
F-count	Time (seconds)	Best Fval	Current Fval	Trial type
86	19.68	0.0000e+00	1.3991e+01	adaptive
87	19.91	0.0000e+00	1.2277e+00	adaptive
88	20.11	0.0000e+00	2.9889e-01	adaptive
89	20.33	0.0000e+00	1.7339e+01	adaptive
90	20.52	0.0000e+00	1.4137e+01	adaptive
91	20.75	0.0000e+00	1.5791e+00	adaptive
92	20.94	0.0000e+00	1.5680e-01	adaptive
93	21.16	0.0000e+00	1.6867e+01	adaptive
94	21.35	0.0000e+00	1.7729e+01	adaptive
95	21.58	0.0000e+00	5.5407e-01	adaptive
96	21.77	0.0000e+00	1.5705e+00	adaptive
97	21.99	0.0000e+00	1.5396e+01	adaptive
98	22.18	0.0000e+00	1.2863e+01	adaptive
99	22.41	0.0000e+00	1.2726e-01	adaptive
100	22.60	0.0000e+00	8.2329e-01	adaptive
101	22.83	0.0000e+00	1.1894e+01	adaptive
102	23.03	0.0000e+00	8.7596e+00	adaptive
103	23.25	0.0000e+00	7.2451e-01	adaptive
104	23.45	0.0000e+00	6.9289e-02	adaptive
105	23.68	0.0000e+00	1.2199e+01	adaptive
106	23.90	0.0000e+00	9.2055e+00	adaptive
107	24.15	0.0000e+00	5.2201e-01	adaptive
108	24.39	0.0000e+00	1.3867e-01	adaptive
109	24.74	0.0000e+00	1.2400e+01	adaptive
110	24.95	0.0000e+00	4.9548e+00	adaptive
111	25.20	0.0000e+00	3.1678e-01	adaptive
112	25.42	0.0000e+00	2.2218e-01	adaptive
113	25.69	0.0000e+00	7.6347e+00	adaptive
114	25.90	0.0000e+00	5.9884e+00	adaptive
115	26.14	0.0000e+00	2.3948e-01	adaptive
116	26.38	0.0000e+00	1.4895e-01	adaptive
117	26.62	0.0000e+00	6.2047e+00	adaptive
118	26.84	0.0000e+00	3.7563e+00	adaptive
119	27.09	0.0000e+00	4.3077e-01	adaptive
120	27.31	0.0000e+00	2.0976e-01	adaptive

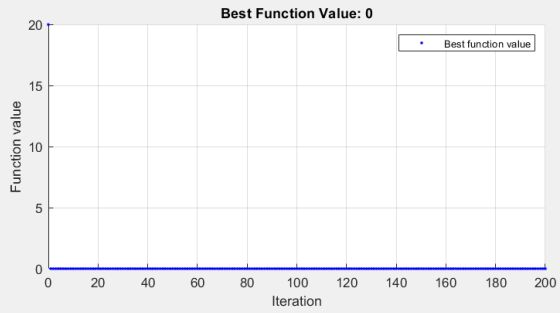
F-count	Time (seconds)	Best Fval	Current Fval	Trial type
121	27.55	0.0000e+00	3.3955e+00	adaptive
122	27.77	0.0000e+00	2.7139e+00	adaptive
123	28.02	0.0000e+00	1.3447e-01	adaptive
124	28.24	0.0000e+00	1.4685e-01	adaptive
125	28.54	0.0000e+00	2.2146e+01	random
126	28.73	0.0000e+00	2.1024e+01	random
127	28.94	0.0000e+00	2.0120e+01	random
128	29.13	0.0000e+00	1.9470e+01	random
129	29.36	0.0000e+00	2.1624e+01	random
130	29.55	0.0000e+00	2.1833e+01	random
131	29.79	0.0000e+00	2.0489e+01	random
132	30.00	0.0000e+00	2.0927e+01	random
133	30.24	0.0000e+00	2.1603e+01	random
134	30.43	0.0000e+00	2.1063e+01	random
135	30.68	0.0000e+00	9.0806e+00	random
136	30.89	0.0000e+00	2.1316e+01	random
137	31.15	0.0000e+00	1.7842e+01	random
138	31.34	0.0000e+00	2.1827e+01	random
139	31.56	0.0000e+00	2.1353e+01	random
140	31.74	0.0000e+00	1.8820e+01	random
141	31.96	0.0000e+00	2.1024e+01	random
142	32.15	0.0000e+00	2.2146e+01	random
143	32.37	0.0000e+00	1.9470e+01	random

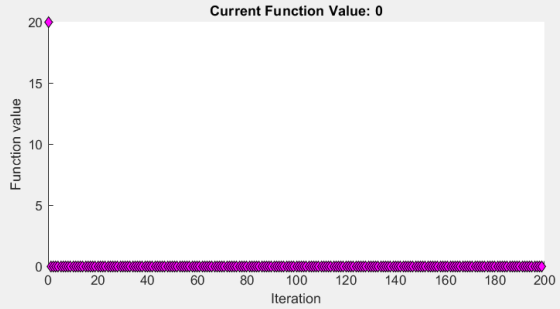
F-count	Time (seconds)	Best Fval	Current Fval	Trial type
144	32.55	0.0000e+00	2.0120e+01	random
145	32.77	0.0000e+00	1.9901e+01	adaptive
146	32.96	0.0000e+00	2.0507e+01	adaptive
147	33.18	0.0000e+00	6.8016e+00	adaptive
148	33.37	0.0000e+00	4.5815e+00	adaptive
149	33.59	0.0000e+00	2.1562e+01	adaptive
150	33.78	0.0000e+00	2.0013e+01	adaptive

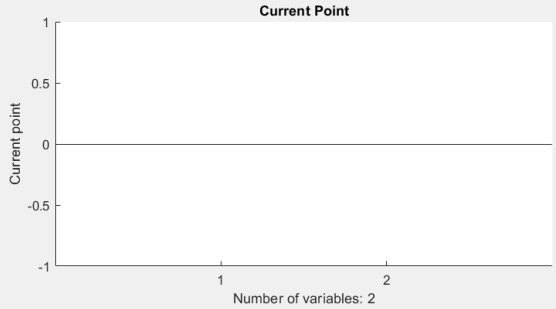
F-count	Time (seconds)	Best Fval	Current Fval	Trial type
151	33.99	0.0000e+00	4.6120e+00	adaptive
152	34.18	0.0000e+00	5.4528e+00	adaptive
153	34.41	0.0000e+00	2.1347e+01	adaptive
154	34.59	0.0000e+00	1.9907e+01	adaptive
155	34.82	0.0000e+00	3.6037e+00	adaptive
156	35.00	0.0000e+00	3.3826e+00	adaptive
157	35.23	0.0000e+00	1.9968e+01	adaptive
158	35.42	0.0000e+00	4.7946e+00	adaptive
159	35.63	0.0000e+00	3.4094e+00	adaptive
160	35.82	0.0000e+00	4.7167e-01	adaptive
161	36.07	0.0000e+00	2.0052e+01	adaptive
162	36.27	0.0000e+00	2.0388e+01	adaptive
163	36.49	0.0000e+00	3.7651e+00	adaptive
164	36.68	0.0000e+00	2.7885e+00	adaptive
165	36.90	0.0000e+00	2.1347e+01	adaptive
166	37.09	0.0000e+00	1.2542e+01	adaptive
167	37.31	0.0000e+00	4.7640e-01	adaptive
168	37.50	0.0000e+00	9.7829e-01	adaptive
169	37.74	0.0000e+00	1.6455e+01	adaptive
170	37.94	0.0000e+00	1.6242e+01	adaptive
171	38.17	0.0000e+00	4.2527e-01	adaptive
172	38.37	0.0000e+00	7.4765e-01	adaptive
173	38.61	0.0000e+00	1.0022e+01	adaptive
174	38.87	0.0000e+00	8.4530e+00	adaptive
175	39.13	0.0000e+00	5.8117e-01	adaptive
176	39.36	0.0000e+00	9.5151e-01	adaptive
177	39.64	0.0000e+00	6.7348e+00	adaptive
178	39.85	0.0000e+00	6.4663e+00	adaptive
179	40.08	0.0000e+00	4.5387e-01	adaptive
180	40.30	0.0000e+00	6.4293e-01	adaptive

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
181	40.54	0.0000e+00	6.6076e+00	adaptive
182	40.76	0.0000e+00	4.5363e+00	adaptive
183	41.01	0.0000e+00	4.0169e-01	adaptive
184	41.24	0.0000e+00	2.1528e-01	adaptive
185	41.49	0.0000e+00	5.7473e+00	adaptive
186	41.72	0.0000e+00	3.3599e+00	adaptive
187	41.97	0.0000e+00	1.8096e-01	adaptive
188	42.20	0.0000e+00	9.4763e-02	adaptive
189	42.45	0.0000e+00	5.6678e+00	adaptive
190	42.68	0.0000e+00	3.6783e+00	adaptive
191	42.93	0.0000e+00	2.7617e-01	adaptive
192	43.15	0.0000e+00	7.8405e-02	adaptive
193	43.41	0.0000e+00	5.6699e+00	adaptive
194	43.64	0.0000e+00	2.5437e+00	adaptive
195	43.89	0.0000e+00	1.1867e-01	adaptive
196	44.12	0.0000e+00	2.2382e-01	adaptive
197	44.37	0.0000e+00	5.6451e+00	adaptive
198	44.60	0.0000e+00	3.7187e+00	adaptive
199	44.86	0.0000e+00	1.2533e+00	adaptive
200	45.09	0.0000e+00	1.8530e-01	adaptive










```
surrogateopt stopped because it exceeded the function evaluation limit set by
'options.MaxFunctionEvaluations'.
```

```
% Clear variables
clearvars options6
```

```
disp(['Solution = ',num2str(solution5)])
```

```
Solution = 0  0
```

```
disp(['Function value = ', num2str(objectiveValue5)])
```

```
Function value = 0
```

```
nvar = 2
```

```
nvar = 2
```

```
fun = @
```

```
fun = function_handle with value:
    @booth
```

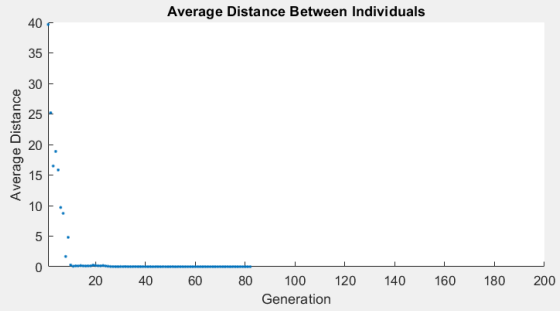
```
% Set nondefault solver options
options = optimoptions("ga","Display","iter","PlotFcn",["gaplotdistance",...
    "gaplotscores","gaplotbestf","gaplotexpectation"]);

% Solve
[solution,objectiveValue] = ga(fun,nvar,[],[],[],[],repmat(-35,nvar,1),...
    repmat(35,nvar,1),[],[],options);
```

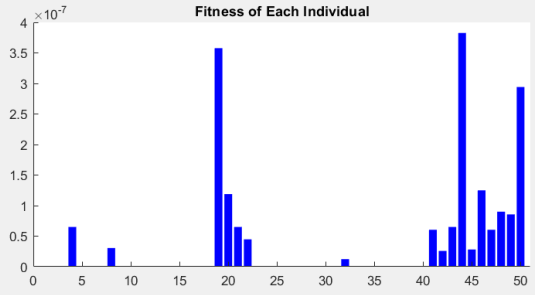
```
Single objective optimization:
2 Variable(s)

Options:
CreationFcn:       @gacreationuniform
CrossoverFcn:      @crossoverscattered
SelectionFcn:      @selectionstochunif
MutationFcn:       @mutationadaptfeasible

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
    1              100         0.03286            Inf        0
    2              147         0.03286            Inf        1
    3              194         0.02759            Inf        0
    4              241         0.02759            Inf        1
    5              288         0.02759            Inf        2
    6              335         0.02759            Inf        3
    7              382         0.02759            Inf        4
    8              429         0.02759            Inf        5
    9              476         0.01849            Inf        0
   10              523         0.01204            Inf        0
   11              570        0.007487         0.0451        0
   12              617        0.007487        0.07226        1
   13              664        0.002421        0.06717        0
   14              711        0.002421         0.1019        1
   15              758        0.002421        0.06073        2
   16              805        0.001298        0.04252        0
   17              852        0.001233        0.05784        0
   18              899        0.001228         0.1061        0
   19              946        0.001228         0.3137        1
   20              993        0.001228         0.3118        2
   21             1040       0.0009351         0.1526        0
   22             1087       0.0009351         0.1997        1
   23             1134       0.0009351           0.15        2
   24             1181       0.0009351        0.03671        3
   25             1228       0.0009351        0.01644        4
   26             1275       0.0009351        0.01043        5
   27             1322       0.0006949       0.004485        0
   28             1369       0.0001642       0.001658        0
   29             1416       0.0001642       0.002296        1
   30             1463       0.0001642        0.00176        2

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
```

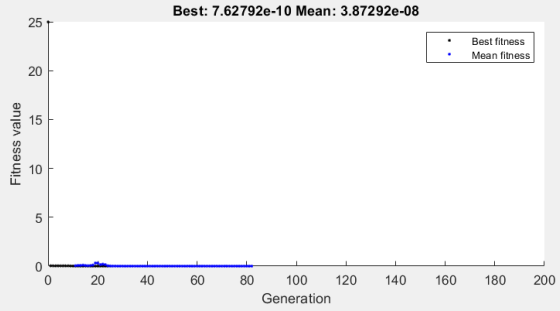
Generation	Func-count	Best f(x)	Mean f(x)	Stall Generations
31	1510	0.0001642	0.001091	3
32	1557	4.715e-05	0.0008561	0
33	1604	2.523e-05	0.0007468	0
34	1651	1.84e-05	0.0006489	0
35	1698	1.84e-05	0.00122	1
36	1745	1.84e-05	0.001129	2
37	1792	1.84e-05	0.0007443	3
38	1839	1.361e-05	0.0005332	0
39	1886	1.361e-05	0.0003751	1
40	1933	7.128e-06	0.0002983	0
41	1980	7.128e-06	0.0001268	1
42	2027	7.128e-06	5.138e-05	2
43	2074	4.431e-06	3.37e-05	0
44	2121	2.74e-06	3.765e-05	0
45	2168	2.74e-06	0.0001038	1
46	2215	2.459e-06	5.599e-05	0
47	2262	2.459e-06	0.0001096	1
48	2309	2.459e-06	8.396e-05	2
49	2356	2.459e-06	4.064e-05	3
50	2403	1.159e-07	2.827e-05	0
51	2450	1.159e-07	2.927e-05	1
52	2497	1.159e-07	1.494e-05	2
53	2544	1.159e-07	1.451e-05	3
54	2591	7.506e-08	4.177e-06	0
55	2638	2.94e-08	2.549e-06	0
56	2685	2.94e-08	1.906e-06	1
57	2732	2.94e-08	1.614e-06	2
58	2779	4.634e-09	1.185e-06	0
59	2826	4.634e-09	7.101e-07	1
60	2873	1.814e-09	3.098e-07	0

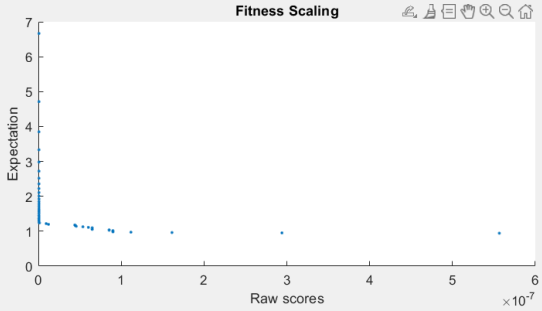
Generation	Func-count	Best f(x)	Mean f(x)	Stall Generations
61	2920	1.814e-09	3.303e-07	1
62	2967	1.814e-09	2.222e-07	2
63	3014	1.814e-09	1.207e-07	3
64	3061	1.814e-09	7.725e-08	4
65	3108	1.814e-09	7.75e-08	5
66	3155	1.814e-09	4.503e-08	6
67	3202	1.814e-09	5.259e-08	7
68	3249	1.814e-09	3.873e-08	8
69	3296	1.814e-09	4.457e-08	9
70	3343	1.814e-09	3.873e-08	10
71	3390	7.628e-10	2.685e-08	0
72	3437	7.628e-10	9.611e-08	1
73	3484	7.628e-10	3.577e-08	2
74	3531	7.628e-10	3.115e-08	3
75	3578	7.628e-10	5.316e-08	4
76	3625	7.628e-10	4.064e-08	5
77	3672	7.628e-10	2.413e-08	6
78	3719	7.628e-10	2.805e-08	7
79	3766	7.628e-10	3.862e-08	8
80	3813	7.628e-10	4.431e-08	9
81	3860	7.628e-10	4.417e-08	10
82	3907	7.628e-10	3.873e-08	11

Optimization terminated: average change in the fitness value less than options.FunctionTolerance.










```
% Clear variables
clearvars options
```

```
disp(['Solution = ',num2str(solution)])
```

```
Solution = 1          3
```

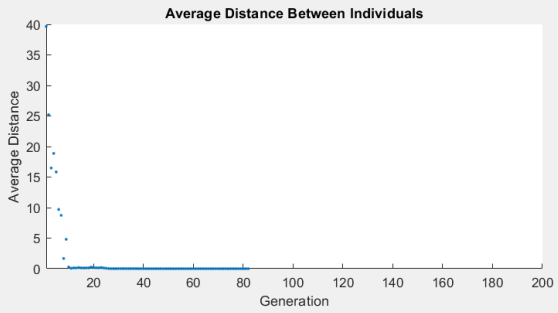
```
disp(['Function value = ', num2str(objectiveValue)])
```

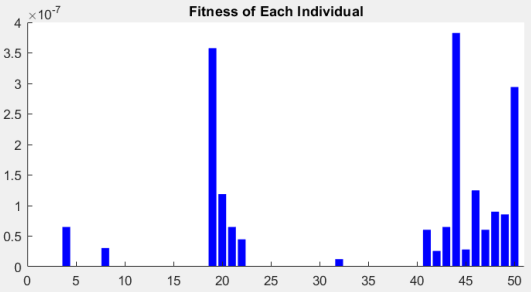
```
Function value = 7.6279e-10
```

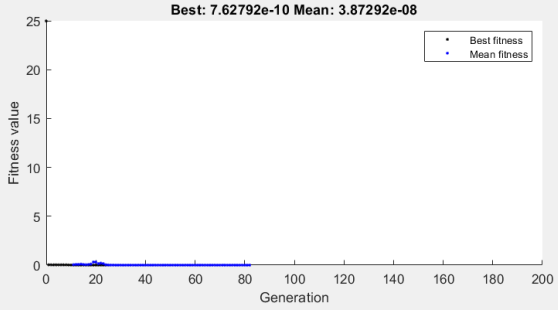
```
% Set nondefault solver options
options3 = optimoptions("particleswarm","Display","iter","PlotFcn",...
    "pswplotbestf");

% Solve
[solution2,objectiveValue2] = particleswarm(fun,nvar,repmat(-35,nvar,1),...
    repmat(35,nvar,1),options3);
```

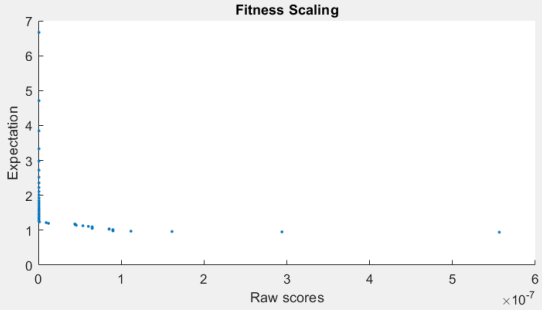
```
                                Best           Mean     Stall
Iteration     f-count           f(x)           f(x)    Iterations
    0             20          393.3            Inf        0
    1             40          393.3            Inf        0
    2             60          4.659            Inf        0
    3             80          4.659            Inf        1
    4            100          4.659            Inf        2
    5            120          4.659            Inf        3
    6            140          3.876            Inf        0
    7            160          3.876            Inf        1
    8            180          3.876            Inf        2
```

9	200	3.876	Inf	3
10	220	3.876	Inf	4





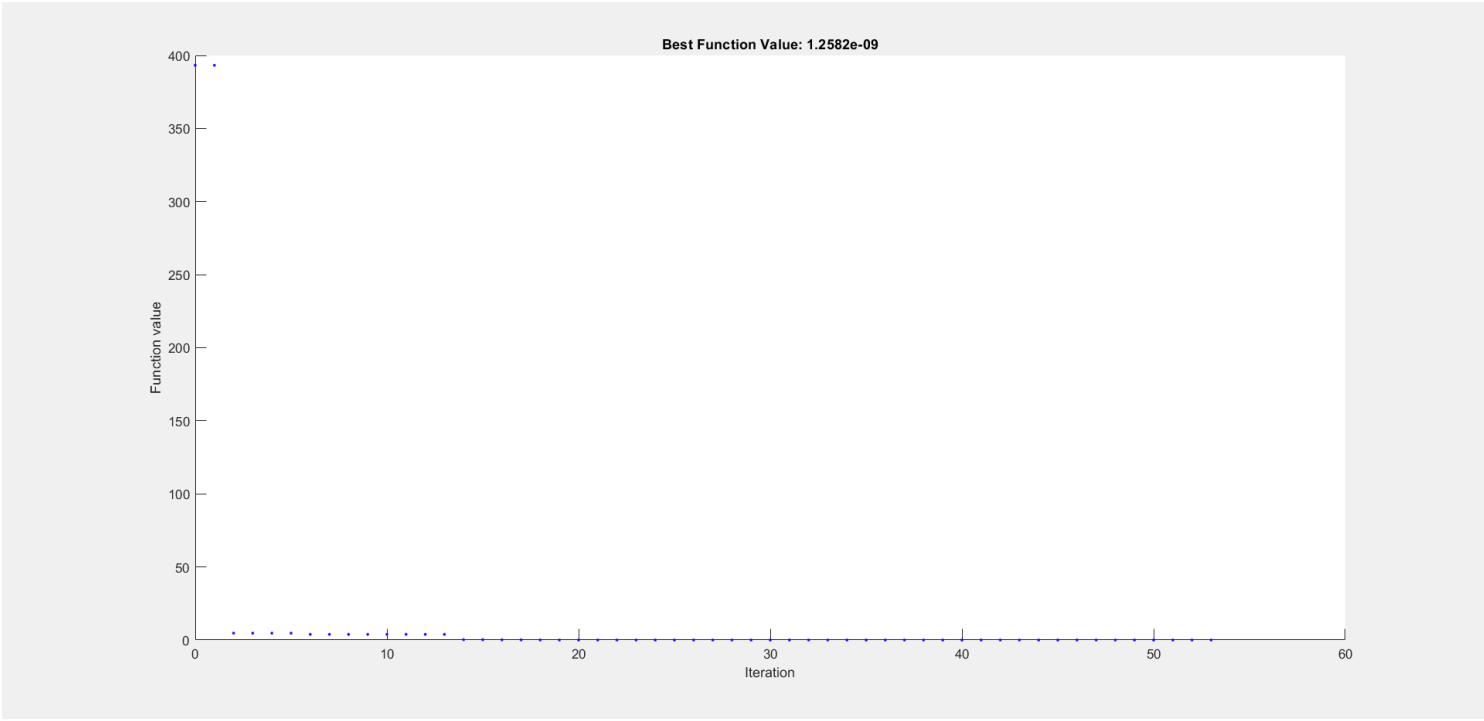




11	240	3.876	Inf	5
12	260	3.876	Inf	6
13	280	3.876	Inf	7
14	300	0.2303	Inf	0
15	320	0.2303	Inf	1
16	340	0.1492	Inf	0
17	360	0.1275	Inf	0
18	380	0.04499	Inf	0
19	400	0.02996	Inf	0
20	420	0.01758	Inf	0
21	440	0.0002228	Inf	0
22	460	0.0002228	Inf	1
23	480	0.0002228	Inf	2
24	500	0.0002134	Inf	0
25	520	0.0002053	Inf	0
26	540	9.789e-05	Inf	0
27	560	2.556e-05	Inf	0
28	580	1.246e-05	Inf	0
29	600	1.246e-05	Inf	1
30	620	1.141e-05	Inf	0

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
31	640	1.141e-05	Inf	1
32	660	1.266e-06	Inf	0
33	680	1.266e-06	Inf	1
34	700	2.803e-07	Inf	0
35	720	2.803e-07	Inf	1
36	740	2.803e-07	Inf	2
37	760	2.803e-07	Inf	3
38	780	2.803e-07	62.67	4
39	800	2.803e-07	Inf	5
40	820	2.803e-07	Inf	6
41	840	2.803e-07	Inf	7
42	860	2.803e-07	10.82	8
43	880	2.803e-07	8.704	9
44	900	6.533e-08	0.9474	0

```
   45            920       5.698e-08          0.6488        0
   46            940       4.017e-08         0.03286        0
   47            960       2.225e-08       0.0007688        0
   48            980       2.113e-08        0.000609        0
   49           1000       1.825e-08       0.0006542        0
   50           1020       7.984e-09       4.231e-06        0
   51           1040       7.984e-09       6.486e-06        1
   52           1060       1.258e-09       5.956e-06        0
   53           1080       1.258e-09       1.129e-06        1
Optimization ended: relative change in the objective value
over the last OPTIONS.MaxStallIterations iterations is less than OPTIONS.FunctionTolerance.
```




```
% Clear variables
clearvars options3
```

```
disp(['Solution = ',num2str(solution2)])
```

```
Solution = 0.99997          3
```

```
disp(['Function value = ', num2str(objectiveValue2)])
```

```
Function value = 1.2582e-09
```

```
x0 = [-0.5, -0.5]
```

```
x0 = 1×2
   -0.5000   -0.5000
```

```
% Set nondefault solver options
options4 = optimoptions("simulannealbnd","Display","iter","PlotFcn",...
    ["saplotbestf","saplotbestx","saplotf","saplottemperature"]);
```

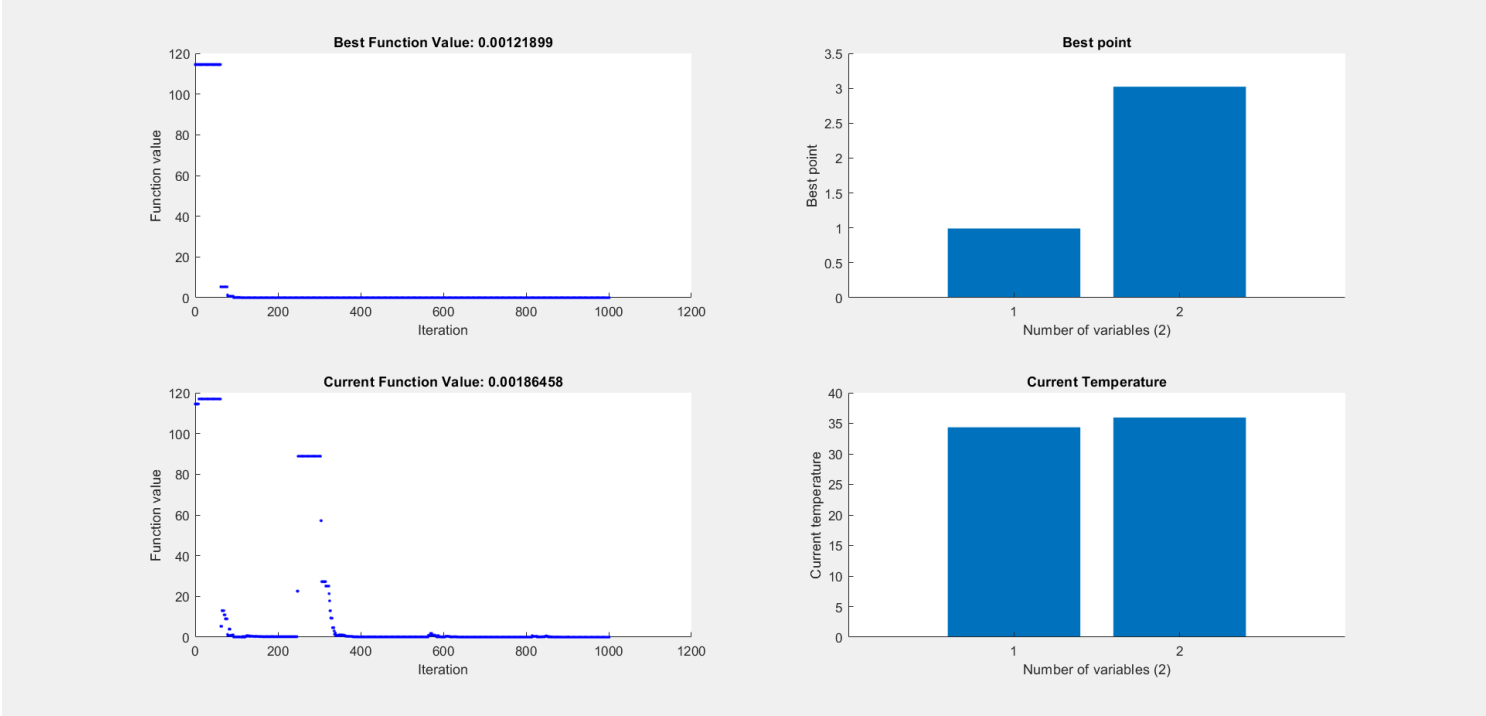
```
% Solve
[solution3,objectiveValue3] = simulannealbnd(fun,x0,repmat(-35,size(x0)),...
    repmat(35,size(x0)),options4);
```

```
                          Best        Current           Mean
Iteration    f-count       f(x)         f(x)        temperature
     0           1         114.5         114.5            100
    10          11         114.5       116.947          56.88
    20          21         114.5       116.947        34.0562
    30          31         114.5       116.947        20.3907
    40          41         114.5       116.947        12.2087
    50          51         114.5       116.947        7.30977
    60          61         114.5       116.947        4.37663
    70          71       5.32074       10.9349        2.62045
    80          81       0.69133       0.69133        1.56896
    90          91       0.69133       1.05516       0.939395
   100         101     0.0674495     0.0674495        0.56245
   110         111     0.0674495     0.0718567        0.33676
   120         121    0.00660563     0.0213164       0.201631
   130         131    0.00660563      0.611343       0.120724
   140         141    0.00660563      0.419329      0.0722817
   150         151    0.00660563      0.368147      0.0432777
   160         161    0.00660563      0.279218       0.025912
   170         171    0.00660563      0.221467      0.0155145
   180         181    0.00660563      0.241097     0.00928908
   190         191    0.00660563      0.232251     0.00556171
   200         201    0.00660563      0.225896        0.00333
   210         211    0.00660563      0.221613      0.0019938
   220         221    0.00660563       0.22421     0.00119376
   230         231    0.00660563      0.224276    0.000714748
   240         241    0.00660563       0.22318    0.000427946
*  241         244    0.00660563      0.222628        57.8375
   250         253    0.00660563       88.8378         36.452
   260         263    0.00660563       88.8378        21.8252
   270         273    0.00660563       88.8378        13.0675
   280         283    0.00660563       88.8378        7.82402
   290         293    0.00660563       88.8378        4.68453
   300         303    0.00660563       88.8378         2.8048

                          Best        Current           Mean
Iteration    f-count       f(x)         f(x)        temperature
   310         313    0.00660563       27.2556        1.67934
   320         323    0.00660563       25.0649        1.00548
   330         333    0.00660563       9.32175       0.602019
   340         343    0.00660563      0.718381       0.360451
   350         353    0.00660563      0.813945       0.215815
   360         363    0.00660563      0.928431       0.129217
   370         373    0.00660563      0.308126      0.0773667
   380         383    0.00660563        0.2533      0.0463223
   390         393    0.00660563      0.126822      0.0277349
   400         403    0.00660563     0.0895874      0.0166059
   410         413    0.00660563     0.0666521     0.00994257
   420         423    0.00660563     0.0903598     0.00595298
   430         433    0.00660563       0.08732     0.00356427
   440         443    0.00660563     0.0797349     0.00213406
   450         453    0.00660563     0.0751557     0.00127774
   460         463    0.00660563     0.0751904     0.00076503
   470         473    0.00660563     0.0746074    0.000458052
*  477         482    0.00660563     0.0744351        50.7786
   480         485    0.00660563     0.0744351        43.5363
   490         495    0.00660563     0.0744351        26.0668
   500         505    0.00660563     0.0744351        15.6071
   510         515    0.00660563     0.0744351        9.34457
   520         525    0.00660563     0.0744351        5.59494
```

530	535	0.00660563	0.0744351	3.3499
540	545	0.00660563	0.0744351	2.00571
550	555	0.00660563	0.0744351	1.20089
560	565	0.00660563	0.0744351	0.719018
570	575	0.00660563	1.79258	0.430503
580	585	0.00660563	0.940077	0.257758
590	595	0.00660563	0.180969	0.154329
600	605	0.00660563	0.0152661	0.0924025

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
610	615	0.00660563	0.407451	0.0553248
620	625	0.00660563	0.104058	0.033125
630	635	0.00660563	0.143041	0.0198332
640	645	0.00660563	0.0478284	0.0118748
650	655	0.00660563	0.0372207	0.00710991
660	665	0.00660563	0.027415	0.00425697
670	675	0.00660563	0.0250148	0.0025488
680	685	0.00660563	0.024536	0.00152606
690	695	0.00660563	0.0242544	0.00091371
700	705	0.00660563	0.0236217	0.000547072
710	715	0.00660563	0.0230369	0.000327552
720	725	0.00660563	0.0226588	0.000196118
730	735	0.00660563	0.0227684	0.000117423
* 736	743	0.00660563	0.0226517	50.3087
740	747	0.00660563	0.0226517	40.9768
750	757	0.00660563	0.0226517	24.5343
760	767	0.00660563	0.0226517	14.6896
770	777	0.00660563	0.0226517	8.79521
780	787	0.00660563	0.0226517	5.26601
790	797	0.00660563	0.0226517	3.15296
800	807	0.00660563	0.0226517	1.88779
810	817	0.00660563	0.0226517	1.13029
820	827	0.00660563	0.350433	0.676747
830	837	0.00660563	0.0634867	0.405193
840	847	0.00660563	0.163873	0.242604
850	857	0.00660563	0.456601	0.145256
860	867	0.00660563	0.061266	0.0869702
870	877	0.00660563	0.0196921	0.0520723
880	887	0.00581838	0.0249397	0.0311776
890	897	0.00458973	0.00458973	0.0186672
900	907	0.00458973	0.019698	0.0111767

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
910	917	0.00448664	0.00448664	0.00669192
920	927	0.00121899	0.00121899	0.0040067
930	937	0.00121899	0.00152287	0.00239896
940	947	0.00121899	0.00192615	0.00143635
950	957	0.00121899	0.0022998	0.000859993
960	967	0.00121899	0.00217474	0.00051491
970	977	0.00121899	0.00202325	0.000308295
980	987	0.00121899	0.00190854	0.000184588
990	997	0.00121899	0.00189285	0.00011052
* 995	1004	0.00121899	0.00186458	47.8203
1000	1009	0.00121899	0.00186458	37.0024




```
Stop requested.
```

```
% Clear variables
clearvars options4
```

```
disp(['Solution = ',num2str(solution3)])
```

```
Solution = 0.99084      3.0219
```

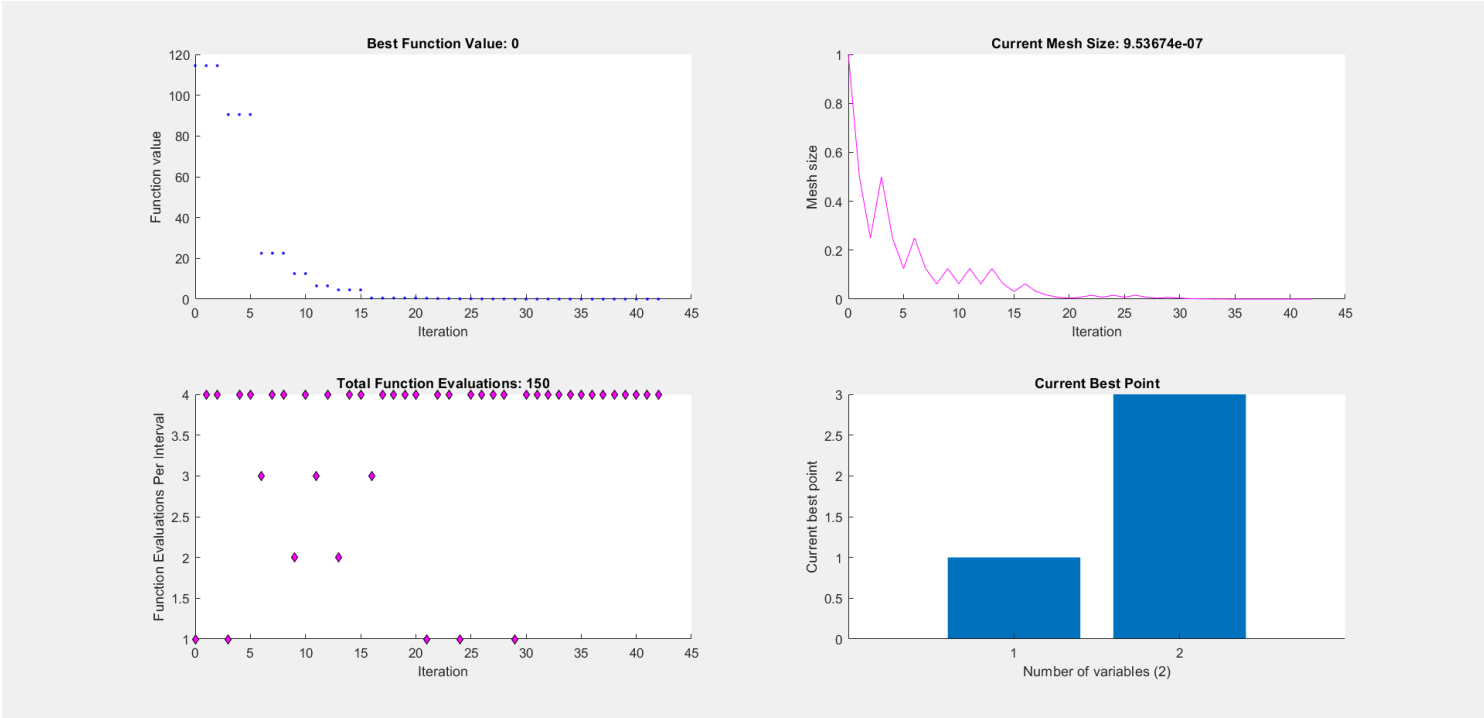
```
disp(['Function value = ', num2str(objectiveValue3)])
```

```
Function value = 0.001219
```

```
% Set nondefault solver options
options5 = optimoptions("patternsearch","Display","iter","PlotFcn",...
    ["psplotbestf","psplotmeshsize","psplotfuncount","psplotbestx"]);

% Solve
[solution4,objectiveValue4] = patternsearch(fun,x0,[],[],[],[],repmat(-35,...
    size(x0)),repmat(35,size(x0)),[],options5);
```

```
Iter     Func-count       f(x)      MeshSize     Method
    0           1          114.5             1
    1           5          114.5           0.5     Refine Mesh
    2           9          114.5          0.25     Refine Mesh
    3          10           90.5           0.5     Successful Poll
    4          14           90.5          0.25     Refine Mesh
    5          18           90.5         0.125     Refine Mesh
    6          21           22.5          0.25     Successful Poll
    7          25           22.5         0.125     Refine Mesh
    8          29           22.5        0.0625     Refine Mesh
    9          31           12.5         0.125     Successful Poll
```

```
    10          35          12.5        0.0625     Refine Mesh
    11          38           6.5         0.125     Successful Poll
    12          42           6.5        0.0625     Refine Mesh
    13          44           4.5         0.125     Successful Poll
    14          48           4.5        0.0625     Refine Mesh
    15          52           4.5       0.03125     Refine Mesh
    16          55           0.5        0.0625     Successful Poll
    17          59           0.5       0.03125     Refine Mesh
    18          63           0.5       0.01562     Refine Mesh
    19          67           0.5      0.007812     Refine Mesh
    20          71           0.5      0.003906     Refine Mesh
    21          72      0.453125      0.007812     Successful Poll
    22          76      0.265625       0.01562     Successful Poll
    23          80      0.265625      0.007812     Refine Mesh
    24          81      0.140625       0.01562     Successful Poll
    25          85      0.140625      0.007812     Refine Mesh
    26          89      0.078125       0.01562     Successful Poll
    27          93      0.078125      0.007812     Refine Mesh
    28          97      0.078125      0.003906     Refine Mesh
    29          98             0      0.007812     Successful Poll
    30         102             0      0.003906     Refine Mesh

Iter     Func-count         f(x)        MeshSize      Method
    31         106             0      0.001953     Refine Mesh
    32         110             0     0.0009766     Refine Mesh
    33         114             0     0.0004883     Refine Mesh
    34         118             0     0.0002441     Refine Mesh
    35         122             0     0.0001221     Refine Mesh
    36         126             0     6.104e-05     Refine Mesh
    37         130             0     3.052e-05     Refine Mesh
    38         134             0     1.526e-05     Refine Mesh
    39         138             0     7.629e-06     Refine Mesh
    40         142             0     3.815e-06     Refine Mesh
    41         146             0     1.907e-06     Refine Mesh
    42         150             0     9.537e-07     Refine Mesh
Optimization terminated: mesh size less than options.MeshTolerance.
```




```
% Clear variables
```

```
clearvars options5
```

```
disp(['Solution = ',num2str(solution4)])
```

```
Solution = 1  3
```

```
disp(['Function value = ', num2str(objectiveValue4)])
```

```
Function value = 0
```

```
% Set nondefault solver options
options6 = optimoptions("surrogateopt","Display","iter","PlotFcn",...
    ["surrogateoptplot","optimplotfvalconstr","optimplotfval","optimplotx"]);

% Solve
[solution5,objectiveValue5] = surrogateopt(fun,repmat(-35,nvar,1),repmat(35,...
    nvar,1),[],[],[],[],[],options6);
```

```
No objective function
Number of variables: 2
Number of integer constraints: 0
Number of linear inequality constraints: 0
Number of linear equality constraints: 0
Number of nonlinear inequality constraints: 0

F-count    Time       Number of          Current   Trial
        (seconds)     Feas Pts          Max Infeas  type
   1         0.32                      0.0000e+00   random
   2         0.76       7.4000e+01      7.4000e+01   random
   3         1.13       7.4000e+01      Inf          random
   4         1.30       7.4000e+01      Inf          random
   5         1.47       7.4000e+01      1.9212e+02   random
   6         1.64       7.4000e+01      Inf          random
   7         1.81       7.4000e+01      Inf          random
   8         1.98       7.4000e+01      2.6212e+02   random
   9         2.15       7.4000e+01      Inf          random
  10         2.45       7.4000e+01      Inf          random
  11         2.63       7.4000e+01      Inf          random
  12         2.83       7.4000e+01      Inf          random
  13         3.13       7.4000e+01      Inf          random
  14         3.31       7.4000e+01      Inf          random
  15         3.49       7.4000e+01      Inf          random
  16         3.66       7.4000e+01      Inf          random
  17         3.82       7.4000e+01      3.1763e+02   random
  18         4.00       7.4000e+01      Inf          random
  19         4.16       7.4000e+01      Inf          random
  20         4.34       7.4000e+01      Inf          random
  21         4.52       7.4000e+01      Inf          random
  22         4.69       7.4000e+01      Inf          random
  23         4.85       7.4000e+01      Inf          random
  24         5.02       7.4000e+01      Inf          random
  25         5.18       7.4000e+01      Inf          random
  26         5.35       7.4000e+01      Inf          random
  27         5.52       7.4000e+01      Inf          random
  28         5.69       7.4000e+01      Inf          random
  29         5.85       7.4000e+01      Inf          random
  30         6.03       7.4000e+01      Inf          random

F-count       Time        Best          Current         Trial
            (seconds)     Fval          Fval            type
```

31	6.20	7.4000e+01	Inf	random
32	6.36	7.4000e+01	Inf	random
33	6.53	7.4000e+01	Inf	random
34	6.70	7.4000e+01	Inf	random
35	6.87	7.4000e+01	Inf	random
36	7.04	7.4000e+01	1.9260e+02	random
37	7.21	7.4000e+01	Inf	random
38	7.38	7.4000e+01	5.9620e+02	random
39	7.55	7.4000e+01	Inf	random
40	7.73	7.4000e+01	Inf	random
41	7.91	7.4000e+01	Inf	random
42	8.08	7.4000e+01	Inf	random
43	8.24	7.4000e+01	Inf	random
44	8.41	7.4000e+01	Inf	random
45	8.57	7.4000e+01	Inf	random
46	8.74	7.4000e+01	Inf	random
47	8.91	7.4000e+01	Inf	random
48	9.07	7.4000e+01	Inf	random
49	9.24	7.4000e+01	Inf	random
50	9.41	7.4000e+01	Inf	random
51	9.57	1.7604e+01	1.7604e+01	random
52	9.75	1.7604e+01	Inf	random
53	9.91	1.7604e+01	1.6812e+03	random
54	10.08	1.7604e+01	Inf	random
55	10.24	1.7604e+01	Inf	random
56	10.40	1.7604e+01	Inf	random
57	10.57	1.7604e+01	Inf	random
58	10.73	1.7604e+01	Inf	random
59	10.90	1.7604e+01	Inf	random
60	11.06	1.7604e+01	Inf	random

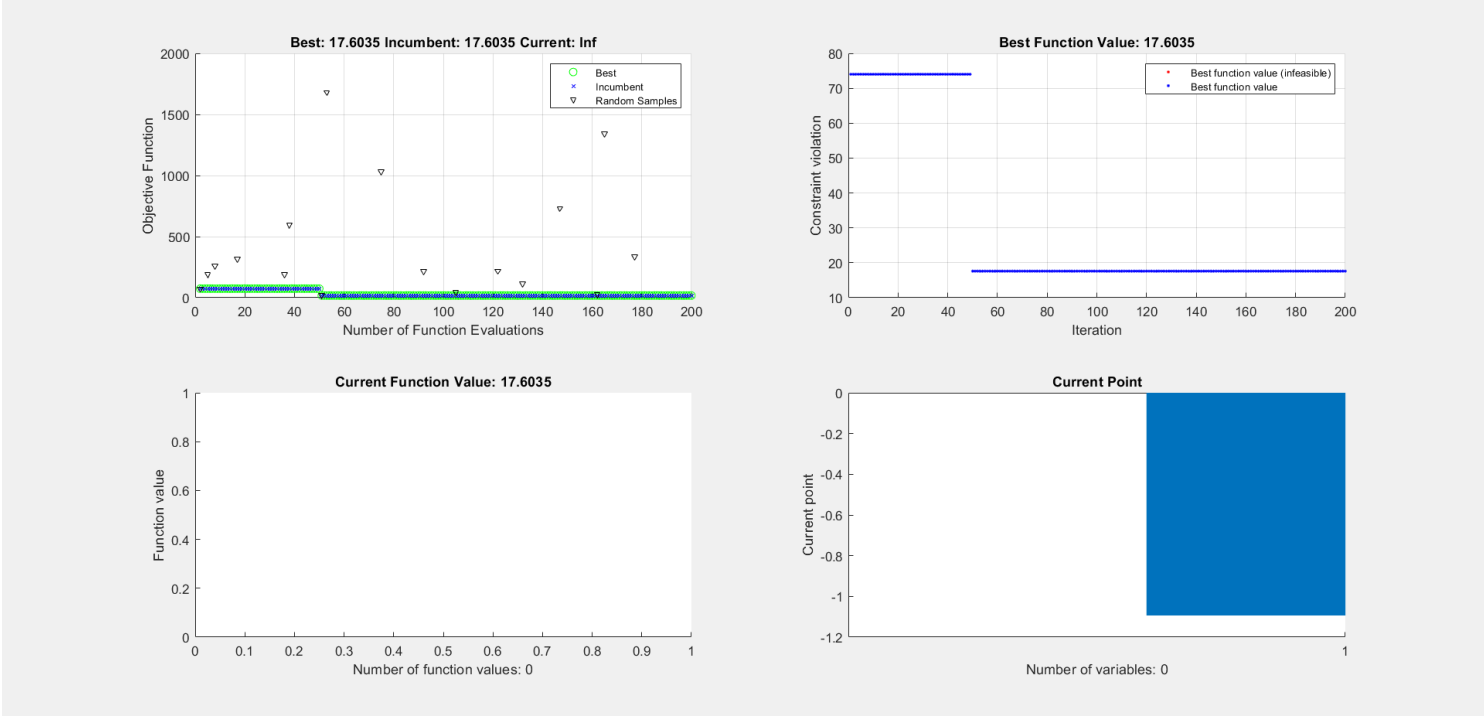
F-count	Time (seconds)	Best Fval	Current Fval	Trial type
61	11.23	1.7604e+01	Inf	random
62	11.39	1.7604e+01	Inf	random
63	11.56	1.7604e+01	Inf	random
64	11.72	1.7604e+01	Inf	random
65	11.88	1.7604e+01	Inf	random
66	12.05	1.7604e+01	Inf	random
67	12.22	1.7604e+01	Inf	random
68	12.38	1.7604e+01	Inf	random
69	12.55	1.7604e+01	Inf	random
70	12.72	1.7604e+01	Inf	random
71	12.89	1.7604e+01	Inf	random
72	13.06	1.7604e+01	Inf	random
73	13.23	1.7604e+01	Inf	random
74	13.39	1.7604e+01	Inf	random
75	13.58	1.7604e+01	1.0320e+03	random
76	13.75	1.7604e+01	Inf	random
77	13.92	1.7604e+01	Inf	random
78	14.09	1.7604e+01	Inf	random
79	14.25	1.7604e+01	Inf	random
80	14.44	1.7604e+01	Inf	random
81	14.65	1.7604e+01	Inf	random
82	14.88	1.7604e+01	Inf	random
83	15.23	1.7604e+01	Inf	random
84	15.62	1.7604e+01	Inf	random
85	15.82	1.7604e+01	Inf	random
86	16.04	1.7604e+01	Inf	random
87	16.26	1.7604e+01	Inf	random
88	16.46	1.7604e+01	Inf	random
89	16.66	1.7604e+01	Inf	random
90	16.86	1.7604e+01	Inf	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
91	17.05	1.7604e+01	Inf	random
92	17.25	1.7604e+01	2.1740e+02	random
93	17.44	1.7604e+01	Inf	random
94	17.62	1.7604e+01	Inf	random
95	17.79	1.7604e+01	Inf	random
96	17.96	1.7604e+01	Inf	random
97	18.12	1.7604e+01	Inf	random
98	18.30	1.7604e+01	Inf	random
99	18.47	1.7604e+01	Inf	random
100	18.64	1.7604e+01	Inf	random
101	18.82	1.7604e+01	Inf	random
102	18.99	1.7604e+01	Inf	random
103	19.16	1.7604e+01	Inf	random
104	19.34	1.7604e+01	Inf	random
105	19.50	1.7604e+01	4.5545e+01	random
106	19.68	1.7604e+01	Inf	random
107	19.84	1.7604e+01	Inf	random
108	20.01	1.7604e+01	Inf	random
109	20.18	1.7604e+01	Inf	random
110	20.35	1.7604e+01	Inf	random
111	20.51	1.7604e+01	Inf	random
112	20.78	1.7604e+01	Inf	random
113	20.95	1.7604e+01	Inf	random
114	21.13	1.7604e+01	Inf	random
115	21.29	1.7604e+01	Inf	random
116	21.46	1.7604e+01	Inf	random
117	21.65	1.7604e+01	Inf	random
118	21.86	1.7604e+01	Inf	random
119	22.03	1.7604e+01	Inf	random
120	22.20	1.7604e+01	Inf	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
121	22.39	1.7604e+01	Inf	random
122	22.56	1.7604e+01	2.1890e+02	random
123	22.79	1.7604e+01	Inf	random
124	22.97	1.7604e+01	Inf	random
125	23.15	1.7604e+01	Inf	random
126	23.33	1.7604e+01	Inf	random
127	23.69	1.7604e+01	Inf	random
128	23.88	1.7604e+01	Inf	random
129	24.18	1.7604e+01	Inf	random
130	24.44	1.7604e+01	Inf	random
131	24.62	1.7604e+01	Inf	random
132	24.83	1.7604e+01	1.1274e+02	random
133	25.13	1.7604e+01	Inf	random
134	25.33	1.7604e+01	Inf	random
135	25.60	1.7604e+01	Inf	random
136	25.78	1.7604e+01	Inf	random
137	25.95	1.7604e+01	Inf	random
138	26.14	1.7604e+01	Inf	random
139	26.31	1.7604e+01	Inf	random
140	26.48	1.7604e+01	Inf	random
141	26.68	1.7604e+01	Inf	random
142	26.87	1.7604e+01	Inf	random
143	27.04	1.7604e+01	Inf	random
144	27.22	1.7604e+01	Inf	random
145	27.39	1.7604e+01	Inf	random
146	27.57	1.7604e+01	Inf	random
147	27.74	1.7604e+01	7.3160e+02	random
148	27.91	1.7604e+01	Inf	random
149	28.08	1.7604e+01	Inf	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
150	28.26	1.7604e+01	Inf	random
151	28.45	1.7604e+01	Inf	random
152	28.63	1.7604e+01	Inf	random
153	28.81	1.7604e+01	Inf	random
154	28.99	1.7604e+01	Inf	random
155	29.17	1.7604e+01	Inf	random
156	29.34	1.7604e+01	Inf	random
157	29.53	1.7604e+01	Inf	random
158	29.73	1.7604e+01	Inf	random
159	29.92	1.7604e+01	Inf	random
160	30.12	1.7604e+01	Inf	random
161	30.32	1.7604e+01	Inf	random
162	30.55	1.7604e+01	2.4589e+01	random
163	30.76	1.7604e+01	Inf	random
164	30.94	1.7604e+01	Inf	random
165	31.11	1.7604e+01	1.3437e+03	random
166	31.30	1.7604e+01	Inf	random
167	31.48	1.7604e+01	Inf	random
168	31.66	1.7604e+01	Inf	random
169	31.83	1.7604e+01	Inf	random
170	32.01	1.7604e+01	Inf	random
171	32.19	1.7604e+01	Inf	random
172	32.36	1.7604e+01	Inf	random
173	32.53	1.7604e+01	Inf	random
174	32.71	1.7604e+01	Inf	random
175	32.88	1.7604e+01	Inf	random
176	33.06	1.7604e+01	Inf	random
177	33.23	1.7604e+01	3.3487e+02	random
178	33.41	1.7604e+01	Inf	random
179	33.58	1.7604e+01	Inf	random
180	33.75	1.7604e+01	Inf	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
181	33.93	1.7604e+01	Inf	random
182	34.10	1.7604e+01	Inf	random
183	34.28	1.7604e+01	Inf	random
184	34.45	1.7604e+01	Inf	random
185	34.62	1.7604e+01	Inf	random
186	34.79	1.7604e+01	Inf	random
187	34.98	1.7604e+01	Inf	random
188	35.16	1.7604e+01	Inf	random
189	35.33	1.7604e+01	Inf	random
190	35.50	1.7604e+01	Inf	random
191	35.68	1.7604e+01	Inf	random
192	35.85	1.7604e+01	Inf	random
193	36.02	1.7604e+01	Inf	random
194	36.19	1.7604e+01	Inf	random
195	36.36	1.7604e+01	Inf	random
196	36.53	1.7604e+01	Inf	random
197	36.70	1.7604e+01	Inf	random
198	36.87	1.7604e+01	Inf	random
199	37.04	1.7604e+01	Inf	random
200	37.21	1.7604e+01	Inf	random




```
surrogateopt stopped because it exceeded the function evaluation limit set by
'options.MaxFunctionEvaluations'.
```

```
% Clear variables
clearvars options6
```

```
disp(['Solution = ',num2str(solution5)])
```

```
Solution = -1.0938      3.2812
```

```
disp(['Function value = ', num2str(objectiveValue5)])
```

```
Function value = 17.6035
```

```
nvar = 2
```

```
nvar = 2
```

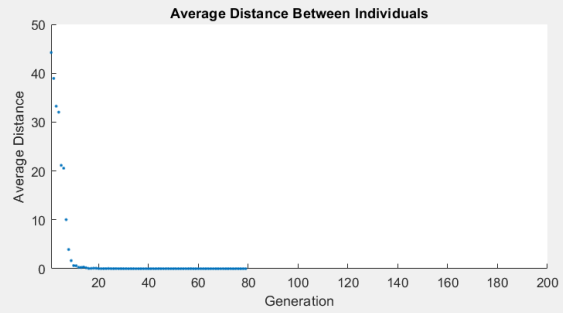
```
fun = @
```

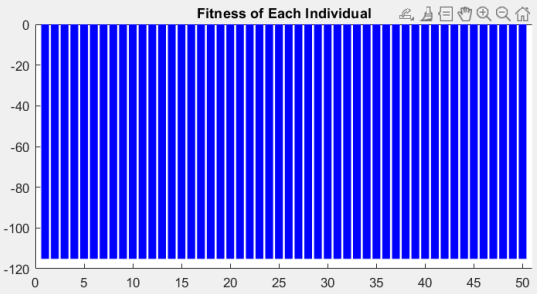
```
fun = function_handle with value:
    @eggholder
```

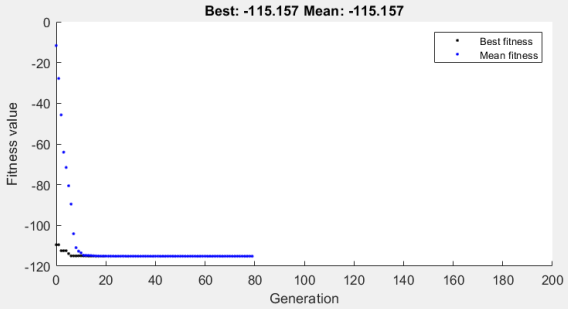
```
% Set nondefault solver options
options = optimoptions("ga","Display","iter","PlotFcn",["gaplotdistance",...
    "gaplotscores","gaplotbestf","gaplotexpectation"]);

% Solve
[solution,objectiveValue] = ga(fun,nvar,[],[],[],[],repmat(-35,nvar,1),...
    repmat(35,nvar,1),[],[],options);
```

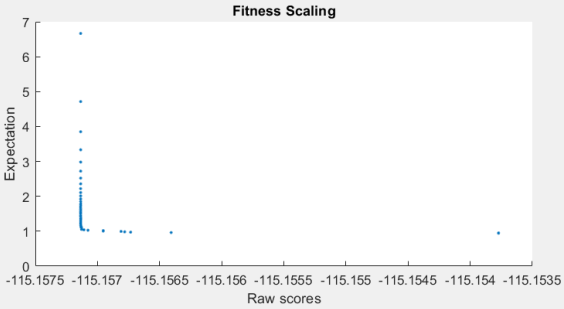
```
Single objective optimization:
2 Variable(s)

Options:
CreationFcn:       @gacreationuniform
CrossoverFcn:      @crossoverscattered
SelectionFcn:      @selectionstochunif
MutationFcn:       @mutationadaptfeasible

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
    1              100          -109.5         -27.85        0
    2              147          -112.4         -45.74        0
    3              194          -112.4         -64.04        1
    4              241          -112.4         -71.54        2
    5              288          -113.8         -80.55        0
    6              335            -115         -89.52        0
    7              382            -115         -104.1        1
    8              429            -115           -111        2
    9              476            -115         -112.7        3
   10              523            -115         -113.5        4
   11              570            -115         -114.7        0
   12              617            -115         -114.7        1
   13              664          -115.1         -114.8        0
   14              711          -115.1         -114.8        1
   15              758          -115.1         -114.9        2
   16              805          -115.1           -115        0
   17              852          -115.1           -115        0
   18              899          -115.1         -115.1        1
   19              946          -115.1         -115.1        2
   20              993          -115.1         -115.1        3
   21             1040          -115.1         -115.1        0
   22             1087          -115.1         -115.1        0
   23             1134          -115.1         -115.1        1
   24             1181          -115.1         -115.1        2
   25             1228          -115.1         -115.1        0
   26             1275          -115.1         -115.1        1
   27             1322          -115.1         -115.1        2
   28             1369          -115.1         -115.1        3
   29             1416          -115.2         -115.1        0
   30             1463          -115.2         -115.1        0

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
```

```
   31            1510          -115.2          -115.1        1
   32            1557          -115.2          -115.1        2
   33            1604          -115.2          -115.1        0
   34            1651          -115.2          -115.1        1
   35            1698          -115.2          -115.2        2
   36            1745          -115.2          -115.2        0
   37            1792          -115.2          -115.2        1
   38            1839          -115.2          -115.2        0
   39            1886          -115.2          -115.2        0
   40            1933          -115.2          -115.2        1
   41            1980          -115.2          -115.2        0
   42            2027          -115.2          -115.2        0
   43            2074          -115.2          -115.2        1
   44            2121          -115.2          -115.2        0
   45            2168          -115.2          -115.2        1
   46            2215          -115.2          -115.2        0
   47            2262          -115.2          -115.2        0
   48            2309          -115.2          -115.1        1
   49            2356          -115.2          -115.2        0
   50            2403          -115.2          -115.2        1
   51            2450          -115.2          -115.2        2
   52            2497          -115.2          -115.2        0
   53            2544          -115.2          -115.2        0
   54            2591          -115.2          -115.2        1
   55            2638          -115.2          -115.2        2
   56            2685          -115.2          -115.2        3
   57            2732          -115.2          -115.2        0
   58            2779          -115.2          -115.2        1
   59            2826          -115.2          -115.2        0
   60            2873          -115.2          -115.2        1

                                 Best            Mean      Stall
Generation      Func-count        f(x)            f(x)    Generations
   61            2920          -115.2          -115.2        2
   62            2967          -115.2          -115.2        0
   63            3014          -115.2          -115.2        1
   64            3061          -115.2          -115.2        2
   65            3108          -115.2          -115.2        0
   66            3155          -115.2          -115.2        0
   67            3202          -115.2          -115.2        0
   68            3249          -115.2          -115.2        1
   69            3296          -115.2          -115.2        2
   70            3343          -115.2          -115.2        3
   71            3390          -115.2          -115.2        0
   72            3437          -115.2          -115.2        0
   73            3484          -115.2          -115.2        1
   74            3531          -115.2          -115.2        0
   75            3578          -115.2          -115.2        1
   76            3625          -115.2          -115.2        2
   77            3672          -115.2          -115.2        3
   78            3719          -115.2          -115.2        4
   79            3766          -115.2          -115.2        0
Optimization terminated: average change in the fitness value less than options.FunctionTolerance.
```










```
% Clear variables
clearvars options
```

```
disp(['Solution = ',num2str(solution)])
```

```
Solution = -35          35
```

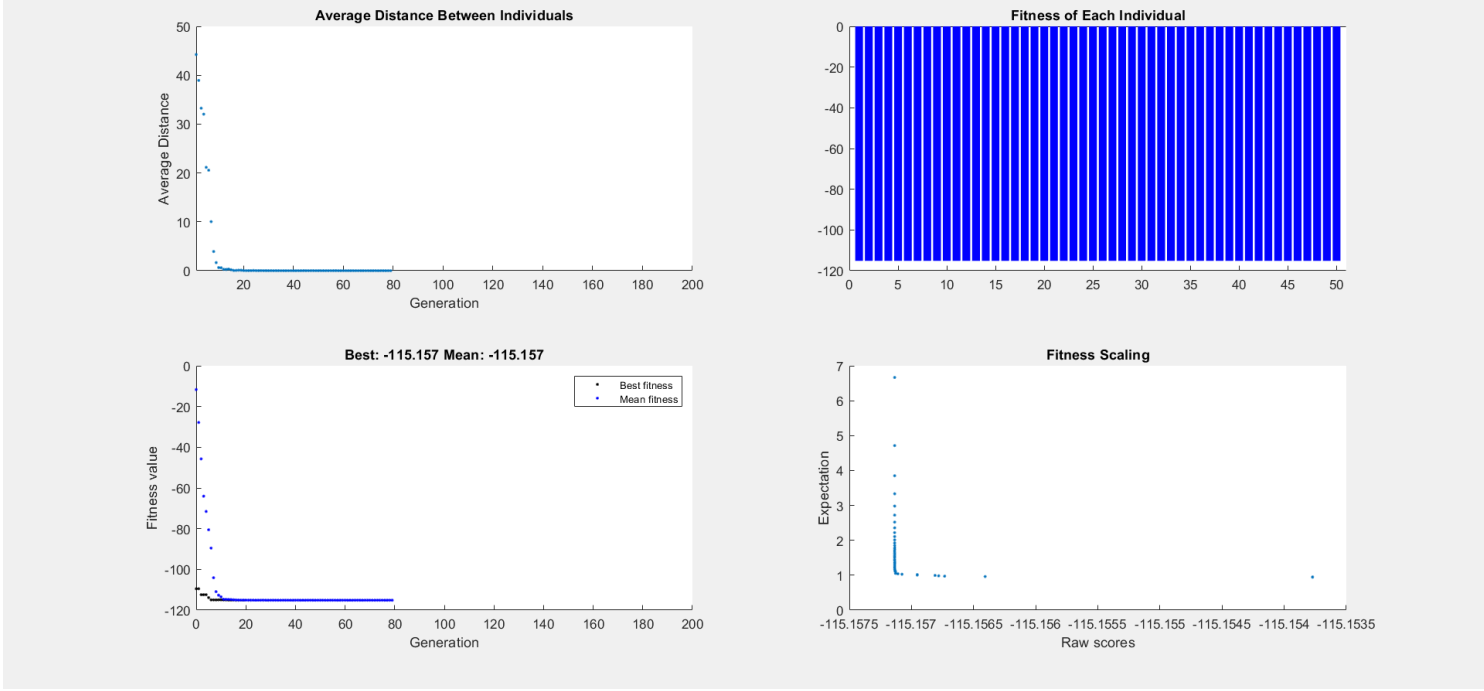
```
disp(['Function value = ', num2str(objectiveValue)])
```

```
Function value = -115.1571
```

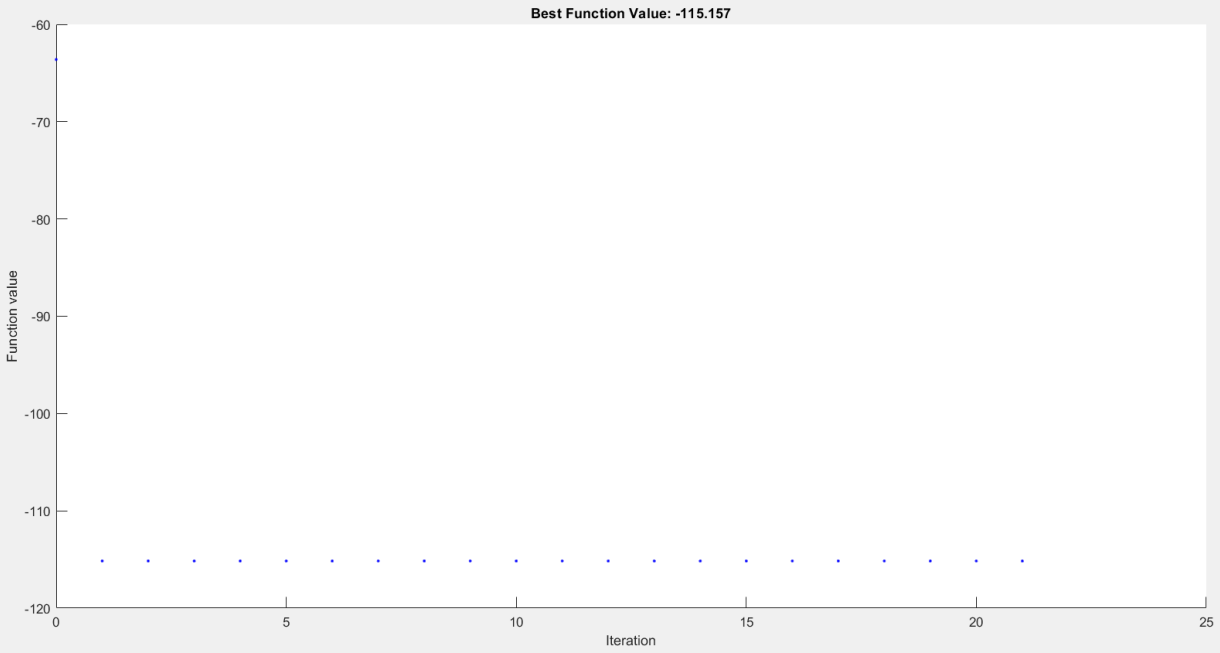
```
% Set nondefault solver options
options3 = optimoptions("particleswarm","Display","iter","PlotFcn",...
    "pswplotbestf");

% Solve
[solution2,objectiveValue2] = particleswarm(fun,nvar,repmat(-35,nvar,1),...
    repmat(35,nvar,1),options3);
```

```
                              Best           Mean     Stall
Iteration     f-count          f(x)           f(x)    Iterations
    0             20         -63.61         -10.34       0
    1             40         -115.2         -19.17       0
    2             60         -115.2         -48.07       1
    3             80         -115.2         -66.07       2
    4            100         -115.2         -82.81       3
    5            120         -115.2          -92.3       4
    6            140         -115.2         -100.2       5
    7            160         -115.2           -114       6
    8            180         -115.2         -115.2       7
    9            200         -115.2         -115.2       8
```

```
   10          220         -115.2         -115.2        9
   11          240         -115.2         -115.2       10
   12          260         -115.2         -115.2       11
   13          280         -115.2         -115.2       12
   14          300         -115.2         -115.2       13
```




```
   15          320         -115.2         -115.2       14
   16          340         -115.2         -115.2       15
   17          360         -115.2         -115.2       16
   18          380         -115.2         -115.2       17
   19          400         -115.2         -115.2       18
   20          420         -115.2         -115.2       19
   21          440         -115.2         -115.2       20
Optimization ended: relative change in the objective value
over the last OPTIONS.MaxStallIterations iterations is less than OPTIONS.FunctionTolerance.
```




```
% Clear variables
clearvars options3
```

```
disp(['Solution = ',num2str(solution2)])
```

```
Solution = -35  35
```

```
disp(['Function value = ', num2str(objectiveValue2)])
```

```
Function value = -115.1571
```

```
x0 = [-0.5, -0.5]
```

```
x0 = 1×2
   -0.5000   -0.5000
```

```
% Set nondefault solver options
options4 = optimoptions("simulannealbnd","Display","iter","PlotFcn",...
    ["saplotbestf","saplotbestx","saplotf","saplottemperature"]);

% Solve
[solution3,objectiveValue3] = simulannealbnd(fun,x0,repmat(-35,size(x0)),...
    repmat(35,size(x0)),options4);
```

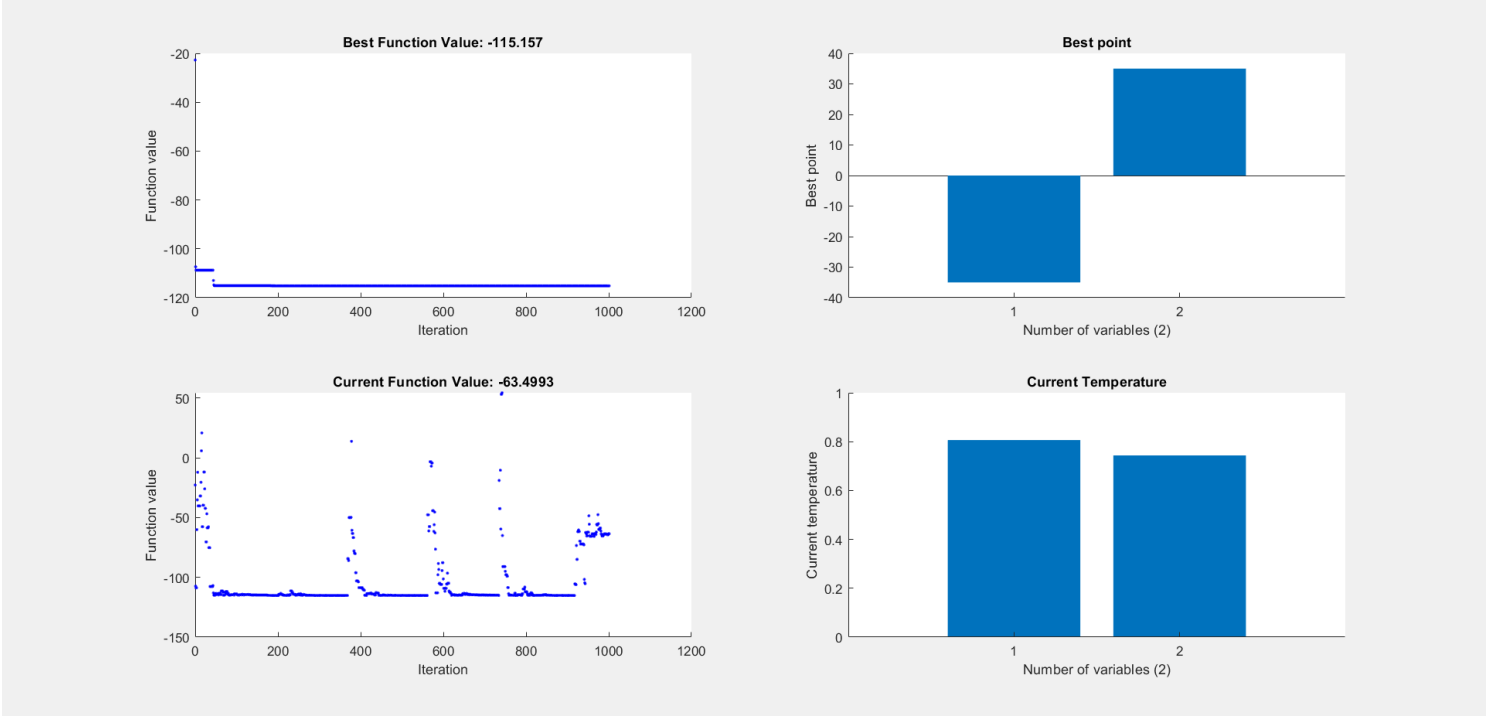
```
                          Best        Current          Mean
Iteration    f-count        f(x)         f(x)        temperature
     0          1       -22.7351       -22.7351           100
    10         11       -108.739       -40.2103          56.88
    20         21       -108.739       -39.6246        34.0562
    30         31       -108.739       -58.5488        20.3907
```

	40	41	-108.739	-107.653	12.2087
	50	51	-115.064	-113.52	7.30977
	60	61	-115.064	-113.245	4.37663
	70	71	-115.064	-114.901	2.62045
	80	81	-115.064	-113.307	1.56896
	90	91	-115.064	-114.484	0.939395
	100	101	-115.064	-113.762	0.56245
	110	111	-115.064	-114.477	0.33676
	120	121	-115.064	-114.346	0.201631
	130	131	-115.064	-114.441	0.120724
	140	141	-115.064	-114.777	0.0722817
	150	151	-115.064	-114.809	0.0432777
	160	161	-115.064	-114.827	0.025912
	170	171	-115.064	-114.788	0.0155145
*	173	176	-115.064	-114.81	61.931
	180	183	-115.087	-115.087	43.2487
	190	193	-115.155	-115.155	25.8946
	200	203	-115.157	-115.157	15.5041
	210	213	-115.157	-114.161	9.28285
	220	223	-115.157	-115.141	5.55799
	230	233	-115.157	-114.641	3.32777
	240	243	-115.157	-114.25	1.99246
	250	253	-115.157	-113.947	1.19296
	260	263	-115.157	-114.413	0.714269
	270	273	-115.157	-114.986	0.427659
	280	283	-115.157	-114.996	0.256055
	290	293	-115.157	-115.135	0.15331
	300	303	-115.157	-115.112	0.0917922

	Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
	310	313	-115.157	-115.136	0.0549594
	320	323	-115.157	-115.142	0.0329062
	330	333	-115.157	-115.153	0.0197022
	340	343	-115.157	-115.117	0.0117964
	350	353	-115.157	-115.151	0.00706295
	360	363	-115.157	-115.149	0.00422885
*	368	373	-115.157	-115.153	56.3604
	370	375	-115.157	-84.3248	50.8653
	380	385	-115.157	-63.25	30.4549
	390	395	-115.157	-102.985	18.2345
	400	405	-115.157	-108.637	10.9177
	410	415	-115.157	-114.901	6.53681
	420	425	-115.157	-113.647	3.91383
	430	435	-115.157	-113.989	2.34335
	440	445	-115.157	-113.066	1.40305
	450	455	-115.157	-115.14	0.840059
	460	465	-115.157	-115.067	0.502975
	470	475	-115.157	-114.965	0.301149
	480	485	-115.157	-115.121	0.180309
	490	495	-115.157	-115.148	0.107958
	500	505	-115.157	-115.096	0.0646383
	510	515	-115.157	-115.15	0.0387014
	520	525	-115.157	-115.144	0.0231719
	530	535	-115.157	-115.126	0.0138739
	540	545	-115.157	-115.156	0.00830681
	550	555	-115.157	-115.155	0.0049736
*	557	564	-115.157	-115.147	56.9794
	560	567	-115.157	-115.157	48.8527
	570	577	-115.157	-3.27841	29.2499
	580	587	-115.157	-62.8123	17.513
	590	597	-115.157	-105.017	10.4857
	600	607	-115.157	-101.331	6.27816

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
610	617	-115.157	-96.5134	3.75897
620	627	-115.157	-114.971	2.25063
630	637	-115.157	-114.778	1.34754
640	647	-115.157	-114.726	0.80682
650	657	-115.157	-113.463	0.483073
660	667	-115.157	-114.543	0.289234
670	677	-115.157	-114.508	0.173175
680	687	-115.157	-114.587	0.103686
690	697	-115.157	-114.787	0.0620808
700	707	-115.157	-114.84	0.03717
710	717	-115.157	-114.873	0.0222551
720	727	-115.157	-114.889	0.0133249
730	737	-115.157	-114.892	0.00797813
* 731	740	-115.157	-114.892	60.0119
740	749	-115.157	53.2166	37.8225
750	759	-115.157	-94.9143	22.6457
760	769	-115.157	-114.926	13.5588
770	779	-115.157	-115.026	8.11817
780	789	-115.157	-114.424	4.86065
790	799	-115.157	-115.067	2.91025
800	809	-115.157	-112.06	1.74247
810	819	-115.157	-114.749	1.04328
820	829	-115.157	-115.025	0.624652
830	839	-115.157	-115.03	0.374002
840	849	-115.157	-114.933	0.223929
850	859	-115.157	-114.869	0.134075
860	869	-115.157	-115.034	0.0802754
870	879	-115.157	-115.142	0.0480639
880	889	-115.157	-115.094	0.0287776
890	899	-115.157	-115.123	0.0172302
900	909	-115.157	-115.126	0.0103164

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
910	919	-115.157	-115.115	0.00617679
* 917	928	-115.157	-115.153	57.6261
920	931	-115.157	-106.108	49.4072
930	941	-115.157	-69.7321	29.5819
940	951	-115.157	-72.7697	17.7118
950	961	-115.157	-62.2339	10.6047
960	971	-115.157	-63.5511	6.34942
970	981	-115.157	-62.0878	3.80163
980	991	-115.157	-58.7447	2.27618
990	1001	-115.157	-63.659	1.36283
1000	1011	-115.157	-63.421	0.815978




```
Stop requested.
```

```
% Clear variables
clearvars options4
```

```
disp(['Solution = ',num2str(solution3)])
```

```
Solution = -34.9999          35
```

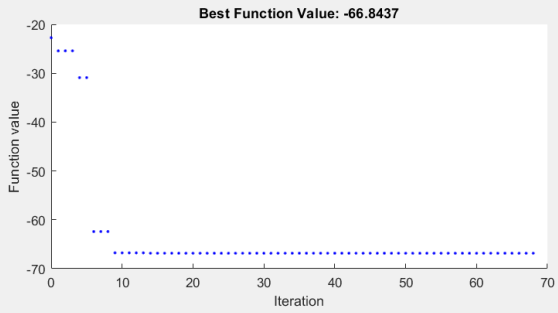
```
disp(['Function value = ', num2str(objectiveValue3)])
```

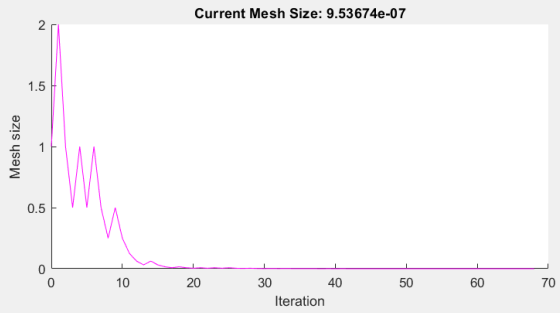
```
Function value = -115.157
```

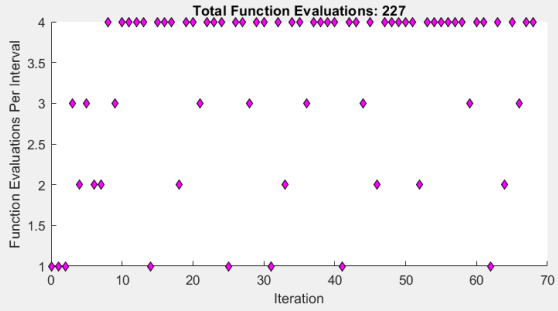
```
% Set nondefault solver options
options5 = optimoptions("patternsearch","Display","iter","PlotFcn",...
    ["psplotbestf","psplotmeshsize","psplotfuncount","psplotbestx"]);

% Solve
[solution4,objectiveValue4] = patternsearch(fun,x0,[],[],[],[],repmat(-35,...
    size(x0)),repmat(35,size(x0)),[],options5);
```

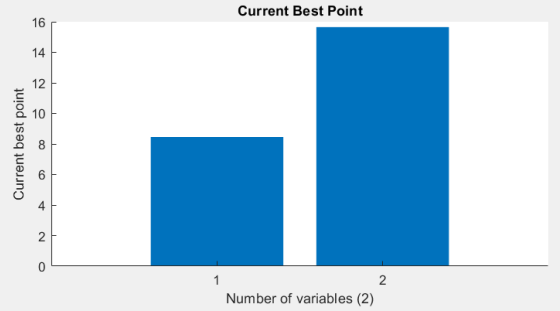
```
Iter     Func-count       f(x)      MeshSize     Method
    0           1       -22.7351             1
    1           2        -25.431             2     Successful Poll
    2           3        -25.431             1     Refine Mesh
    3           6        -25.431           0.5     Refine Mesh
    4           8       -30.8938             1     Successful Poll
    5          11       -30.8938           0.5     Refine Mesh
    6          13       -62.3993             1     Successful Poll
    7          15       -62.3993           0.5     Refine Mesh
    8          19       -62.3993          0.25     Refine Mesh
    9          22        -66.764           0.5     Successful Poll
```

```
    10          26        -66.764          0.25     Refine Mesh
    11          30        -66.764         0.125     Refine Mesh
    12          34        -66.764        0.0625     Refine Mesh
    13          38        -66.764       0.03125     Refine Mesh
    14          39       -66.8406        0.0625     Successful Poll
    15          43       -66.8406       0.03125     Refine Mesh
    16          47       -66.8406       0.01562     Refine Mesh
    17          51       -66.8406      0.007812     Refine Mesh
    18          53        -66.842       0.01562     Successful Poll
    19          57        -66.842      0.007812     Refine Mesh
    20          61        -66.842      0.003906     Refine Mesh
    21          64       -66.8422      0.007812     Successful Poll
    22          68       -66.8422      0.003906     Refine Mesh
    23          72        -66.843      0.007812     Successful Poll
    24          76        -66.843      0.003906     Refine Mesh
    25          77       -66.8435      0.007812     Successful Poll
    26          81       -66.8435      0.003906     Refine Mesh
    27          85       -66.8435      0.001953     Refine Mesh
    28          88       -66.8436      0.003906     Successful Poll
    29          92       -66.8436      0.001953     Refine Mesh
    30          96       -66.8436     0.0009766     Refine Mesh

Iter     Func-count        f(x)       MeshSize      Method
    31          97       -66.8436      0.001953     Successful Poll
    32         101       -66.8436     0.0009766     Refine Mesh
    33         103       -66.8437      0.001953     Successful Poll
    34         107       -66.8437     0.0009766     Refine Mesh
    35         111       -66.8437     0.0004883     Refine Mesh
    36         114       -66.8437     0.0009766     Successful Poll
    37         118       -66.8437     0.0004883     Refine Mesh
    38         122       -66.8437     0.0002441     Refine Mesh
    39         126       -66.8437     0.0004883     Successful Poll
    40         130       -66.8437     0.0002441     Refine Mesh
    41         131       -66.8437     0.0004883     Successful Poll
    42         135       -66.8437     0.0002441     Refine Mesh
    43         139       -66.8437     0.0001221     Refine Mesh
    44         142       -66.8437     0.0002441     Successful Poll
    45         146       -66.8437     0.0001221     Refine Mesh
    46         148       -66.8437     0.0002441     Successful Poll
    47         152       -66.8437     0.0001221     Refine Mesh
    48         156       -66.8437     6.104e-05     Refine Mesh
    49         160       -66.8437     0.0001221     Successful Poll
    50         164       -66.8437     6.104e-05     Refine Mesh
    51         168       -66.8437     3.052e-05     Refine Mesh
    52         170       -66.8437     6.104e-05     Successful Poll
    53         174       -66.8437     3.052e-05     Refine Mesh
    54         178       -66.8437     1.526e-05     Refine Mesh
    55         182       -66.8437     3.052e-05     Successful Poll
    56         186       -66.8437     1.526e-05     Refine Mesh
    57         190       -66.8437     7.629e-06     Refine Mesh
    58         194       -66.8437     3.815e-06     Refine Mesh
    59         197       -66.8437     7.629e-06     Successful Poll
    60         201       -66.8437     3.815e-06     Refine Mesh

Iter     Func-count        f(x)       MeshSize      Method
    61         205       -66.8437     1.907e-06     Refine Mesh
    62         206       -66.8437     3.815e-06     Successful Poll
    63         210       -66.8437     1.907e-06     Refine Mesh
    64         212       -66.8437     3.815e-06     Successful Poll
    65         216       -66.8437     1.907e-06     Refine Mesh
    66         219       -66.8437     3.815e-06     Successful Poll
    67         223       -66.8437     1.907e-06     Refine Mesh
    68         227       -66.8437     9.537e-07     Refine Mesh
Optimization terminated: mesh size less than options.MeshTolerance.
```










```
% Clear variables
clearvars options5
```

```
disp(['Solution = ',num2str(solution4)])
```

```
Solution = 8.45691      15.6509
```

```
disp(['Function value = ', num2str(objectiveValue4)])
```

```
Function value = -66.8437
```

```
% Set nondefault solver options
options6 = optimoptions("surrogateopt","Display","iter","PlotFcn",...
    ["surrogateoptplot","optimplotfvalconstr","optimplotfval","optimplotx"]);

% Solve
[solution5,objectiveValue5] = surrogateopt(fun,repmat(-35,nvar,1),repmat(35,...
    nvar,1),[],[],[],[],[],options6);
```

```
Scalar objective function
Number of variables: 2
Number of integer constraints: 0
Number of linear inequality constraints: 0
Number of linear equality constraints: 0
Number of nonlinear inequality constraints: 0

F-count       Time        Best          Current         Trial
             (seconds)    Fval          Fval            type
   1         0.30       1.0382e+01      1.0382e+01    random
   2         0.69      -2.5460e+01     -2.5460e+01    random
   3         0.90      -2.5460e+01      3.8616e+01    random
```

```
    4        1.08      -5.8619e+01     -5.8619e+01   random
    5        1.26      -5.8619e+01     -3.4513e+01   random
    6        1.44      -5.8619e+01     -9.4974e+00   random
    7        1.62      -8.6609e+01     -8.6609e+01   random
    8        1.79      -8.6609e+01     -2.7159e+00   random
    9        1.97      -8.6609e+01     -6.6435e+01   random
   10        2.17      -8.6609e+01     -1.5056e+01   random
   11        2.35      -8.6609e+01     -2.7126e+01   random
   12        2.58      -8.6609e+01      2.6203e+01   random
   13        2.77      -8.6609e+01      5.4029e+01   random
   14        2.97      -8.6609e+01     -5.8558e+01   random
   15        3.15      -8.6609e+01      5.2604e+00   random
   16        3.33      -8.6609e+01     -1.8643e+01   random
   17        3.51      -8.6609e+01     -1.3287e+01   random
   18        3.68      -8.6609e+01      1.2150e+01   random
   19        3.86      -8.6609e+01      3.4191e+01   random
   20        4.04      -8.6609e+01     -6.2655e+01   random
   21        4.23      -8.6609e+01     -2.5756e+01   adaptive
   22        4.45      -1.1516e+02     -1.1516e+02   adaptive
   23        4.63      -1.1516e+02     -9.5742e+01   adaptive
   24        4.81      -1.1516e+02     -1.1501e+02   adaptive
   25        4.99      -1.1516e+02     -6.2240e+01   adaptive
   26        5.16      -1.1516e+02     -9.7017e+01   adaptive
   27        5.34      -1.1516e+02     -1.1093e+02   adaptive
   28        5.52      -1.1516e+02     -1.1507e+02   adaptive
   29        5.70      -1.1516e+02     -8.0872e+01   adaptive
   30        5.87      -1.1516e+02     -1.0095e+02   adaptive

F-count      Time         Best          Current         Trial
            (seconds)     Fval          Fval            type
   31        6.05      -1.1516e+02     -1.1364e+02   adaptive
   32        6.23      -1.1516e+02     -1.1513e+02   adaptive
   33        6.41      -1.1516e+02     -1.0624e+02   adaptive
   34        6.59      -1.1516e+02     -1.0744e+02   adaptive
   35        6.77      -1.1516e+02     -1.1451e+02   adaptive
   36        6.95      -1.1516e+02     -1.1515e+02   adaptive
   37        7.13      -1.1516e+02     -8.3179e+01   adaptive
   38        7.32      -1.1516e+02     -1.1085e+02   adaptive
   39        7.49      -1.1516e+02     -1.1483e+02   adaptive
   40        7.67      -1.1516e+02     -1.1516e+02   adaptive
   41        7.86      -1.1516e+02     -1.1071e+02   adaptive
   42        8.06      -1.1516e+02     -1.1290e+02   adaptive
   43        8.34      -1.1516e+02     -8.2445e+01   random
   44        8.53      -1.1516e+02      5.3248e+00   random
   45        8.71      -1.1516e+02     -2.1725e+01   random
   46        8.89      -1.1516e+02     -4.5203e+00   random
   47        9.08      -1.1516e+02      2.7505e+01   random
   48        9.26      -1.1516e+02      2.9949e+00   random
   49        9.45      -1.1516e+02     -6.1293e+01   random
   50        9.63      -1.1516e+02     -4.2651e+01   random
   51        9.81      -1.1516e+02      1.4421e+01   random
   52       10.00      -1.1516e+02     -5.1890e+01   random
   53       10.18      -1.1516e+02      6.4710e+01   random
   54       10.36      -1.1516e+02     -4.8899e+01   random
   55       10.54      -1.1516e+02     -4.1991e+01   random
   56       10.73      -1.1516e+02      1.4381e+00   random
   57       10.91      -1.1516e+02     -1.1017e+02   random
   58       11.09      -1.1516e+02     -1.6078e+01   random
   59       11.27      -1.1516e+02     -7.8881e+00   random
   60       11.45      -1.1516e+02     -5.2843e+01   random

F-count      Time         Best          Current         Trial
            (seconds)     Fval          Fval            type
   61       11.64      -1.1516e+02      2.4464e+01   random
```

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
62	11.82	-1.1516e+02	-2.5934e+01	random
63	12.02	-1.1516e+02	-7.0816e+01	adaptive
64	12.20	-1.1516e+02	-5.8884e+01	adaptive
65	12.39	-1.1516e+02	-1.1361e+02	adaptive
66	12.58	-1.1516e+02	-1.1468e+02	adaptive
67	12.76	-1.1516e+02	2.4876e+01	adaptive
68	12.94	-1.1516e+02	-4.0369e+01	adaptive
69	13.12	-1.1516e+02	-9.0581e+01	adaptive
70	13.31	-1.1516e+02	-1.1498e+02	adaptive
71	13.49	-1.1516e+02	-6.3366e+01	adaptive
72	13.67	-1.1516e+02	-4.9123e+01	adaptive
73	13.86	-1.1516e+02	-1.0578e+02	adaptive
74	14.04	-1.1516e+02	-1.1515e+02	adaptive
75	14.22	-1.1516e+02	1.5297e+01	adaptive
76	14.40	-1.1516e+02	-6.2791e+01	adaptive
77	14.59	-1.1516e+02	-1.1468e+02	adaptive
78	14.79	-1.1516e+02	-1.1490e+02	adaptive
79	15.00	-1.1516e+02	-6.7261e+01	adaptive
80	15.19	-1.1516e+02	-9.8604e+01	adaptive
81	15.37	-1.1516e+02	-1.1411e+02	adaptive
82	15.56	-1.1516e+02	-1.1513e+02	adaptive
83	15.75	-1.1516e+02	-6.5250e+01	adaptive
84	15.93	-1.1516e+02	-9.9199e+01	adaptive
85	16.12	-1.1516e+02	-1.1246e+02	adaptive
86	16.30	-1.1516e+02	-1.1515e+02	adaptive
87	16.49	-1.1516e+02	-1.0505e+02	adaptive
88	16.68	-1.1516e+02	-1.0392e+02	adaptive
89	16.86	-1.1516e+02	-1.1510e+02	adaptive
90	17.05	-1.1516e+02	-1.1514e+02	adaptive

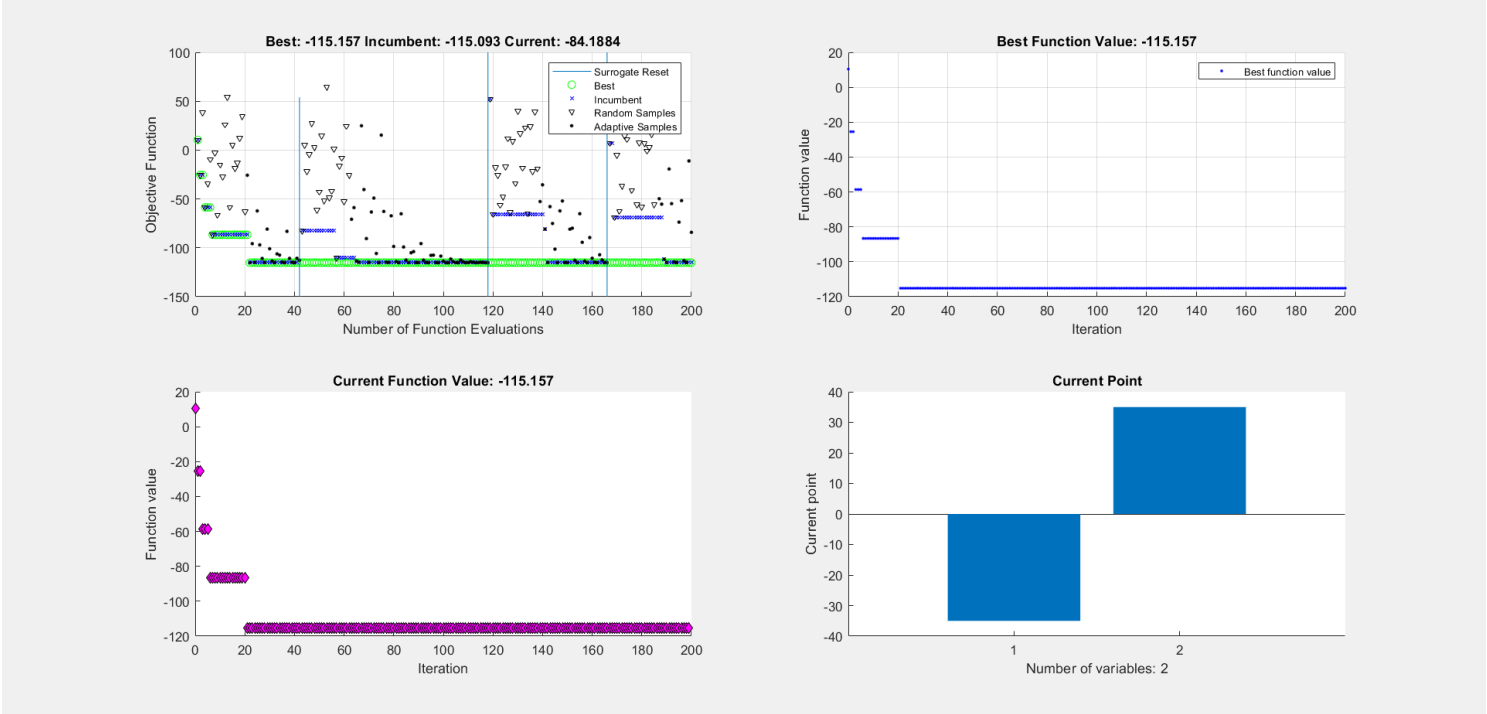
F-count	Time (seconds)	Best Fval	Current Fval	Trial type
91	17.23	-1.1516e+02	-9.5653e+01	adaptive
92	17.42	-1.1516e+02	-1.1262e+02	adaptive
93	17.63	-1.1516e+02	-1.1502e+02	adaptive
94	17.83	-1.1516e+02	-1.1515e+02	adaptive
95	18.02	-1.1516e+02	-1.0772e+02	adaptive
96	18.20	-1.1516e+02	-1.0747e+02	adaptive
97	18.40	-1.1516e+02	-1.1511e+02	adaptive
98	18.60	-1.1516e+02	-1.1516e+02	adaptive
99	18.79	-1.1516e+02	-1.0846e+02	adaptive
100	18.99	-1.1516e+02	-1.1366e+02	adaptive
101	19.19	-1.1516e+02	-1.1515e+02	adaptive
102	19.39	-1.1516e+02	-1.1516e+02	adaptive
103	19.59	-1.1516e+02	-1.1138e+02	adaptive
104	19.80	-1.1516e+02	-1.1416e+02	adaptive
105	20.01	-1.1516e+02	-1.1515e+02	adaptive
106	20.23	-1.1516e+02	-1.1516e+02	adaptive
107	20.47	-1.1516e+02	-1.1236e+02	adaptive
108	20.69	-1.1516e+02	-1.1428e+02	adaptive
109	20.90	-1.1516e+02	-1.1516e+02	adaptive
110	21.11	-1.1516e+02	-1.1515e+02	adaptive
111	21.32	-1.1516e+02	-1.1413e+02	adaptive
112	21.52	-1.1516e+02	-1.1462e+02	adaptive
113	21.73	-1.1516e+02	-1.1515e+02	adaptive
114	21.95	-1.1516e+02	-1.1515e+02	adaptive
115	22.16	-1.1516e+02	-1.1483e+02	adaptive
116	22.37	-1.1516e+02	-1.1486e+02	adaptive
117	22.58	-1.1516e+02	-1.1515e+02	adaptive
118	22.79	-1.1516e+02	-1.1515e+02	adaptive
119	23.06	-1.1516e+02	5.2101e+01	random
120	23.24	-1.1516e+02	-6.5544e+01	random

F-count	Time	Best	Current	Trial

	(seconds)	Fval	Fval	type
121	23.42	-1.1516e+02	-1.7553e+01	random
122	23.60	-1.1516e+02	-2.5712e+01	random
123	23.79	-1.1516e+02	-5.6259e+01	random
124	23.98	-1.1516e+02	-4.7631e+01	random
125	24.16	-1.1516e+02	-1.6880e+01	random
126	24.35	-1.1516e+02	1.1866e+01	random
127	24.53	-1.1516e+02	-6.3913e+01	random
128	24.71	-1.1516e+02	9.0198e+00	random
129	24.89	-1.1516e+02	-3.4123e+01	random
130	25.07	-1.1516e+02	3.9972e+01	random
131	25.27	-1.1516e+02	1.7189e+01	random
132	25.47	-1.1516e+02	-1.8312e+01	random
133	25.65	-1.1516e+02	2.3001e+01	random
134	25.84	-1.1516e+02	-6.4791e+01	random
135	26.02	-1.1516e+02	2.4199e+01	random
136	26.20	-1.1516e+02	-2.1734e+01	random
137	26.39	-1.1516e+02	3.9289e+01	random
138	26.57	-1.1516e+02	-1.9064e+01	random
139	26.75	-1.1516e+02	-5.2676e+01	adaptive
140	26.94	-1.1516e+02	-3.5527e+01	adaptive
141	27.12	-1.1516e+02	-8.0966e+01	adaptive
142	27.31	-1.1516e+02	-1.1504e+02	adaptive
143	27.49	-1.1516e+02	-5.7836e+01	adaptive
144	27.67	-1.1516e+02	-7.5081e+01	adaptive
145	27.85	-1.1516e+02	-1.0132e+02	adaptive
146	28.03	-1.1516e+02	-1.1515e+02	adaptive
147	28.21	-1.1516e+02	-6.2224e+01	adaptive
148	28.39	-1.1516e+02	-5.2110e+01	adaptive
149	28.57	-1.1516e+02	-1.1507e+02	adaptive
150	28.75	-1.1516e+02	-1.1513e+02	adaptive

F-count	Time	Best	Current	Trial
	(seconds)	Fval	Fval	type
151	28.93	-1.1516e+02	-8.0998e+01	adaptive
152	29.12	-1.1516e+02	-7.9901e+01	adaptive
153	29.31	-1.1516e+02	-1.1284e+02	adaptive
154	29.50	-1.1516e+02	-1.1512e+02	adaptive
155	29.68	-1.1516e+02	-6.5150e+01	adaptive
156	29.86	-1.1516e+02	-9.4356e+01	adaptive
157	30.05	-1.1516e+02	-1.1364e+02	adaptive
158	30.24	-1.1516e+02	-1.1513e+02	adaptive
159	30.42	-1.1516e+02	-8.9546e+01	adaptive
160	30.61	-1.1516e+02	-1.1073e+02	adaptive
161	30.80	-1.1516e+02	-1.1476e+02	adaptive
162	30.99	-1.1516e+02	-1.1515e+02	adaptive
163	31.22	-1.1516e+02	-1.0717e+02	adaptive
164	31.41	-1.1516e+02	-1.1231e+02	adaptive
165	31.60	-1.1516e+02	-1.1509e+02	adaptive
166	31.80	-1.1516e+02	-1.1515e+02	adaptive
167	32.09	-1.1516e+02	7.1179e+00	random
168	32.27	-1.1516e+02	2.2143e+01	random
169	32.46	-1.1516e+02	-6.8696e+01	random
170	32.65	-1.1516e+02	-5.0107e+00	random
171	32.84	-1.1516e+02	-6.2604e+01	random
172	33.02	-1.1516e+02	-3.6839e+01	random
173	33.21	-1.1516e+02	1.4836e+01	random
174	33.40	-1.1516e+02	1.1175e+01	random
175	33.59	-1.1516e+02	6.0044e+01	random
176	33.80	-1.1516e+02	-4.1018e+01	random
177	34.00	-1.1516e+02	2.5073e+01	random
178	34.18	-1.1516e+02	-5.5511e+01	random
179	34.37	-1.1516e+02	7.5225e+00	random
180	34.55	-1.1516e+02	-5.8222e+01	random

```
F-count        Time          Best          Current         Trial
             (seconds)     Fval          Fval            type
 181          34.75      -1.1516e+02      6.8194e+00    random
 182          34.93      -1.1516e+02     -8.7806e-01    random
 183          35.12      -1.1516e+02      2.6895e+00    random
 184          35.31      -1.1516e+02      1.6237e+01    random
 185          35.51      -1.1516e+02     -5.5660e+01    random
 186          35.71      -1.1516e+02      2.1197e+01    random
 187          35.90      -1.1516e+02     -4.9726e+01    adaptive
 188          36.09      -1.1516e+02     -5.5299e+01    adaptive
 189          36.27      -1.1516e+02     -1.1166e+02    adaptive
 190          36.46      -1.1516e+02     -1.1508e+02    adaptive
 191          36.64      -1.1516e+02     -1.9366e+01    adaptive
 192          36.83      -1.1516e+02     -5.4843e+01    adaptive
 193          37.01      -1.1516e+02     -1.1441e+02    adaptive
 194          37.20      -1.1516e+02     -1.1509e+02    adaptive
 195          37.38      -1.1516e+02     -7.3710e+01    adaptive
 196          37.56      -1.1516e+02     -5.1734e+01    adaptive
 197          37.75      -1.1516e+02     -1.1318e+02    adaptive
 198          37.93      -1.1516e+02     -1.1499e+02    adaptive
 199          38.12      -1.1516e+02     -1.1118e+01    adaptive
 200          38.31      -1.1516e+02     -8.4188e+01    adaptive
```




```
surrogateopt stopped because it exceeded the function evaluation limit set by
'options.MaxFunctionEvaluations'.
```

```
% Clear variables
clearvars options6
```

```
disp(['Solution = ',num2str(solution5)])
```

```
Solution = -35  35
```

```
disp(['Function value = ', num2str(objectiveValue5)])
```

```
Function value = -115.1571
```

```
nvar = 2
```

```
nvar = 2
```

```
fun = @
```

```
fun = function_handle with value:
    @leon
```

```
% Set nondefault solver options
options = optimoptions("ga","Display","iter","PlotFcn",["gaplotdistance",...
    "gaplotscores","gaplotbestf","gaplotexpectation"]);

% Solve
[solution,objectiveValue] = ga(fun,nvar,[],[],[],[],repmat(-35,nvar,1),...
    repmat(35,nvar,1),[],[],options);
```

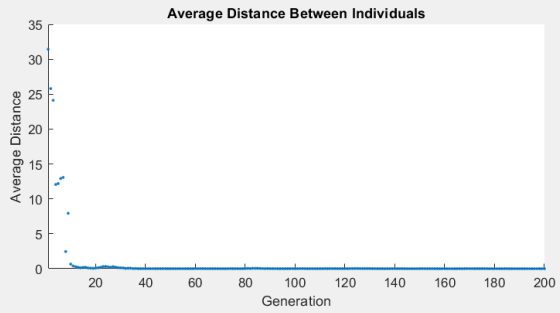
```
Single objective optimization:
2 Variable(s)

Options:
CreationFcn:       @gacreationuniform
CrossoverFcn:      @crossoverscattered
SelectionFcn:      @selectionstochunif
MutationFcn:       @mutationadaptfeasible

                                 Best           Mean      Stall
Generation      Func-count       f(x)           f(x)    Generations
    1              100            Inf            Inf        0
    2              150          95.45            Inf        0
    3              200          3.944            Inf        0
    4              250          1.719            Inf        0
    5              300          1.719            Inf        1
    6              350          1.719            Inf        2
    7              400         0.8388            Inf        0
    8              450         0.5979            Inf        0
    9              500         0.5979            Inf        1
   10              550         0.5979          13.76        2
   11              600         0.5979          8.211        3
   12              650         0.5979           7.48        4
   13              700         0.5227          4.665        0
   14              750         0.5227          3.869        1
   15              800         0.5098          2.696        0
   16              850         0.5098          2.744        1
   17              900         0.5098         0.8966        2
   18              950         0.4139         0.6238        0
   19             1000         0.4105         0.6172        0
   20             1050         0.2751         0.6398        0
   21             1100         0.1965          1.538        0
   22             1150         0.1965          6.749        1
   23             1200         0.1965          4.785        2
   24             1250         0.1725          3.736        0
   25             1300         0.1725          4.053        1
   26             1350         0.1598          3.054        0
   27             1400         0.1598          3.409        1
   28             1450         0.1598          3.904        2
   29             1500         0.1598          2.053        3
   30             1550         0.1598          1.466        4

                                 Best           Mean      Stall
Generation      Func-count       f(x)           f(x)    Generations
```

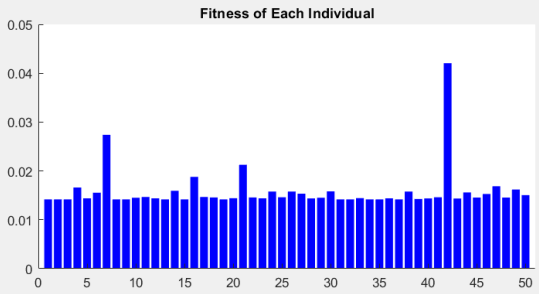
Generation	Func-count	Best f(x)	Mean f(x)	Stall Generations
31	1600	0.08588	1.303	0
32	1650	0.08588	0.6888	1
33	1700	0.08482	0.582	0
34	1750	0.08482	0.4681	1
35	1800	0.08482	0.2883	2
36	1850	0.08482	0.2159	3
37	1900	0.08324	0.1023	0
38	1950	0.08021	0.09941	0
39	2000	0.08021	0.09754	1
40	2050	0.07746	0.0875	0
41	2100	0.07746	0.09373	1
42	2150	0.07746	0.09057	2
43	2200	0.07618	0.08668	0
44	2250	0.07612	0.08539	0
45	2300	0.07612	0.09747	1
46	2350	0.07612	0.08922	2
47	2400	0.07319	0.08425	0
48	2450	0.07319	0.08435	1
49	2500	0.07319	0.08149	2
50	2550	0.07267	0.0772	0
51	2600	0.0714	0.07545	0
52	2650	0.0714	0.07591	1
53	2700	0.07009	0.07596	0
54	2750	0.07009	0.07493	1
55	2800	0.0695	0.07382	0
56	2850	0.0695	0.0757	1
57	2900	0.06826	0.07301	0
58	2950	0.06825	0.07394	0
59	3000	0.06467	0.07926	0
60	3050	0.06467	0.1178	1
61	3100	0.06467	0.1235	2
62	3150	0.06467	0.1003	3
63	3200	0.06345	0.08543	0
64	3250	0.06345	0.08231	1
65	3300	0.06345	0.07409	2
66	3350	0.06285	0.06857	0
67	3400	0.06261	0.06819	0
68	3450	0.06261	0.07111	1
69	3500	0.06261	0.06697	2
70	3550	0.06178	0.06591	0
71	3600	0.06133	0.06667	0
72	3650	0.06072	0.06843	0
73	3700	0.06064	0.07602	0
74	3750	0.06064	0.1078	1
75	3800	0.06064	0.08867	2
76	3850	0.06064	0.07062	3
77	3900	0.05849	0.06939	0
78	3950	0.05787	0.06605	0
79	4000	0.05751	0.07512	0
80	4050	0.0554	0.1109	0
81	4100	0.0554	0.2751	1
82	4150	0.04358	0.1995	0
83	4200	0.04358	0.3212	1
84	4250	0.04358	0.3491	2
85	4300	0.038	0.1823	0
86	4350	0.038	0.1809	1
87	4400	0.038	0.1504	2
88	4450	0.038	0.1034	3
89	4500	0.038	0.08171	4
90	4550	0.03733	0.05466	0

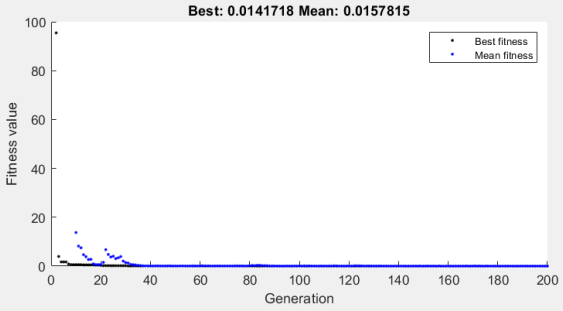
Generation	Func-count	Best f(x)	Mean f(x)	Stall Generations
91	4600	0.03733	0.05124	1
92	4650	0.03696	0.04436	0
93	4700	0.03669	0.04158	0
94	4750	0.03669	0.04304	1
95	4800	0.03622	0.04186	0
96	4850	0.03515	0.04152	0
97	4900	0.03515	0.05135	1
98	4950	0.03506	0.05105	0
99	5000	0.03506	0.05353	1
100	5050	0.03502	0.04613	0
101	5100	0.03215	0.05432	0
102	5150	0.03215	0.1159	1
103	5200	0.03215	0.08799	2
104	5250	0.03215	0.06813	3
105	5300	0.03212	0.05019	0
106	5350	0.03212	0.04279	1
107	5400	0.03086	0.03718	0
108	5450	0.03086	0.04453	1
109	5500	0.03083	0.04195	0
110	5550	0.03062	0.04468	0
111	5600	0.02929	0.03849	0
112	5650	0.02929	0.07155	1
113	5700	0.02801	0.06725	0
114	5750	0.02801	0.1304	1
115	5800	0.02801	0.09148	2
116	5850	0.02795	0.04681	0
117	5900	0.02795	0.05818	1
118	5950	0.02793	0.04676	0
119	6000	0.02793	0.05089	1
120	6050	0.02793	0.0388	0

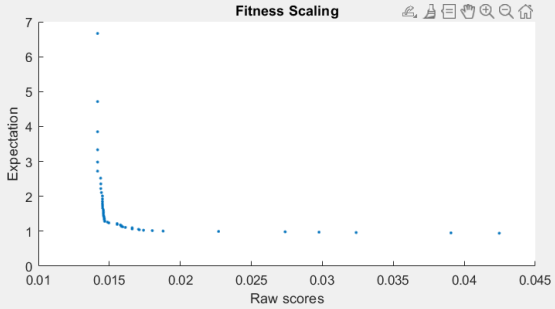
Generation	Func-count	Best f(x)	Mean f(x)	Stall Generations
121	6100	0.02643	0.04565	0
122	6150	0.02643	0.1217	1
123	6200	0.02357	0.1137	0
124	6250	0.02357	0.1195	1
125	6300	0.02357	0.09177	2
126	6350	0.02357	0.09708	3
127	6400	0.02281	0.08755	0
128	6450	0.02146	0.0564	0
129	6500	0.02146	0.0639	1
130	6550	0.02012	0.06852	0
131	6600	0.02012	0.06692	1
132	6650	0.02012	0.052	2
133	6700	0.02012	0.0407	3
134	6750	0.02012	0.02758	4
135	6800	0.02001	0.02846	0
136	6850	0.02	0.02183	0
137	6900	0.01983	0.02172	0
138	6950	0.0187	0.02321	0
139	7000	0.0187	0.03644	1
140	7050	0.0187	0.03665	2
141	7100	0.0187	0.03268	3
142	7150	0.0187	0.03139	4
143	7200	0.01854	0.02309	0
144	7250	0.01854	0.02104	1
145	7300	0.01854	0.01918	0
146	7350	0.01839	0.01886	0
147	7400	0.01839	0.02017	1
148	7450	0.0183	0.0197	0
149	7500	0.01795	0.01936	0

```
  150            7550         0.01752         0.02117        0

                                Best           Mean      Stall
Generation      Func-count      f(x)           f(x)    Generations
  151            7600         0.01752         0.03441        1
  152            7650         0.01752         0.03687        2
  153            7700         0.01752         0.02694        3
  154            7750         0.01723         0.02249        0
  155            7800         0.01723         0.02324        1
  156            7850         0.01723         0.02117        2
  157            7900         0.01723         0.01968        3
  158            7950         0.01719         0.01819        0
  159            8000         0.01719         0.01773        1
  160            8050         0.01719         0.01748        2
  161            8100         0.01716         0.01748        0
  162            8150         0.01712         0.01747        0
  163            8200          0.0171         0.01751        0
  164            8250         0.01697         0.01771        0
  165            8300         0.01665         0.01898        0
  166            8350         0.01665         0.02241        1
  167            8400         0.01647         0.02076        0
  168            8450         0.01647         0.02599        0
  169            8500         0.01647         0.03826        1
  170            8550         0.01647           0.042        2
  171            8600         0.01536         0.03936        0
  172            8650         0.01536         0.03395        1
  173            8700         0.01493         0.02923        0
  174            8750         0.01493         0.02638        1
  175            8800         0.01493         0.02887        2
  176            8850         0.01493         0.02261        3
  177            8900         0.01493         0.01876        4
  178            8950         0.01489         0.01582        0
  179            9000         0.01489         0.01584        1
  180            9050         0.01485         0.01571        0

                                Best           Mean      Stall
Generation      Func-count      f(x)           f(x)    Generations
  181            9100         0.01481         0.01608        0
  182            9150         0.01481         0.01633        0
  183            9200         0.01478         0.01741        0
  184            9250         0.01478         0.01938        1
  185            9300         0.01478         0.01906        2
  186            9350         0.01478         0.01821        3
  187            9400         0.01477         0.01632        0
  188            9450         0.01475          0.0159        0
  189            9500         0.01475         0.01644        1
  190            9550         0.01461         0.01613        0
  191            9600         0.01461         0.01708        1
  192            9650         0.01461         0.01667        2
  193            9700         0.01461         0.01564        3
  194            9750         0.01453         0.01527        0
  195            9800         0.01451         0.01486        0
  196            9850          0.0144         0.01494        0
  197            9900         0.01417         0.01586        0
  198            9950         0.01417         0.02051        1
  199           10000         0.01417         0.01726        2
  200           10050         0.01417         0.01578        3
Optimization terminated: maximum number of generations exceeded.
```










```
% Clear variables
clearvars options
```

```
disp(['Solution = ',num2str(solution)])
```

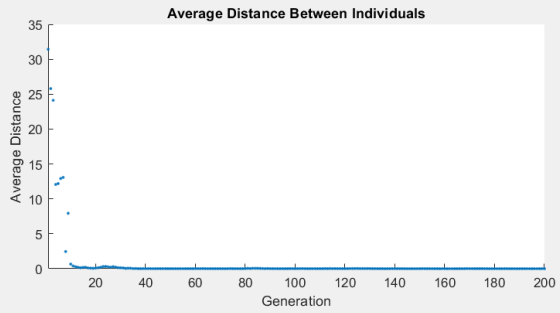
```
Solution = 0.88097     0.68392
```

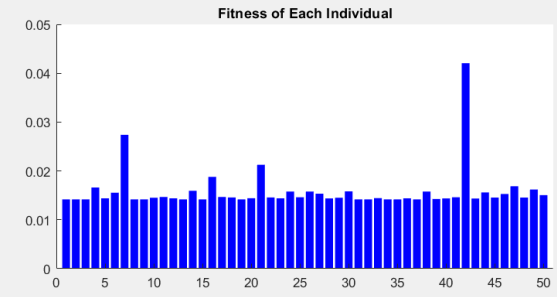
```
disp(['Function value = ', num2str(objectiveValue)])
```

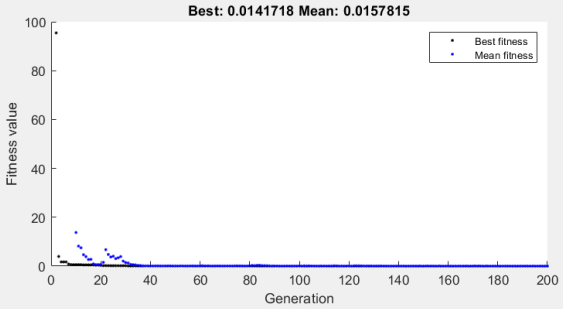
```
Function value = 0.014172
```

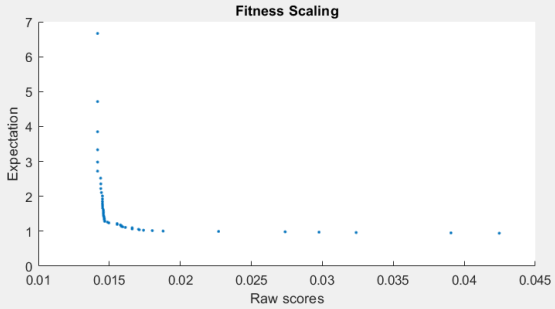
```
% Set nondefault solver options
options3 = optimoptions("particleswarm","Display","iter","PlotFcn",...
    "pswplotbestf");

% Solve
[solution2,objectiveValue2] = particleswarm(fun,nvar,repmat(-35,nvar,1),...
    repmat(35,nvar,1),options3);
```

```
                                Best           Mean     Stall
Iteration     f-count           f(x)           f(x)    Iterations
    0             20            NaN            NaN        0
    1             40            NaN            Inf        0
    2             60            NaN            NaN        1
    3             80            NaN            Inf        2
    4            100            NaN            Inf        3
    5            120            NaN            Inf        4
    6            140            NaN            NaN        5
    7            160            NaN            NaN        6
    8            180            NaN            Inf        7
    9            200            NaN            Inf        8
```









10	220	NaN	Inf	9
11	240	NaN	Inf	10
12	260	NaN	NaN	11
13	280	NaN	NaN	12
14	300	NaN	NaN	13
15	320	NaN	NaN	14
16	340	NaN	NaN	15
17	360	NaN	NaN	16
18	380	NaN	NaN	17
19	400	NaN	NaN	18
20	420	NaN	NaN	19
21	440	NaN	NaN	20
22	460	NaN	NaN	21
23	480	NaN	NaN	22
24	500	NaN	NaN	23
25	520	NaN	NaN	24
26	540	NaN	NaN	25
27	560	NaN	NaN	26
28	580	NaN	NaN	27
29	600	NaN	NaN	28
30	620	NaN	NaN	29

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
31	640	NaN	NaN	30
32	660	NaN	NaN	31
33	680	NaN	NaN	32
34	700	NaN	NaN	33
35	720	NaN	NaN	34
36	740	NaN	NaN	35
37	760	NaN	NaN	36
38	780	NaN	NaN	37
39	800	NaN	NaN	38
40	820	NaN	NaN	39
41	840	NaN	NaN	40
42	860	NaN	NaN	41
43	880	NaN	NaN	42
44	900	NaN	NaN	43
45	920	NaN	NaN	44

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
46	940	NaN	NaN	45
47	960	NaN	NaN	46
48	980	NaN	NaN	47
49	1000	NaN	NaN	48
50	1020	NaN	NaN	49
51	1040	NaN	NaN	50
52	1060	NaN	NaN	51
53	1080	NaN	NaN	52
54	1100	NaN	NaN	53
55	1120	NaN	NaN	54
56	1140	NaN	NaN	55
57	1160	NaN	NaN	56
58	1180	NaN	NaN	57
59	1200	NaN	NaN	58
60	1220	NaN	NaN	59

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
61	1240	NaN	NaN	60
62	1260	NaN	NaN	61
63	1280	NaN	NaN	62
64	1300	NaN	NaN	63
65	1320	NaN	NaN	64
66	1340	NaN	NaN	65
67	1360	NaN	NaN	66
68	1380	NaN	NaN	67
69	1400	NaN	NaN	68
70	1420	NaN	NaN	69
71	1440	NaN	NaN	70
72	1460	NaN	NaN	71
73	1480	NaN	NaN	72
74	1500	NaN	NaN	73
75	1520	NaN	NaN	74
76	1540	NaN	NaN	75
77	1560	NaN	NaN	76
78	1580	NaN	NaN	77
79	1600	NaN	NaN	78
80	1620	NaN	NaN	79
81	1640	NaN	NaN	80
82	1660	NaN	NaN	81
83	1680	NaN	NaN	82
84	1700	NaN	NaN	83
85	1720	NaN	NaN	84
86	1740	NaN	NaN	85
87	1760	NaN	NaN	86
88	1780	NaN	NaN	87
89	1800	NaN	NaN	88
90	1820	NaN	NaN	89

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
91	1840	NaN	NaN	90
92	1860	NaN	NaN	91
93	1880	NaN	NaN	92
94	1900	NaN	NaN	93
95	1920	NaN	NaN	94
96	1940	NaN	NaN	95
97	1960	NaN	NaN	96
98	1980	NaN	NaN	97
99	2000	NaN	NaN	98
100	2020	NaN	NaN	99
101	2040	NaN	NaN	100
102	2060	NaN	NaN	101
103	2080	NaN	NaN	102

104	2100	NaN	NaN	103
105	2120	NaN	NaN	104
106	2140	NaN	NaN	105
107	2160	NaN	NaN	106
108	2180	NaN	NaN	107
109	2200	NaN	NaN	108
110	2220	NaN	NaN	109
111	2240	NaN	NaN	110
112	2260	NaN	NaN	111
113	2280	NaN	NaN	112
114	2300	NaN	NaN	113
115	2320	NaN	NaN	114
116	2340	NaN	NaN	115
117	2360	NaN	NaN	116
118	2380	NaN	NaN	117
119	2400	NaN	NaN	118
120	2420	NaN	NaN	119

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
121	2440	NaN	NaN	120
122	2460	NaN	NaN	121
123	2480	NaN	NaN	122
124	2500	NaN	NaN	123
125	2520	NaN	NaN	124
126	2540	NaN	NaN	125
127	2560	NaN	NaN	126
128	2580	NaN	NaN	127
129	2600	NaN	NaN	128
130	2620	NaN	NaN	129
131	2640	NaN	NaN	130
132	2660	NaN	NaN	131
133	2680	NaN	NaN	132
134	2700	NaN	NaN	133
135	2720	NaN	NaN	134
136	2740	NaN	NaN	135
137	2760	NaN	NaN	136
138	2780	NaN	NaN	137
139	2800	NaN	NaN	138
140	2820	NaN	NaN	139
141	2840	NaN	NaN	140
142	2860	NaN	NaN	141
143	2880	NaN	NaN	142
144	2900	NaN	NaN	143
145	2920	NaN	NaN	144
146	2940	NaN	NaN	145
147	2960	NaN	NaN	146
148	2980	NaN	NaN	147
149	3000	NaN	NaN	148
150	3020	NaN	NaN	149

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
151	3040	NaN	NaN	150
152	3060	NaN	NaN	151
153	3080	NaN	NaN	152
154	3100	NaN	NaN	153
155	3120	NaN	NaN	154
156	3140	NaN	NaN	155
157	3160	NaN	NaN	156
158	3180	NaN	NaN	157
159	3200	NaN	NaN	158
160	3220	NaN	NaN	159
161	3240	NaN	NaN	160

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
162	3260	NaN	NaN	161
163	3280	NaN	NaN	162
164	3300	NaN	NaN	163
165	3320	NaN	NaN	164
166	3340	NaN	NaN	165
167	3360	NaN	NaN	166
168	3380	NaN	NaN	167
169	3400	NaN	NaN	168
170	3420	NaN	NaN	169
171	3440	NaN	NaN	170
172	3460	NaN	NaN	171
173	3480	NaN	NaN	172
174	3500	NaN	NaN	173
175	3520	NaN	NaN	174
176	3540	NaN	NaN	175
177	3560	NaN	NaN	176
178	3580	NaN	NaN	177
179	3600	NaN	NaN	178
180	3620	NaN	NaN	179

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
181	3640	NaN	NaN	180
182	3660	NaN	NaN	181
183	3680	NaN	NaN	182
184	3700	NaN	NaN	183
185	3720	NaN	NaN	184
186	3740	NaN	NaN	185
187	3760	NaN	NaN	186
188	3780	NaN	NaN	187
189	3800	NaN	NaN	188
190	3820	NaN	NaN	189
191	3840	NaN	NaN	190
192	3860	NaN	NaN	191
193	3880	NaN	NaN	192
194	3900	NaN	NaN	193
195	3920	NaN	NaN	194
196	3940	NaN	NaN	195
197	3960	NaN	NaN	196
198	3980	NaN	NaN	197
199	4000	NaN	NaN	198
200	4020	NaN	NaN	199
201	4040	NaN	NaN	200
202	4060	NaN	NaN	201
203	4080	NaN	NaN	202
204	4100	NaN	NaN	203
205	4120	NaN	NaN	204
206	4140	NaN	NaN	205
207	4160	NaN	NaN	206
208	4180	NaN	NaN	207
209	4200	NaN	NaN	208
210	4220	NaN	NaN	209

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
211	4240	NaN	NaN	210
212	4260	NaN	NaN	211
213	4280	NaN	NaN	212
214	4300	NaN	NaN	213
215	4320	NaN	NaN	214
216	4340	NaN	NaN	215
217	4360	NaN	NaN	216
218	4380	NaN	NaN	217
219	4400	NaN	NaN	218

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
220	4420	NaN	NaN	219
221	4440	NaN	NaN	220
222	4460	NaN	NaN	221
223	4480	NaN	NaN	222
224	4500	NaN	NaN	223
225	4520	NaN	NaN	224
226	4540	NaN	NaN	225
227	4560	NaN	NaN	226
228	4580	NaN	NaN	227
229	4600	NaN	NaN	228
230	4620	NaN	NaN	229
231	4640	NaN	NaN	230
232	4660	NaN	NaN	231
233	4680	NaN	NaN	232
234	4700	NaN	NaN	233
235	4720	NaN	NaN	234
236	4740	NaN	NaN	235
237	4760	NaN	NaN	236
238	4780	NaN	NaN	237
239	4800	NaN	NaN	238
240	4820	NaN	NaN	239

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
241	4840	NaN	NaN	240
242	4860	NaN	NaN	241
243	4880	NaN	NaN	242
244	4900	NaN	NaN	243
245	4920	NaN	NaN	244
246	4940	NaN	NaN	245
247	4960	NaN	NaN	246
248	4980	NaN	NaN	247
249	5000	NaN	NaN	248
250	5020	NaN	NaN	249
251	5040	NaN	NaN	250
252	5060	NaN	NaN	251
253	5080	NaN	NaN	252
254	5100	NaN	NaN	253
255	5120	NaN	NaN	254
256	5140	NaN	NaN	255
257	5160	NaN	NaN	256
258	5180	NaN	NaN	257
259	5200	NaN	NaN	258
260	5220	NaN	NaN	259
261	5240	NaN	NaN	260
262	5260	NaN	NaN	261
263	5280	NaN	NaN	262
264	5300	NaN	NaN	263
265	5320	NaN	NaN	264
266	5340	NaN	NaN	265
267	5360	NaN	NaN	266
268	5380	NaN	NaN	267
269	5400	NaN	NaN	268
270	5420	NaN	NaN	269

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
271	5440	NaN	NaN	270
272	5460	NaN	NaN	271
273	5480	NaN	NaN	272
274	5500	NaN	NaN	273
275	5520	NaN	NaN	274
276	5540	NaN	NaN	275
277	5560	NaN	NaN	276

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
278	5580	NaN	NaN	277
279	5600	NaN	NaN	278
280	5620	NaN	NaN	279
281	5640	NaN	NaN	280
282	5660	NaN	NaN	281
283	5680	NaN	NaN	282
284	5700	NaN	NaN	283
285	5720	NaN	NaN	284
286	5740	NaN	NaN	285
287	5760	NaN	NaN	286
288	5780	NaN	NaN	287
289	5800	NaN	NaN	288
290	5820	NaN	NaN	289
291	5840	NaN	NaN	290
292	5860	NaN	NaN	291
293	5880	NaN	NaN	292
294	5900	NaN	NaN	293
295	5920	NaN	NaN	294
296	5940	NaN	NaN	295
297	5960	NaN	NaN	296
298	5980	NaN	NaN	297
299	6000	NaN	NaN	298
300	6020	NaN	NaN	299

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
301	6040	NaN	NaN	300
302	6060	NaN	NaN	301
303	6080	NaN	NaN	302
304	6100	NaN	NaN	303
305	6120	NaN	NaN	304
306	6140	NaN	NaN	305
307	6160	NaN	NaN	306
308	6180	NaN	NaN	307
309	6200	NaN	NaN	308
310	6220	NaN	NaN	309
311	6240	NaN	NaN	310
312	6260	NaN	NaN	311
313	6280	NaN	NaN	312
314	6300	NaN	NaN	313
315	6320	NaN	NaN	314
316	6340	NaN	NaN	315
317	6360	NaN	NaN	316
318	6380	NaN	NaN	317
319	6400	NaN	NaN	318
320	6420	NaN	NaN	319
321	6440	NaN	NaN	320
322	6460	NaN	NaN	321
323	6480	NaN	NaN	322
324	6500	NaN	NaN	323
325	6520	NaN	NaN	324
326	6540	NaN	NaN	325
327	6560	NaN	NaN	326
328	6580	NaN	NaN	327
329	6600	NaN	NaN	328
330	6620	NaN	NaN	329

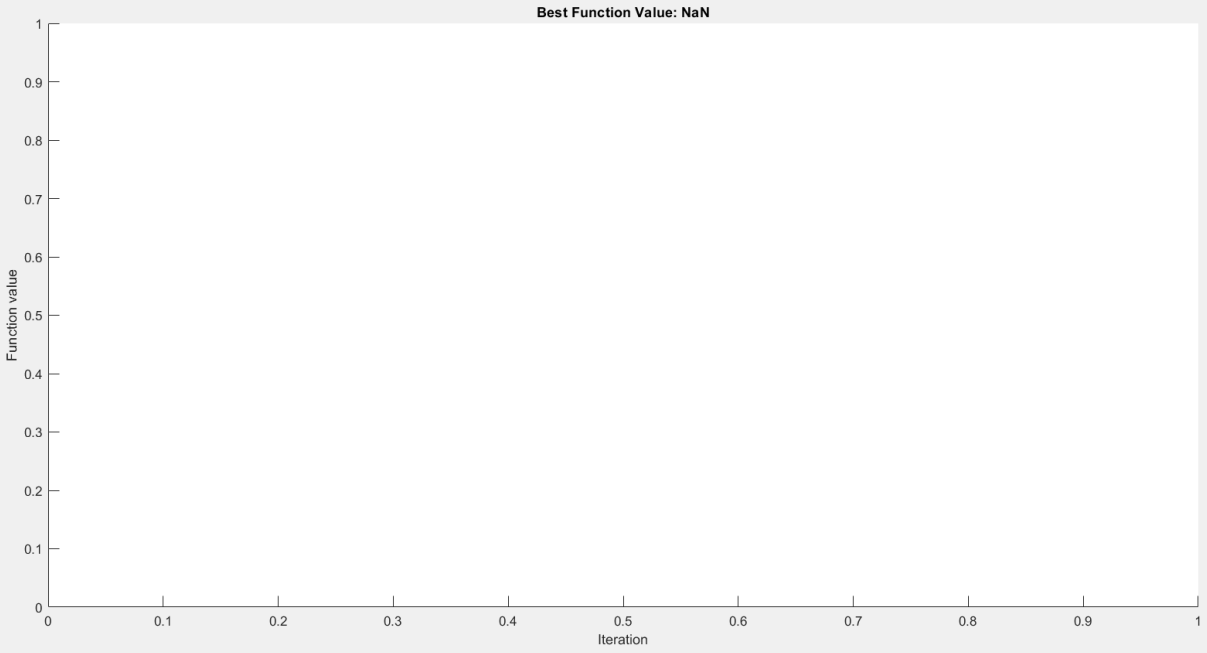
Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
331	6640	NaN	NaN	330
332	6660	NaN	NaN	331
333	6680	NaN	NaN	332
334	6700	NaN	NaN	333
335	6720	NaN	NaN	334

336	6740	NaN	NaN	335
337	6760	NaN	NaN	336
338	6780	NaN	NaN	337
339	6800	NaN	NaN	338
340	6820	NaN	NaN	339
341	6840	NaN	NaN	340
342	6860	NaN	NaN	341
343	6880	NaN	NaN	342
344	6900	NaN	NaN	343
345	6920	NaN	NaN	344
346	6940	NaN	NaN	345
347	6960	NaN	NaN	346
348	6980	NaN	NaN	347
349	7000	NaN	NaN	348
350	7020	NaN	NaN	349
351	7040	NaN	NaN	350
352	7060	NaN	NaN	351
353	7080	NaN	NaN	352
354	7100	NaN	NaN	353
355	7120	NaN	NaN	354
356	7140	NaN	NaN	355
357	7160	NaN	NaN	356
358	7180	NaN	NaN	357
359	7200	NaN	NaN	358
360	7220	NaN	NaN	359

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
361	7240	NaN	NaN	360
362	7260	NaN	NaN	361
363	7280	NaN	NaN	362
364	7300	NaN	NaN	363
365	7320	NaN	NaN	364
366	7340	NaN	NaN	365
367	7360	NaN	NaN	366
368	7380	NaN	NaN	367
369	7400	NaN	NaN	368
370	7420	NaN	NaN	369
371	7440	NaN	NaN	370
372	7460	NaN	NaN	371
373	7480	NaN	NaN	372
374	7500	NaN	NaN	373
375	7520	NaN	NaN	374
376	7540	NaN	NaN	375
377	7560	NaN	NaN	376
378	7580	NaN	NaN	377
379	7600	NaN	NaN	378
380	7620	NaN	NaN	379
381	7640	NaN	NaN	380
382	7660	NaN	NaN	381
383	7680	NaN	NaN	382
384	7700	NaN	NaN	383
385	7720	NaN	NaN	384
386	7740	NaN	NaN	385
387	7760	NaN	NaN	386
388	7780	NaN	NaN	387
389	7800	NaN	NaN	388
390	7820	NaN	NaN	389

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
391	7840	NaN	NaN	390
392	7860	NaN	NaN	391
393	7880	NaN	NaN	392

```
  394           7900            NaN            NaN      393
  395           7920            NaN            NaN      394
  396           7940            NaN            NaN      395
  397           7960            NaN            NaN      396
  398           7980            NaN            NaN      397
  399           8000            NaN            NaN      398
  400           8020            NaN            NaN      399
Optimization ended: number of iterations exceeded OPTIONS.MaxIterations.
```




```
% Clear variables
clearvars options3
```

```
disp(['Solution = ',num2str(solution2)])
```

```
Solution = -18.6383      27.9048
```

```
disp(['Function value = ', num2str(objectiveValue2)])
```

```
Function value = NaN
```

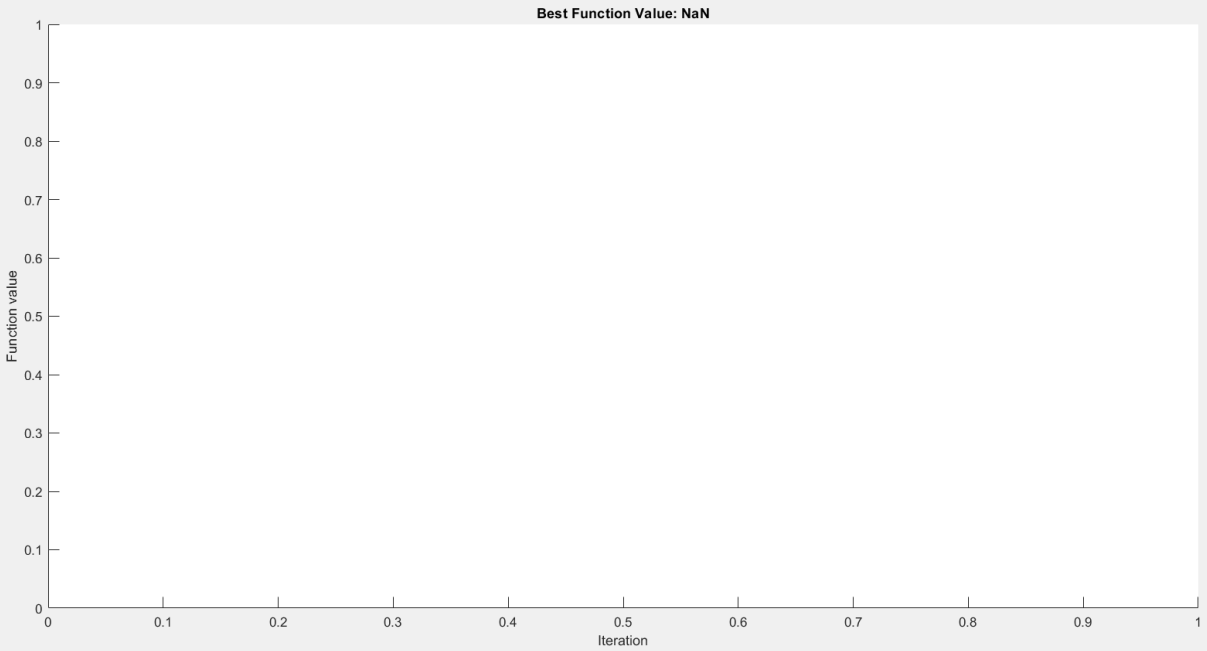
```
x0 = [-0.5, -0.5]
```

```
x0 = 1×2
   -0.5000   -0.5000
```

```
% Set nondefault solver options
options4 = optimoptions("simulannealbnd","Display","iter","PlotFcn",...
    ["saplotbestf","saplotbestx","saplotf","saplottemperature"]);

% Solve
[solution3,objectiveValue3] = simulannealbnd(fun,x0,repmat(-35,size(x0)),...
```

```
    repmat(35,size(x0)),options4);
```

```
                            Best        Current          Mean
Iteration    f-count         f(x)         f(x)        temperature
     0           1         16.3125       16.3125           100
```

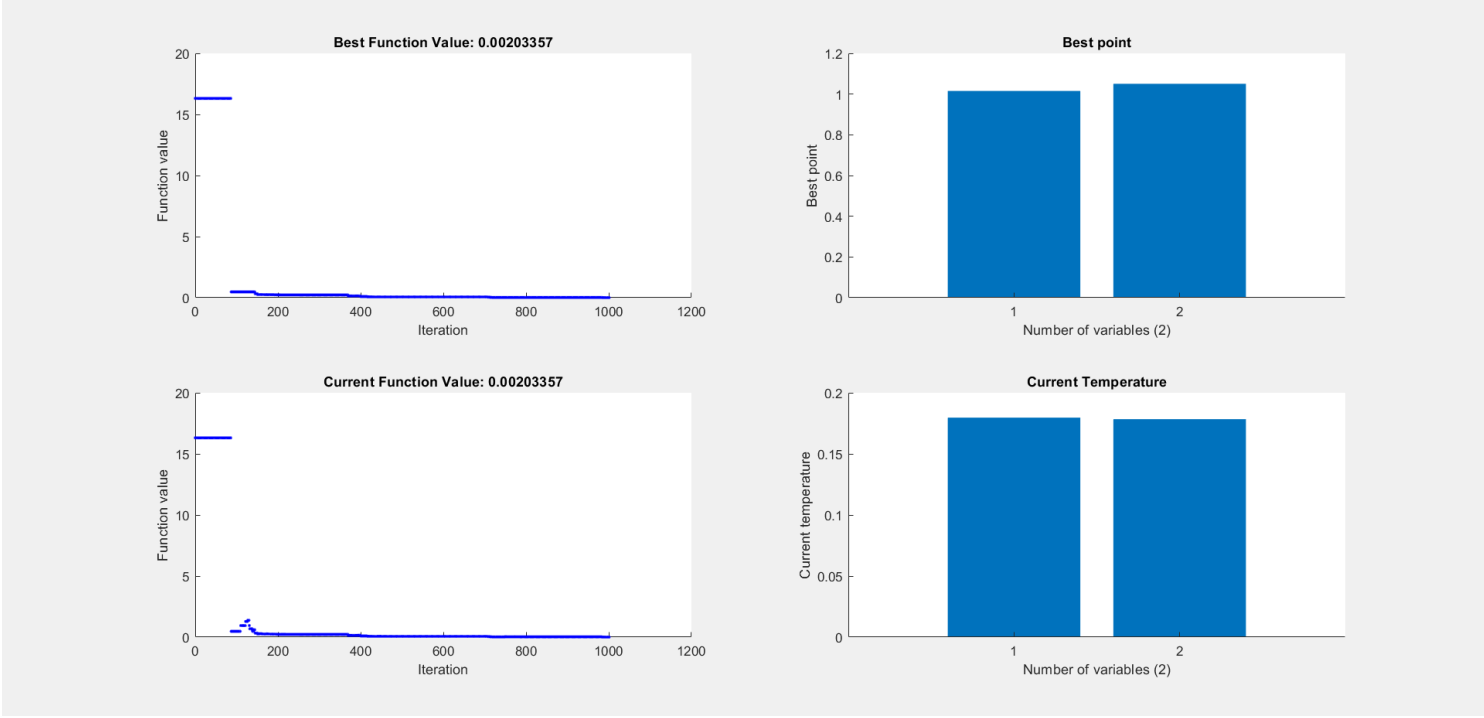



```
    10          11         16.3125       16.3125          56.88
    20          21         16.3125       16.3125        34.0562
    30          31         16.3125       16.3125        20.3907
    40          41         16.3125       16.3125        12.2087
    50          51         16.3125       16.3125        7.30977
    60          61         16.3125       16.3125        4.37663
    70          71         16.3125       16.3125        2.62045
    80          81         16.3125       16.3125        1.56896
    90          91        0.474006      0.474006       0.939395
   100         101        0.474006      0.474006        0.56245
   110         111        0.474006      0.945016        0.33676
   120         121        0.474006      0.945016       0.201631
   130         131        0.474006       1.37831       0.120724
   140         141         0.47339      0.476768      0.0722817
   150         151        0.321102      0.333342      0.0432777
   160         161        0.251265      0.279564       0.025912
   170         171        0.245128      0.245128      0.0155145
   180         181        0.245128      0.249713     0.00928908
   190         191        0.244629       0.25079     0.00556171
   200         201        0.234355      0.234355        0.00333
   210         211        0.229139      0.230347      0.0019938
   220         221        0.229139      0.229351     0.00119376
   230         231        0.226183      0.226183    0.000714748
   240         241        0.224322      0.224322    0.000427946
   250         251        0.223363      0.223363    0.000256227
   260         261        0.222676      0.222704    0.000153413
   270         271        0.222514      0.222571    9.18538e-05
   280         281        0.222431      0.222431    5.49963e-05
*  282         285        0.222431      0.222436        48.2838
   290         293        0.222431      0.222436        32.0325
   300         303        0.222431      0.222436         19.179

                            Best        Current          Mean
Iteration    f-count         f(x)         f(x)        temperature
```

310	313	0.222431	0.222436	11.4832
320	323	0.222431	0.222436	6.87541
330	333	0.222431	0.222436	4.11656
340	343	0.222431	0.222436	2.46474
350	353	0.222431	0.222436	1.47573
360	363	0.222431	0.222436	0.883574
370	373	0.139277	0.139277	0.529028
380	383	0.139277	0.139277	0.316749
390	393	0.139277	0.139277	0.189649
400	403	0.0934468	0.0934468	0.11355
410	413	0.0934468	0.0934468	0.0679866
420	423	0.0707637	0.0707637	0.0407061
430	433	0.0636023	0.0636023	0.0243722
440	443	0.0636023	0.0636023	0.0145926
450	453	0.0636023	0.0679561	0.0087371
460	463	0.0603264	0.0603264	0.00523123
470	473	0.0603264	0.0613618	0.00313213
480	483	0.0603264	0.0630216	0.00187532
490	493	0.0603264	0.062903	0.00112282
500	503	0.0603264	0.0624746	0.000672276
510	513	0.0603264	0.0620981	0.000402516
520	523	0.0603264	0.0619552	0.000241001
530	533	0.0603264	0.0618088	0.000144296
540	543	0.0603264	0.0618312	8.63956e-05
550	553	0.0603264	0.0617366	5.17283e-05
560	563	0.0603264	0.061697	3.09716e-05
570	573	0.0603264	0.0616883	1.85439e-05
580	583	0.0603264	0.0616576	1.11029e-05
* 590	595	0.0603264	0.0616489	43.0722
600	605	0.0603264	0.0616489	25.7889

Iteration	f-count	Best f(x)	Current f(x)	Mean temperature
610	615	0.0603264	0.0616489	15.4408
620	625	0.0603264	0.0616489	9.24496
630	635	0.0603264	0.0616489	5.5353
640	645	0.0603264	0.0616489	3.31419
650	655	0.0603264	0.0616489	1.98433
660	665	0.0603264	0.0616489	1.18809
670	675	0.0603264	0.0616489	0.711353
680	685	0.0603264	0.0616489	0.425913
690	695	0.0603264	0.0616489	0.25501
700	705	0.0603264	0.0616489	0.152684
710	715	0.0439447	0.0439447	0.0914175
720	725	0.0188463	0.0188463	0.0547351
730	735	0.0188463	0.0188463	0.0327719
740	745	0.01623	0.01623	0.0196217
750	755	0.01623	0.0363392	0.0117483
760	765	0.01623	0.0263296	0.00703412
770	775	0.01623	0.0224612	0.00421159
780	785	0.01623	0.0217926	0.00252163
790	795	0.01623	0.0209948	0.00150979
800	805	0.01623	0.0208024	0.00090397
810	815	0.01623	0.0207701	0.00054124
820	825	0.01623	0.020514	0.00032406
830	835	0.01623	0.020464	0.000194027
840	845	0.01623	0.0204738	0.000116171
850	855	0.01623	0.0204431	6.95559e-05
860	865	0.01623	0.0204088	4.16457e-05
870	875	0.01623	0.0204013	2.49348e-05
880	885	0.01623	0.0204005	1.49294e-05
890	895	0.01623	0.0204089	8.93878e-06
* 894	901	0.01623	0.0204046	43.307
900	907	0.01623	0.0204046	31.8346

```
                                Best        Current          Mean
Iteration    f-count             f(x)         f(x)       temperature
   910         917           0.01623      0.0204046         19.0606
   920         927           0.01623      0.0204046         11.4123
   930         937           0.01623      0.0204046         6.83294
   940         947           0.01623      0.0204046         4.09113
   950         957           0.01623      0.0204046         2.44951
   960         967           0.01623      0.0204046         1.46661
   970         977           0.01623      0.0204046        0.878116
   980         987           0.01623      0.0204046         0.52576
   990         997        0.00203357     0.00203357        0.314792
  1000        1007        0.00203357     0.00203357        0.188478
```




```
Stop requested.
```

```
% Clear variables
clearvars options4
```

```
disp(['Solution = ',num2str(solution3)])
```

```
Solution = 1.0151      1.0504
```

```
disp(['Function value = ', num2str(objectiveValue3)])
```

```
Function value = 0.0020336
```

```
% Set nondefault solver options
options5 = optimoptions("patternsearch","Display","iter","PlotFcn",...
    ["psplotbestf","psplotmeshsize","psplotfuncount","psplotbestx"]);

% Solve
[solution4,objectiveValue4] = patternsearch(fun,x0,[],[],[],[],repmat(-35,...
```

```
    size(x0)),repmat(35,size(x0)),[],options5);
```

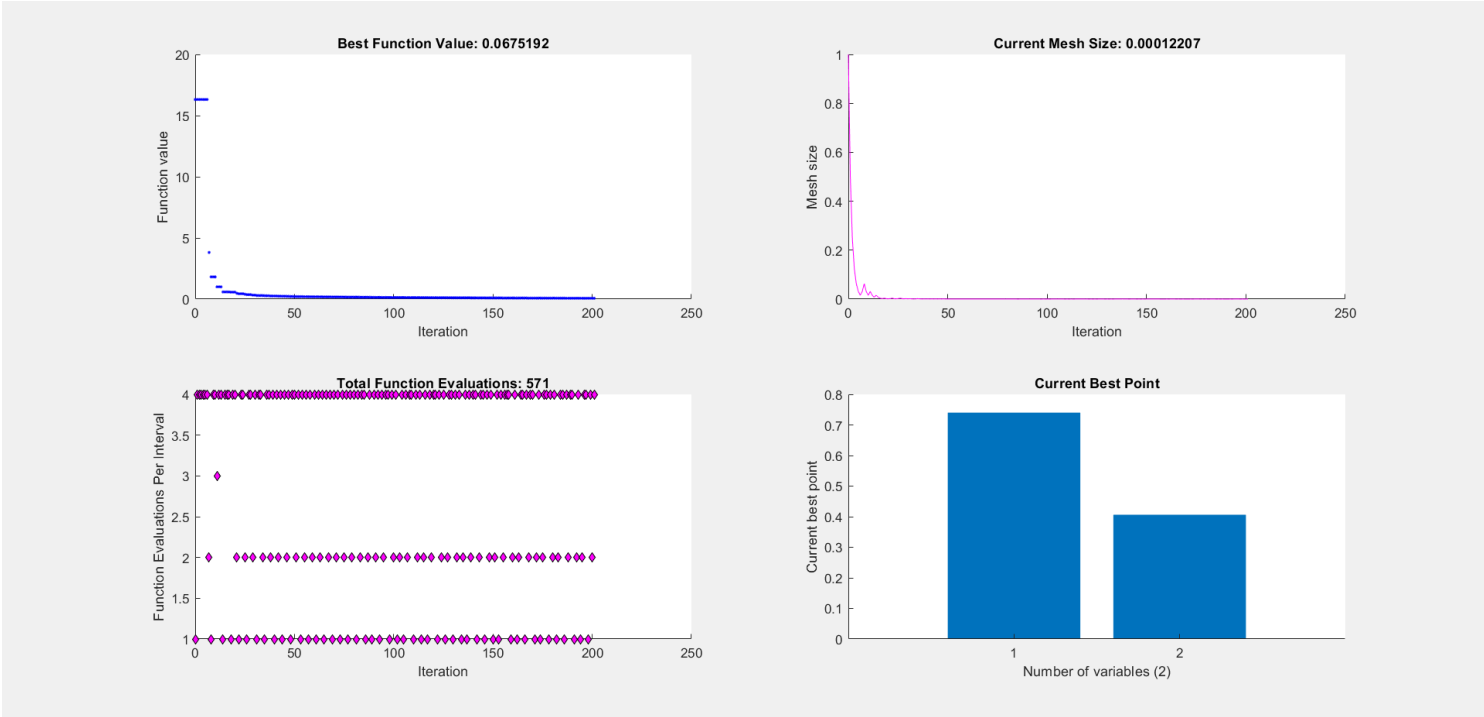
```
Iter     Func-count       f(x)      MeshSize     Method
    0           1        16.3125            1
    1           5        16.3125          0.5     Refine Mesh
    2           9        16.3125         0.25     Refine Mesh
    3          13        16.3125        0.125     Refine Mesh
    4          17        16.3125       0.0625     Refine Mesh
    5          21        16.3125      0.03125     Refine Mesh
    6          25        16.3125      0.01562     Refine Mesh
    7          27         3.8125      0.03125     Successful Poll
    8          28         1.8125       0.0625     Successful Poll
    9          32         1.8125      0.03125     Refine Mesh
   10          36         1.8125      0.01562     Refine Mesh
   11          39              1      0.03125     Successful Poll
   12          43              1      0.01562     Refine Mesh
   13          47              1     0.007812     Refine Mesh
   14          48       0.586914      0.01562     Successful Poll
   15          52       0.586914     0.007812     Refine Mesh
   16          56       0.586914     0.003906     Refine Mesh
   17          60       0.586914     0.001953     Refine Mesh
   18          61       0.565789     0.003906     Successful Poll
   19          65       0.565789     0.001953     Refine Mesh
   20          69       0.565789    0.0009766     Refine Mesh
   21          71        0.47271     0.001953     Successful Poll
   22          72       0.436783     0.003906     Successful Poll
   23          76       0.436783     0.001953     Refine Mesh
   24          80       0.436783    0.0009766     Refine Mesh
   25          82       0.400162     0.001953     Successful Poll
   26          83       0.361521     0.003906     Successful Poll
   27          87       0.361521     0.001953     Refine Mesh
   28          91       0.361521    0.0009766     Refine Mesh
   29          93       0.326426     0.001953     Successful Poll
   30          97       0.326426    0.0009766     Refine Mesh

Iter     Func-count        f(x)       MeshSize      Method
   31          98       0.290777     0.001953     Successful Poll
   32         102       0.290777    0.0009766     Refine Mesh
   33         106       0.290777    0.0004883     Refine Mesh
   34         108       0.286295    0.0009766     Successful Poll
   35         109       0.274414     0.001953     Successful Poll
   36         113       0.274414    0.0009766     Refine Mesh
   37         117       0.274414    0.0004883     Refine Mesh
   38         119           0.25    0.0009766     Successful Poll
   39         123           0.25    0.0004883     Refine Mesh
   40         124       0.249233    0.0009766     Successful Poll
   41         128       0.249233    0.0004883     Refine Mesh
   42         130        0.23587    0.0009766     Successful Poll
   43         134        0.23587    0.0004883     Refine Mesh
   44         135        0.22839    0.0009766     Successful Poll
   45         139        0.22839    0.0004883     Refine Mesh
   46         141       0.223717    0.0009766     Successful Poll
   47         145       0.223717    0.0004883     Refine Mesh
   48         146       0.210659    0.0009766     Successful Poll
   49         150       0.210659    0.0004883     Refine Mesh
   50         154       0.210659    0.0002441     Refine Mesh
   51         156       0.205348    0.0004883     Successful Poll
   52         160       0.205348    0.0002441     Refine Mesh
   53         161       0.202663    0.0004883     Successful Poll
   54         165       0.202663    0.0002441     Refine Mesh
   55         167        0.19845    0.0004883     Successful Poll
   56         171        0.19845    0.0002441     Refine Mesh
   57         172       0.195132    0.0004883     Successful Poll
   58         176       0.195132    0.0002441     Refine Mesh
```

```
   59         178       0.191698     0.0004883     Successful Poll
   60         182       0.191698     0.0002441     Refine Mesh

Iter     Func-count        f(x)       MeshSize      Method
   61         183       0.188007     0.0004883     Successful Poll
   62         187       0.188007     0.0002441     Refine Mesh
   63         189       0.185032     0.0004883     Successful Poll
   64         193       0.185032     0.0002441     Refine Mesh
   65         194       0.181257     0.0004883     Successful Poll
   66         198       0.181257     0.0002441     Refine Mesh
   67         200       0.178414     0.0004883     Successful Poll
   68         204       0.178414     0.0002441     Refine Mesh
   69         205       0.174874     0.0004883     Successful Poll
   70         209       0.174874     0.0002441     Refine Mesh
   71         211       0.171832     0.0004883     Successful Poll
   72         215       0.171832     0.0002441     Refine Mesh
   73         216       0.168877     0.0004883     Successful Poll
   74         220       0.168877     0.0002441     Refine Mesh
   75         222       0.165301     0.0004883     Successful Poll
   76         226       0.165301     0.0002441     Refine Mesh
   77         227       0.163315     0.0004883     Successful Poll
   78         231       0.163315     0.0002441     Refine Mesh
   79         233       0.158864     0.0004883     Successful Poll
   80         237       0.158864     0.0002441     Refine Mesh
   81         238       0.158264     0.0004883     Successful Poll
   82         242       0.158264     0.0002441     Refine Mesh
   83         244       0.152596     0.0004883     Successful Poll
   84         248       0.152596     0.0002441     Refine Mesh
   85         252       0.152596     0.0001221     Refine Mesh
   86         253       0.151233     0.0002441     Successful Poll
   87         255       0.150929     0.0004883     Successful Poll
   88         259       0.150929     0.0002441     Refine Mesh
   89         260       0.146291     0.0004883     Successful Poll
   90         264       0.146291     0.0002441     Refine Mesh

Iter     Func-count        f(x)       MeshSize      Method
   91         266       0.144244     0.0004883     Successful Poll
   92         270       0.144244     0.0002441     Refine Mesh
   93         271       0.142013     0.0004883     Successful Poll
   94         275       0.142013     0.0002441     Refine Mesh
   95         277       0.137868     0.0004883     Successful Poll
   96         281       0.137868     0.0002441     Refine Mesh
   97         285       0.137868     0.0001221     Refine Mesh
   98         286        0.13599     0.0002441     Successful Poll
   99         290        0.13599     0.0001221     Refine Mesh
  100         292       0.134851     0.0002441     Successful Poll
  101         296       0.134851     0.0001221     Refine Mesh
  102         297        0.13376     0.0002441     Successful Poll
  103         299       0.133259     0.0004883     Successful Poll
  104         303       0.133259     0.0002441     Refine Mesh
  105         304       0.129997     0.0004883     Successful Poll
  106         308       0.129997     0.0002441     Refine Mesh
  107         310       0.126675     0.0004883     Successful Poll
  108         314       0.126675     0.0002441     Refine Mesh
  109         318       0.126675     0.0001221     Refine Mesh
  110         319       0.124568     0.0002441     Successful Poll
  111         323       0.124568     0.0001221     Refine Mesh
  112         325       0.123658     0.0002441     Successful Poll
  113         329       0.123658     0.0001221     Refine Mesh
  114         330       0.122603     0.0002441     Successful Poll
  115         332       0.122192     0.0004883     Successful Poll
  116         336       0.122192     0.0002441     Refine Mesh
  117         337       0.119654     0.0004883     Successful Poll
  118         341       0.119654     0.0002441     Refine Mesh
```

Iter	Func-count	f(x)	MeshSize	Method
119	343	0.115679	0.0004883	Successful Poll
120	347	0.115679	0.0002441	Refine Mesh
121	351	0.115679	0.0001221	Refine Mesh
122	352	0.114279	0.0002441	Successful Poll
123	356	0.114279	0.0001221	Refine Mesh
124	358	0.112856	0.0002441	Successful Poll
125	362	0.112856	0.0001221	Refine Mesh
126	363	0.112812	0.0002441	Successful Poll
127	365	0.110999	0.0004883	Successful Poll
128	369	0.110999	0.0002441	Refine Mesh
129	373	0.110999	0.0001221	Refine Mesh
130	374	0.108298	0.0002441	Successful Poll
131	378	0.108298	0.0001221	Refine Mesh
132	380	0.10786	0.0002441	Successful Poll
133	384	0.10786	0.0001221	Refine Mesh
134	385	0.106661	0.0002441	Successful Poll
135	387	0.106626	0.0004883	Successful Poll
136	391	0.106626	0.0002441	Refine Mesh
137	392	0.104934	0.0004883	Successful Poll
138	396	0.104934	0.0002441	Refine Mesh
139	398	0.100188	0.0004883	Successful Poll
140	402	0.100188	0.0002441	Refine Mesh
141	406	0.100188	0.0001221	Refine Mesh
142	407	0.099808	0.0002441	Successful Poll
143	409	0.0986636	0.0004883	Successful Poll
144	413	0.0986636	0.0002441	Refine Mesh
145	417	0.0986636	0.0001221	Refine Mesh
146	418	0.0958045	0.0002441	Successful Poll
147	422	0.0958045	0.0001221	Refine Mesh
148	424	0.095458	0.0002441	Successful Poll
149	428	0.095458	0.0001221	Refine Mesh
150	429	0.0945353	0.0002441	Successful Poll

Iter	Func-count	f(x)	MeshSize	Method
151	431	0.0941949	0.0004883	Successful Poll
152	435	0.0941949	0.0002441	Refine Mesh
153	436	0.0941729	0.0004883	Successful Poll
154	440	0.0941729	0.0002441	Refine Mesh
155	442	0.0881349	0.0004883	Successful Poll
156	446	0.0881349	0.0002441	Refine Mesh
157	450	0.0881349	0.0001221	Refine Mesh
158	454	0.0881349	6.104e-05	Refine Mesh
159	455	0.0877985	0.0001221	Successful Poll
160	457	0.0870878	0.0002441	Successful Poll
161	461	0.0870878	0.0001221	Refine Mesh
162	462	0.0870083	0.0002441	Successful Poll
163	464	0.0855887	0.0004883	Successful Poll
164	468	0.0855887	0.0002441	Refine Mesh
165	472	0.0855887	0.0001221	Refine Mesh
166	473	0.0832875	0.0002441	Successful Poll
167	477	0.0832875	0.0001221	Refine Mesh
168	479	0.082528	0.0002441	Successful Poll
169	483	0.082528	0.0001221	Refine Mesh
170	487	0.082528	6.104e-05	Refine Mesh
171	488	0.0817161	0.0001221	Successful Poll
172	490	0.0816755	0.0002441	Successful Poll
173	494	0.0816755	0.0001221	Refine Mesh
174	495	0.0807989	0.0002441	Successful Poll
175	497	0.0804651	0.0004883	Successful Poll
176	501	0.0804651	0.0002441	Refine Mesh
177	505	0.0804651	0.0001221	Refine Mesh
178	506	0.0774928	0.0002441	Successful Poll

```
  179         510      0.0774928     0.0001221     Refine Mesh
  180         512      0.0771482     0.0002441     Successful Poll

Iter     Func-count         f(x)       MeshSize      Method
  181         516      0.0771482     0.0001221     Refine Mesh
  182         517       0.076922     0.0002441     Successful Poll
  183         519      0.0757739     0.0004883     Successful Poll
  184         523      0.0757739     0.0002441     Refine Mesh
  185         527      0.0757739     0.0001221     Refine Mesh
  186         528      0.0735762     0.0002441     Successful Poll
  187         532      0.0735762     0.0001221     Refine Mesh
  188         534      0.0727207     0.0002441     Successful Poll
  189         538      0.0727207     0.0001221     Refine Mesh
  190         542      0.0727207     6.104e-05     Refine Mesh
  191         543      0.0721164     0.0001221     Successful Poll
  192         545      0.0718636     0.0002441     Successful Poll
  193         549      0.0718636     0.0001221     Refine Mesh
  194         550      0.0717229     0.0002441     Successful Poll
  195         552      0.0704976     0.0004883     Successful Poll
  196         556      0.0704976     0.0002441     Refine Mesh
  197         560      0.0704976     0.0001221     Refine Mesh
  198         561      0.0685445     0.0002441     Successful Poll
  199         565      0.0685445     0.0001221     Refine Mesh
  200         567      0.0675192     0.0002441     Successful Poll
  201         571      0.0675192     0.0001221     Refine Mesh
Maximum number of iterations exceeded: increase options.MaxIterations.
```




```
% Clear variables
clearvars options5
```

```
disp(['Solution = ',num2str(solution4)])
```

```
Solution = 0.74023     0.40625
```

```
disp(['Function value = ', num2str(objectiveValue4)])
```

```
Function value = 0.067519
```

```
% Set nondefault solver options
options6 = optimoptions("surrogateopt","Display","iter","PlotFcn",...
    ["surrogateoptplot","optimplotfvalconstr","optimplotfval","optimplotx"]);

% Solve
[solution5,objectiveValue5] = surrogateopt(fun,repmat(-35,nvar,1),repmat(35,...
    nvar,1),[],[],[],[],[],options6);
```

```
Objective or constraint function returned NaN.
Scalar objective function
Number of variables: 2
Number of integer constraints: 0
Number of linear inequality constraints: 0
Number of linear equality constraints: 0
Number of nonlinear inequality constraints: 0

F-count       Time        Best          Current         Trial
             (seconds)    Fval          Fval            type
   2         1.68       1.0000e+00      1.0000e+00   random
   3         2.05       1.0000e+00     NaN           random
   4         2.24       1.0000e+00     NaN           random
   5         2.42       1.0000e+00     NaN           random
   6         2.59       1.0000e+00     NaN           random
   7         2.77       1.0000e+00     NaN           random
   8         2.94       1.0000e+00     NaN           random
   9         3.11       1.0000e+00     NaN           random
  10         3.29       1.0000e+00     NaN           random
  11         3.47       1.0000e+00     NaN           random
  12         3.64       1.0000e+00     NaN           random
  13         3.82       1.0000e+00     NaN           random
  14         3.99       1.0000e+00     NaN           random
  15         4.16       1.0000e+00     NaN           random
  16         4.33       1.0000e+00     NaN           random
  17         4.50       1.0000e+00     NaN           random
  18         4.68       1.0000e+00     NaN           random
  19         4.85       1.0000e+00     NaN           random
  20         5.03       1.0000e+00     NaN           random
  21         5.22       1.0000e+00     NaN           random
  22         5.39       1.0000e+00     NaN           random
  23         5.56       1.0000e+00     NaN           random
  24         5.73       1.0000e+00     NaN           random
  25         5.90       1.0000e+00     NaN           random
  26         6.07       1.0000e+00     NaN           random
  27         6.25       1.0000e+00     NaN           random
  28         6.44       1.0000e+00     NaN           random
  29         6.65       1.0000e+00     NaN           random
  30         6.83       1.0000e+00     NaN           random

F-count       Time        Best          Current         Trial
             (seconds)    Fval          Fval            type
  31         7.00       1.0000e+00     NaN           random
  32         7.18       1.0000e+00     NaN           random
  33         7.36       1.0000e+00     NaN           random
  34         7.53       1.0000e+00     NaN           random
  35         7.70       1.0000e+00     NaN           random
  36         7.87       1.0000e+00      Inf          random
  37         8.05       1.0000e+00     NaN           random
  38         8.22       1.0000e+00     NaN           random
  39         8.40       1.0000e+00     NaN           random
```

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
40	8.57	1.0000e+00	NaN	random
41	8.74	1.0000e+00	NaN	random
42	8.92	1.0000e+00	NaN	random
43	9.09	1.0000e+00	NaN	random
44	9.26	1.0000e+00	Inf	random
45	9.43	1.0000e+00	NaN	random
46	9.61	1.0000e+00	NaN	random
47	9.80	1.0000e+00	NaN	random
48	9.98	1.0000e+00	NaN	random
49	10.15	1.0000e+00	NaN	random
50	10.33	1.0000e+00	NaN	random
51	10.50	1.0000e+00	Inf	random
52	10.68	1.0000e+00	NaN	random
53	10.85	1.0000e+00	NaN	random
54	11.02	1.0000e+00	NaN	random
55	11.19	1.0000e+00	NaN	random
56	11.36	1.0000e+00	NaN	random
57	11.54	1.0000e+00	NaN	random
58	11.71	1.0000e+00	NaN	random
59	11.88	1.0000e+00	Inf	random
60	12.05	1.0000e+00	NaN	random

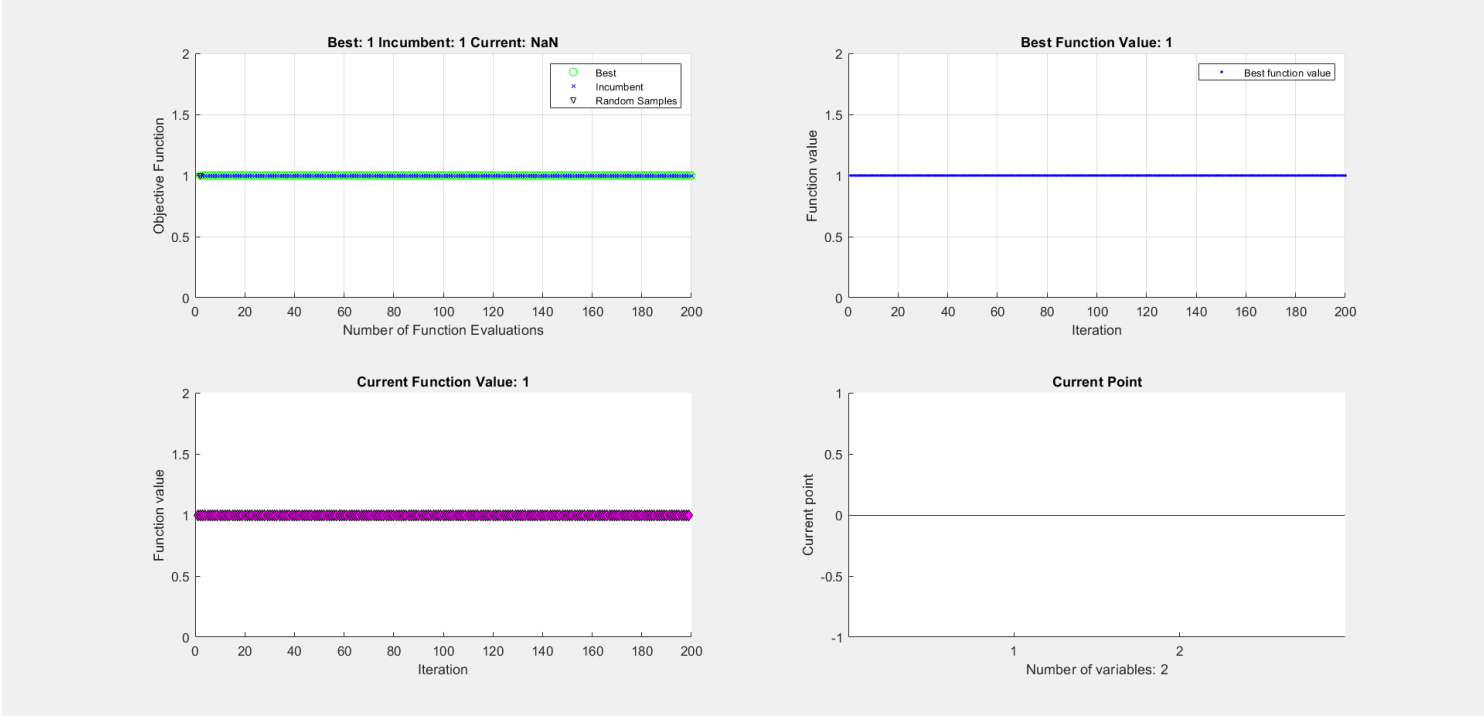
F-count	Time (seconds)	Best Fval	Current Fval	Trial type
61	12.23	1.0000e+00	NaN	random
62	12.40	1.0000e+00	NaN	random
63	12.58	1.0000e+00	NaN	random
64	12.75	1.0000e+00	NaN	random
65	12.93	1.0000e+00	NaN	random
66	13.10	1.0000e+00	NaN	random
67	13.27	1.0000e+00	NaN	random
68	13.44	1.0000e+00	NaN	random
69	13.61	1.0000e+00	NaN	random
70	13.78	1.0000e+00	NaN	random
71	13.95	1.0000e+00	NaN	random
72	14.13	1.0000e+00	NaN	random
73	14.30	1.0000e+00	NaN	random
74	14.47	1.0000e+00	NaN	random
75	14.64	1.0000e+00	NaN	random
76	14.81	1.0000e+00	NaN	random
77	14.98	1.0000e+00	Inf	random
78	15.17	1.0000e+00	NaN	random
79	15.38	1.0000e+00	NaN	random
80	15.55	1.0000e+00	NaN	random
81	15.73	1.0000e+00	NaN	random
82	15.90	1.0000e+00	NaN	random
83	16.08	1.0000e+00	NaN	random
84	16.26	1.0000e+00	NaN	random
85	16.44	1.0000e+00	Inf	random
86	16.61	1.0000e+00	NaN	random
87	16.79	1.0000e+00	NaN	random
88	16.96	1.0000e+00	NaN	random
89	17.13	1.0000e+00	NaN	random
90	17.32	1.0000e+00	NaN	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
91	17.49	1.0000e+00	NaN	random
92	17.67	1.0000e+00	NaN	random
93	17.84	1.0000e+00	NaN	random
94	18.02	1.0000e+00	NaN	random
95	18.19	1.0000e+00	NaN	random
96	18.37	1.0000e+00	NaN	random
97	18.54	1.0000e+00	NaN	random

```
  98         18.71      1.0000e+00     NaN          random
  99         18.93      1.0000e+00     NaN          random
 100         19.14      1.0000e+00     NaN          random
 101         19.33      1.0000e+00     NaN          random
 102         19.50      1.0000e+00     NaN          random
 103         19.68      1.0000e+00     NaN          random
 104         19.85      1.0000e+00      Inf         random
 105         20.02      1.0000e+00     NaN          random
 106         20.19      1.0000e+00     NaN          random
 107         20.37      1.0000e+00     NaN          random
 108         20.54      1.0000e+00     NaN          random
 109         20.71      1.0000e+00     NaN          random
 110         20.88      1.0000e+00     NaN          random
 111         21.05      1.0000e+00     NaN          random
 112         21.22      1.0000e+00     NaN          random
 113         21.40      1.0000e+00     NaN          random
 114         21.57      1.0000e+00     NaN          random
 115         21.74      1.0000e+00     NaN          random
 116         21.91      1.0000e+00     NaN          random
 117         22.08      1.0000e+00     NaN          random
 118         22.24      1.0000e+00     NaN          random
 119         22.41      1.0000e+00     NaN          random
 120         22.58      1.0000e+00      Inf         random

F-count       Time         Best          Current         Trial
             (seconds)     Fval          Fval            type
 121         22.75      1.0000e+00     NaN          random
 122         22.92      1.0000e+00     NaN          random
 123         23.09      1.0000e+00     NaN          random
 124         23.26      1.0000e+00     NaN          random
 125         23.43      1.0000e+00     NaN          random
 126         23.62      1.0000e+00     NaN          random
 127         23.81      1.0000e+00     NaN          random
 128         23.98      1.0000e+00     NaN          random
 129         24.15      1.0000e+00     NaN          random
 130         24.33      1.0000e+00     NaN          random
 131         24.50      1.0000e+00     NaN          random
 132         24.67      1.0000e+00     NaN          random
 133         24.84      1.0000e+00     NaN          random
 134         25.01      1.0000e+00     NaN          random
 135         25.19      1.0000e+00     NaN          random
 136         25.36      1.0000e+00     NaN          random
 137         25.53      1.0000e+00     NaN          random
 138         25.70      1.0000e+00     NaN          random
 139         25.87      1.0000e+00     NaN          random
 140         26.05      1.0000e+00     NaN          random
 141         26.26      1.0000e+00     NaN          random
 142         26.44      1.0000e+00     NaN          random
 143         26.62      1.0000e+00     NaN          random
 144         26.79      1.0000e+00     NaN          random
 145         26.96      1.0000e+00     NaN          random
 146         27.14      1.0000e+00     NaN          random
 147         27.31      1.0000e+00     NaN          random
 148         27.48      1.0000e+00     NaN          random
 149         27.65      1.0000e+00     NaN          random
 150         27.82      1.0000e+00     NaN          random

F-count       Time         Best          Current         Trial
             (seconds)     Fval          Fval            type
 151         27.99      1.0000e+00     NaN          random
 152         28.17      1.0000e+00     NaN          random
 153         28.35      1.0000e+00      Inf         random
 154         28.53      1.0000e+00     NaN          random
 155         28.70      1.0000e+00      Inf         random
```

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
156	28.88	1.0000e+00	NaN	random
157	29.05	1.0000e+00	NaN	random
158	29.23	1.0000e+00	NaN	random
159	29.40	1.0000e+00	NaN	random
160	29.57	1.0000e+00	NaN	random
161	29.75	1.0000e+00	NaN	random
162	29.92	1.0000e+00	Inf	random
163	30.10	1.0000e+00	NaN	random
164	30.27	1.0000e+00	NaN	random
165	30.44	1.0000e+00	NaN	random
166	30.64	1.0000e+00	NaN	random
167	30.83	1.0000e+00	NaN	random
168	31.02	1.0000e+00	NaN	random
169	31.19	1.0000e+00	NaN	random
170	31.37	1.0000e+00	NaN	random
171	31.54	1.0000e+00	NaN	random
172	31.71	1.0000e+00	Inf	random
173	31.88	1.0000e+00	NaN	random
174	32.05	1.0000e+00	NaN	random
175	32.22	1.0000e+00	NaN	random
176	32.39	1.0000e+00	NaN	random
177	32.56	1.0000e+00	NaN	random
178	32.74	1.0000e+00	NaN	random
179	32.91	1.0000e+00	NaN	random
180	33.08	1.0000e+00	NaN	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
181	33.25	1.0000e+00	NaN	random
182	33.42	1.0000e+00	NaN	random
183	33.60	1.0000e+00	NaN	random
184	33.77	1.0000e+00	NaN	random
185	33.94	1.0000e+00	NaN	random
186	34.11	1.0000e+00	NaN	random
187	34.30	1.0000e+00	NaN	random
188	34.47	1.0000e+00	NaN	random
189	34.64	1.0000e+00	NaN	random
190	34.81	1.0000e+00	NaN	random
191	34.98	1.0000e+00	NaN	random
192	35.16	1.0000e+00	NaN	random
193	35.33	1.0000e+00	NaN	random
194	35.50	1.0000e+00	NaN	random
195	35.68	1.0000e+00	NaN	random
196	35.85	1.0000e+00	NaN	random
197	36.03	1.0000e+00	NaN	random
198	36.20	1.0000e+00	NaN	random
199	36.38	1.0000e+00	NaN	random
200	36.56	1.0000e+00	NaN	random




```
surrogateopt stopped because it exceeded the function evaluation limit set by
'options.MaxFunctionEvaluations'.
```

```
% Clear variables
clearvars options6
```

```
disp(['Solution = ',num2str(solution5)])
```

```
Solution = 0  0
```

```
disp(['Function value = ', num2str(objectiveValue5)])
```

```
Function value = 1
```

```
nvar = 2
```

```
nvar = 2
```

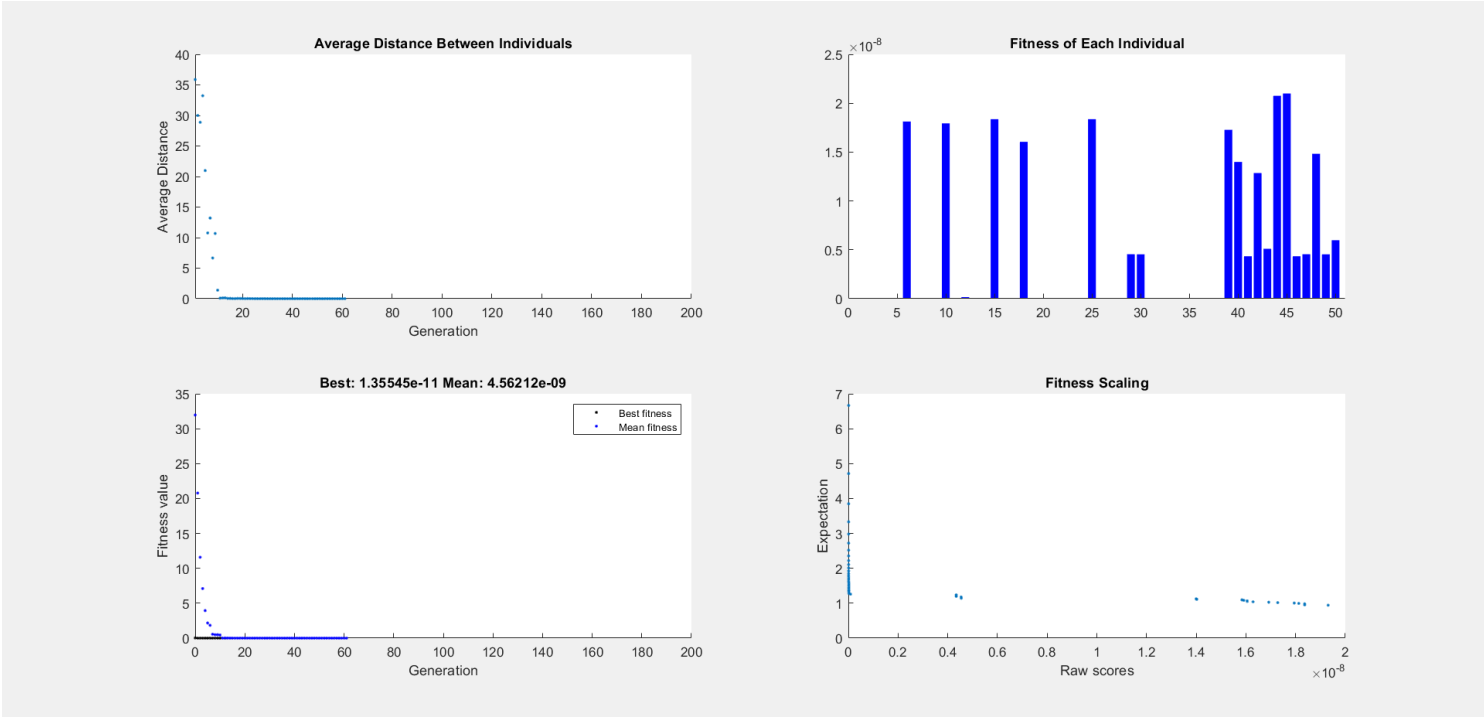
```
fun = @trigonometric
```

```
fun = function_handle with value:
    @trigonometric
```

```
% Set nondefault solver options
options = optimoptions("ga","Display","iter","PlotFcn",["gaplotdistance",...
    "gaplotscores","gaplotbestf","gaplotexpectation"]);

% Solve
[solution,objectiveValue] = ga(fun,nvar,[],[],[],[],repmat(-35,nvar,1),...
    repmat(35,nvar,1),[],[],options);
```

```
Single objective optimization:
2 Variable(s)

Options:
CreationFcn:       @gacreationuniform
CrossoverFcn:      @crossoverscattered
SelectionFcn:      @selectionstochunif
MutationFcn:       @mutationadaptfeasible

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
    1              100        0.002359           20.78        0
    2              147        0.002359           11.58        1
    3              194        0.002359           7.105        2
    4              241        0.002359           3.944        3
    5              288        0.002359           2.165        4
    6              335       0.0007079           1.836        0
    7              382       0.0007079          0.5601        1
    8              429       0.0005875          0.4872        0
    9              476       0.0005875          0.4883        1
   10              523        0.000229          0.4477        0
   11              570        3.01e-05         0.007479        0
   12              617        3.01e-05          0.02832        1
   13              664        3.01e-05          0.01653        2
   14              711        3.01e-05         0.005614        3
   15              758        3.01e-05         0.003708        4
   16              805       2.003e-05        0.0004954        0
   17              852       1.671e-05         0.000399        0
   18              899       1.671e-05         0.001131        1
   19              946       3.795e-06        0.0006393        0
   20              993       3.795e-06        0.0008977        1
   21             1040       3.795e-06        0.0007403        2
   22             1087       3.795e-06        0.0003011        3
   23             1134       3.795e-06        7.356e-05        4
   24             1181       2.631e-07        4.933e-05        0
   25             1228       2.631e-07        3.211e-05        1
   26             1275       2.181e-07        2.131e-05        0
   27             1322       2.181e-07        2.958e-05        1
   28             1369       2.181e-07        1.301e-05        2
   29             1416       2.181e-07        9.069e-06        3
   30             1463       2.181e-07        4.119e-06        4

                                 Best           Mean      Stall
Generation      Func-count        f(x)           f(x)    Generations
```

```
   31            1510       1.173e-07       2.422e-06        0
   32            1557       1.173e-07       1.539e-06        1
   33            1604       1.208e-08       8.993e-07        0
   34            1651       1.208e-08       9.042e-07        1
   35            1698       9.081e-09       7.496e-07        0
   36            1745       9.081e-09       2.872e-07        1
   37            1792       2.959e-09       1.875e-07        0
   38            1839       2.959e-09       2.894e-07        1
   39            1886       2.959e-09       1.996e-07        2
   40            1933       1.924e-09       1.459e-07        0
   41            1980       1.924e-09       1.694e-07        1
   42            2027       1.924e-09       1.037e-07        2
   43            2074       1.328e-09       3.439e-08        0
   44            2121       1.328e-09       1.087e-08        1
   45            2168       6.224e-10       7.207e-09        0
   46            2215       8.945e-11       1.525e-08        0
   47            2262       8.945e-11       3.816e-08        1
   48            2309       8.892e-11       3.007e-08        0
   49            2356       8.892e-11       3.562e-08        1
   50            2403       8.892e-11       2.742e-08        2
   51            2450       2.092e-11       1.904e-08        0
   52            2497       2.092e-11       1.376e-08        1
   53            2544       2.092e-11       1.284e-08        2
   54            2591       2.092e-11       1.028e-08        3
   55            2638       2.092e-11       8.868e-09        4
   56            2685       1.355e-11       4.723e-09        0
   57            2732       1.355e-11        1.12e-08        1
   58            2779       1.355e-11       7.605e-09        2
   59            2826       1.355e-11       5.186e-09        3
   60            2873       1.355e-11       5.968e-09        4

                                Best            Mean     Stall
Generation      Func-count       f(x)            f(x)    Generations
   61            2920       1.355e-11       4.562e-09        5
Optimization terminated: average change in the fitness value less than options.FunctionTolerance.
```




```
% Clear variables
```

```
clearvars options
```

```
disp(['Solution = ',num2str(solution)])
```

```
Solution = -24.8897     -11.9537
```

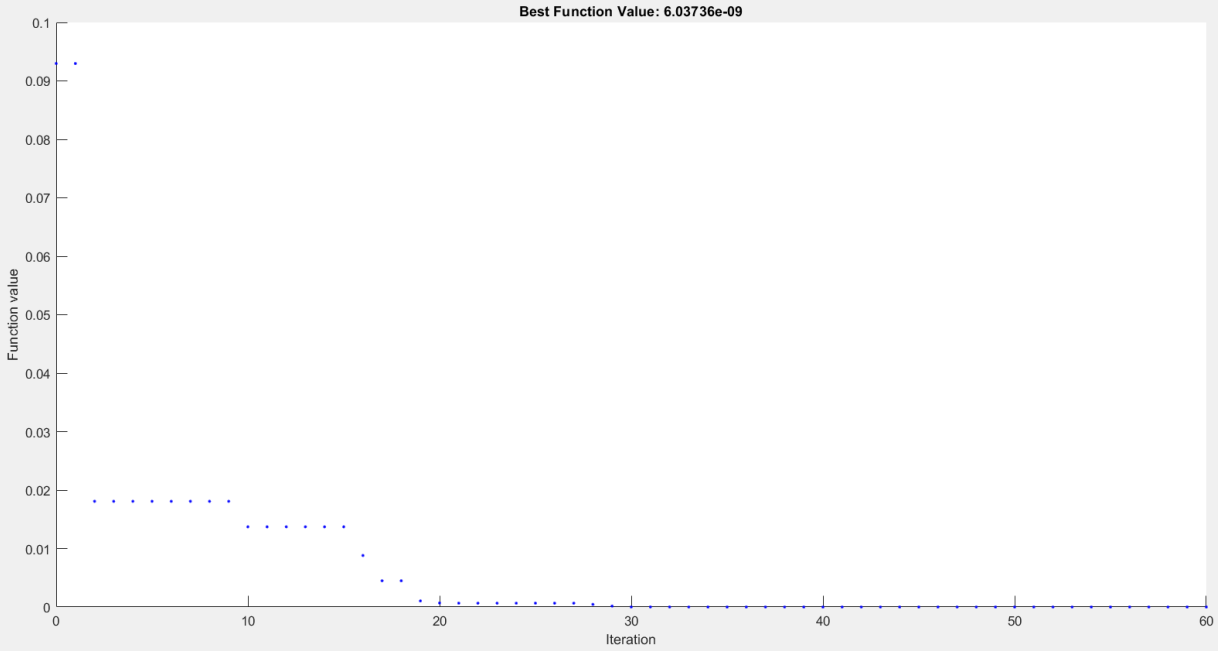
```
disp(['Function value = ', num2str(objectiveValue)])
```

```
Function value = 1.3555e-11
```

```
% Set nondefault solver options
options3 = optimoptions("particleswarm","Display","iter","PlotFcn",...
    "pswplotbestf");

% Solve
[solution2,objectiveValue2] = particleswarm(fun,nvar,repmat(-35,nvar,1),...
    repmat(35,nvar,1),options3);
```

```
                            Best           Mean     Stall
Iteration     f-count           f(x)           f(x)    Iterations
    0              20        0.09297          31.82        0
    1              40        0.09297          61.84        0
    2              60        0.01808          46.93        0
    3              80        0.01808          46.04        1
    4             100        0.01808          48.87        2
    5             120        0.01808          45.89        3
    6             140        0.01808          55.48        4
    7             160        0.01808           37.7        5
    8             180        0.01808          47.88        6
    9             200        0.01808          42.43        7
   10             220        0.01371          34.78        0
   11             240        0.01371          35.03        1
   12             260        0.01371          36.77        2
   13             280        0.01371          24.21        3
   14             300        0.01371          27.68        4
   15             320        0.01371          22.42        5
   16             340       0.008814          28.75        0
   17             360       0.004484          22.27        0
   18             380       0.004484          19.84        1
   19             400        0.00104          31.11        0
   20             420      0.0006869          27.27        0
   21             440      0.0006558          17.88        0
   22             460      0.0006527          19.05        0
   23             480      0.0006524          29.88        0
   24             500      0.0006524          21.62        0
   25             520      0.0006524           21.1        0
   26             540      0.0006524          13.76        0
   27             560      0.0006524          24.17        0
   28             580      0.0004546          23.61        0
   29             600      0.0001571          18.96        0
   30             620      9.378e-06          23.68        0

                            Best           Mean     Stall
Iteration     f-count           f(x)           f(x)    Iterations
   31             640      9.378e-06          29.61        1
   32             660      9.378e-06          29.95        2
   33             680      3.617e-06          31.02        0
   34             700      3.617e-06          34.12        1
   35             720      3.617e-06             18        2
   36             740      3.617e-06          20.57        3
```

```
   37            760       3.617e-06          33.87        4
   38            780       3.617e-06          19.87        5
   39            800       3.617e-06          18.43        6
   40            820       1.229e-06          21.95        0
   41            840       4.845e-07          20.33        0
   42            860       4.845e-07          19.34        1
   43            880       2.983e-07          8.932        0
   44            900       2.639e-07          12.03        0
   45            920       1.969e-07          16.91        0
   46            940       1.884e-07           7.62        0
   47            960       1.884e-07          16.93        1
   48            980       1.884e-07          19.19        2
   49           1000       1.672e-07          16.75        0
   50           1020       1.559e-07          8.291        0
   51           1040       9.726e-08          11.63        0
   52           1060       7.056e-08          20.36        0
   53           1080       6.115e-08          10.39        0
   54           1100       5.414e-08          14.44        0
   55           1120       4.698e-08          12.45        0
   56           1140       1.424e-08          20.38        0
   57           1160       1.351e-08          16.29        0
   58           1180       1.351e-08          17.32        1
   59           1200       1.351e-08          24.49        2
   60           1220       6.037e-09          20.87        0
Optimization ended: relative change in the objective value
over the last OPTIONS.MaxStallIterations iterations is less than OPTIONS.FunctionTolerance.
```




```
% Clear variables
clearvars options3
```

```
disp(['Solution = ',num2str(solution2)])
```

```
Solution = 12.5664      18.8496
```

```
disp(['Function value = ', num2str(objectiveValue2)])
```

```
Function value = 6.0374e-09
```

```
x0 = [-0.5, -0.5]
```

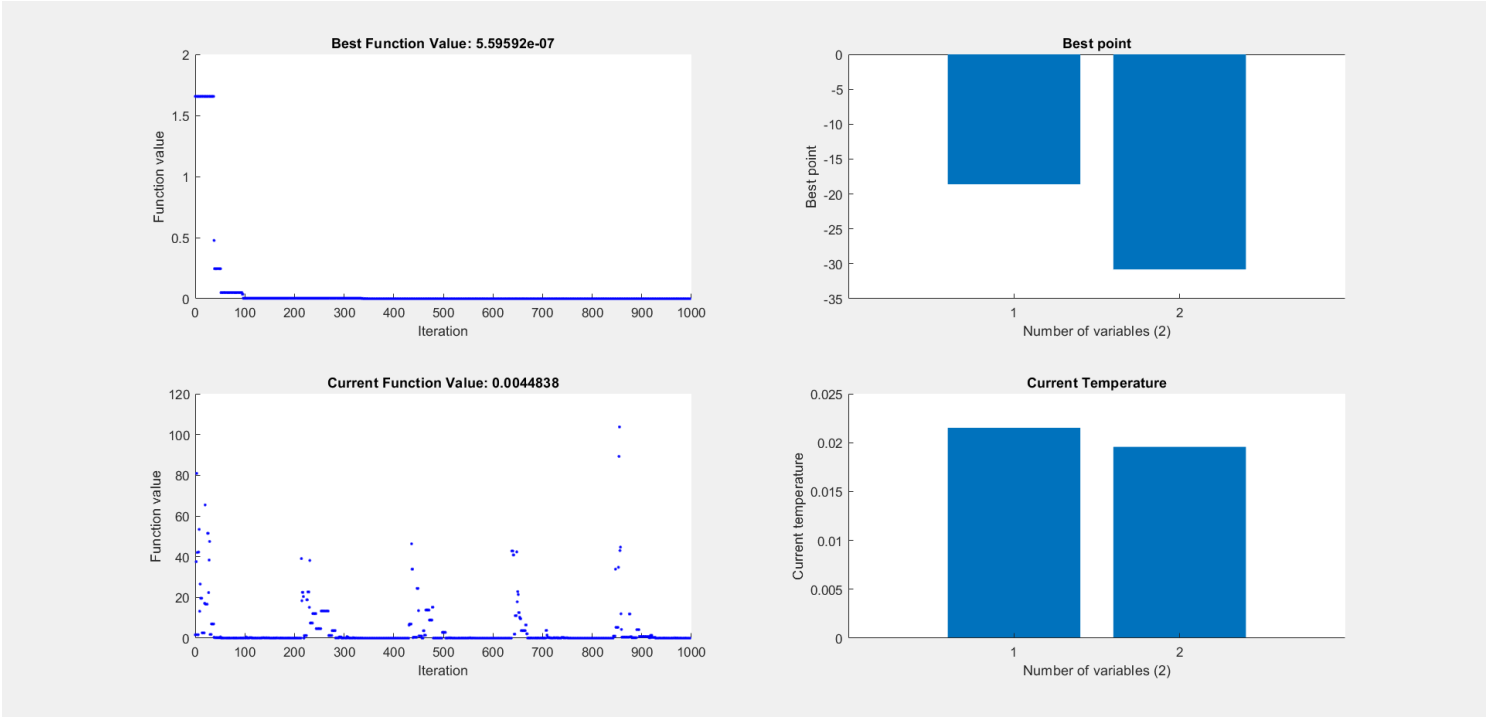
```
x0 = 1×2
   -0.5000   -0.5000
```

```
% Set nondefault solver options
options4 = optimoptions("simulannealbnd","Display","iter","PlotFcn",...
    ["saplotbestf","saplotbestx","saplotf","saplottemperature"]);

% Solve
[solution3,objectiveValue3] = simulannealbnd(fun,x0,repmat(-35,size(x0)),...
    repmat(35,size(x0)),options4);
```

```
                          Best        Current           Mean
Iteration    f-count       f(x)         f(x)        temperature
     0           1        1.65601       1.65601           100
    10          11        1.65601        26.539          56.88
    20          21        1.65601       65.4047         34.0562
    30          31        1.65601       1.80625         20.3907
    40          41       0.245617      0.245617         12.2087
    50          51       0.245617      0.245617         7.30977
    60          61      0.0497008     0.0497008         4.37663
    70          71      0.0497008     0.0497008         2.62045
    80          81      0.0497008     0.0497008         1.56896
    90          91      0.0497008     0.0497008        0.939395
   100         101     0.00366852      0.082779         0.56245
   110         111     0.00366852      0.234463         0.33676
   120         121     0.00366852     0.0360951        0.201631
   130         131     0.00366852     0.0464923        0.120724
   140         141     0.00366852     0.0657392       0.0722817
   150         151     0.00366852      0.043846       0.0432777
   160         161     0.00366852     0.0515403        0.025912
   170         171     0.00366852     0.0527063       0.0155145
   180         181     0.00366852      0.032696      0.00928908
   190         191     0.00366852     0.0283093      0.00556171
   200         201     0.00366852     0.0262781         0.00333
   210         211     0.00366852     0.0248982       0.0019938
*  212         215     0.00366852     0.0247701         55.9811
   220         223     0.00366852       1.25559          37.139
   230         233     0.00366852       15.1112         22.2365
   240         243     0.00366852       12.0542         13.3138
   250         253     0.00366852       4.65336         7.97147
   260         263     0.00366852       13.3057         4.77281
   270         273     0.00366852       1.28774         2.85766
   280         283     0.00366852       3.68232         1.71099
   290         293     0.00366852      0.518562         1.02443
   300         303     0.00366852     0.0689022        0.613364

                          Best        Current           Mean
Iteration    f-count       f(x)         f(x)        temperature
   310         313     0.00366852     0.0759108        0.367244
   320         323     0.00366852     0.0148465        0.219882
   330         333     0.00366852      0.050242        0.131652
   340         343    0.000544961    0.000544961       0.0788248
   350         353    6.37447e-05     0.00319737       0.0471953
   360         363    3.10959e-06    4.44306e-05       0.0282576
   370         373    3.10959e-06    5.58941e-05       0.0169188
```

```
   380        383    3.10959e-06    3.24419e-05      0.0101299
   390        393    3.10959e-06    3.23127e-06     0.00606517
   400        403    3.10959e-06    0.000186424     0.00363144
   410        413    3.10959e-06      0.0001866     0.00217428
   420        423    3.10959e-06    0.000130555     0.00130182
*  425        430    3.10959e-06    0.000232438        57.0046
   430        435    3.10959e-06    0.000232438        44.1091
   440        445    3.10959e-06       0.426524        26.4097
   450        455    3.10959e-06        13.5107        15.8125
   460        465    3.10959e-06        3.62212        9.46752
   470        475    3.10959e-06          13.79        5.66855
   480        485    3.10959e-06      0.0209226        3.39397
   490        495    3.10959e-06      0.0209226         2.0321
   500        505    3.10959e-06        2.83378        1.21669
   510        515    3.10959e-06      0.0866492       0.728478
   520        525    3.10959e-06       0.016913       0.436167
   530        535    3.10959e-06      0.0234464       0.261149
   540        545    3.10959e-06      0.0487901        0.15636
   550        555    3.10959e-06      0.0209484      0.0936183
   560        565    3.10959e-06      0.0275954      0.0560527
   570        575    3.10959e-06     0.00230822      0.0335608
   580        585    3.10959e-06    0.000222241      0.0200941
   590        595    3.10959e-06    0.000355222      0.0120311
   600        605     1.4613e-06    0.000261081     0.00720346

                         Best        Current           Mean
Iteration   f-count       f(x)          f(x)        temperature
   610        615    5.59592e-07    0.000139594     0.00431298
   620        625    5.59592e-07    3.05342e-05     0.00258234
*  628        635    5.59592e-07    1.73441e-06        57.4187
   630        637    5.59592e-07    1.73441e-06        51.8204
   640        647    5.59592e-07        42.8023        31.0268
   650        657    5.59592e-07        22.8755        18.5769
   660        667    5.59592e-07        3.67997        11.1227
   670        677    5.59592e-07      0.0490663        6.65955
   680        687    5.59592e-07      0.0490663        3.98732
   690        697    5.59592e-07      0.0490663        2.38736
   700        707    5.59592e-07      0.0490663         1.4294
   710        717    5.59592e-07       0.251472       0.855833
   720        727    5.59592e-07       0.013845       0.512419
   730        737    5.59592e-07      0.0142036       0.306804
   740        747    5.59592e-07       0.352694       0.183695
   750        757    5.59592e-07       0.126677       0.109985
   760        767    5.59592e-07    0.000905551      0.0658521
   770        777    5.59592e-07    0.000915586      0.0394281
   780        787    5.59592e-07     0.00053445       0.023607
   790        797    5.59592e-07     0.00147527      0.0141344
   800        807    5.59592e-07     0.00280454     0.00846279
   810        817    5.59592e-07    0.000636365     0.00506699
   820        827    5.59592e-07    0.000413227     0.00303379
   830        837    5.59592e-07    0.000386686     0.00181644
   840        847    5.59592e-07    0.000277833     0.00108757
*  842        851    5.59592e-07    0.000275333        58.2828
   850        859    5.59592e-07        5.27112         38.666
   860        869    5.59592e-07       0.459948        23.1508
   870        879    5.59592e-07       0.459948        13.8612
   880        889    5.59592e-07       0.214268        8.29922
   890        899    5.59592e-07         4.1642        4.96905
   900        909    5.59592e-07       0.772752        2.97515

                         Best        Current           Mean
Iteration   f-count       f(x)          f(x)        temperature
   910        919    5.59592e-07       0.772752        1.78133
   920        929    5.59592e-07        1.37321        1.06655
```

```
   930         939     5.59592e-07      0.00840139        0.638583
   940         949     5.59592e-07      0.00182443        0.382343
   950         959     5.59592e-07      0.00943424        0.228923
   960         969     5.59592e-07      0.00988916        0.137065
   970         979     5.59592e-07       0.0449269       0.0820657
   980         989     5.59592e-07       0.0132561       0.0491358
   990         999     5.59592e-07       0.0135766       0.0294194
```




```
Stop requested.
```

```
% Clear variables
clearvars options4
```

```
disp(['Solution = ',num2str(solution3)])
```

```
Solution = -18.6066     -30.8026
```

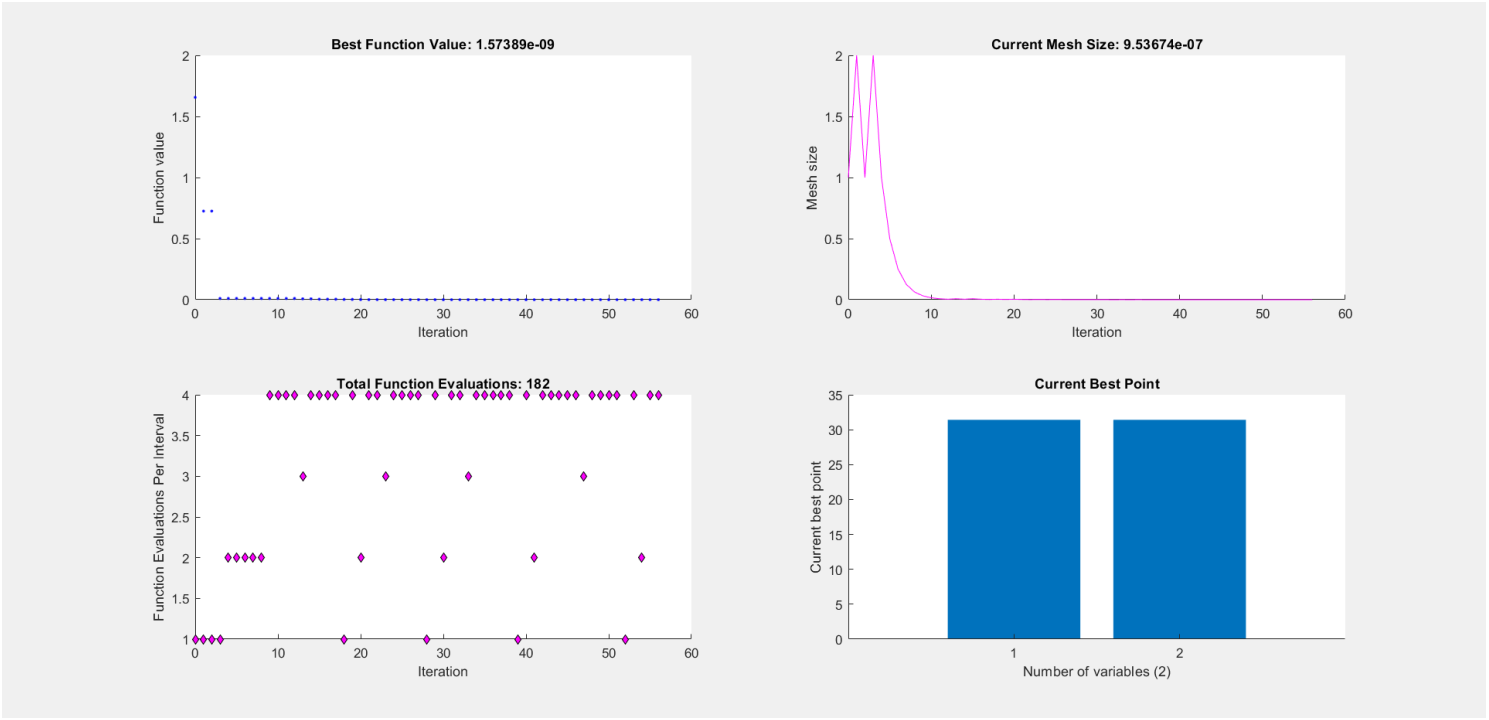
```
disp(['Function value = ', num2str(objectiveValue3)])
```

```
Function value = 5.5959e-07
```

```
% Set nondefault solver options
options5 = optimoptions("patternsearch","Display","iter","PlotFcn",...
    ["psplotbestf","psplotmeshsize","psplotfuncount","psplotbestx"]);

% Solve
[solution4,objectiveValue4] = patternsearch(fun,x0,[],[],[],[],repmat(-35,...
    size(x0)),repmat(35,size(x0)),[],options5);
```

```
Iter     Func-count       f(x)      MeshSize     Method
    0           1        1.65601             1
    1           2       0.724928             2     Successful Poll
    2           3       0.724928             1     Refine Mesh
```

```
     3           4      0.0102628             2     Successful Poll
     4           6      0.0102628             1     Refine Mesh
     5           8      0.0102628           0.5     Refine Mesh
     6          10      0.0102628          0.25     Refine Mesh
     7          12      0.0102628         0.125     Refine Mesh
     8          14      0.0102628        0.0625     Refine Mesh
     9          18      0.0102628       0.03125     Refine Mesh
    10          22      0.0102628       0.01562     Refine Mesh
    11          26      0.0102628      0.007812     Refine Mesh
    12          30      0.0102628      0.003906     Refine Mesh
    13          33      0.0073894      0.007812     Successful Poll
    14          37      0.0073894      0.003906     Refine Mesh
    15          41     0.00384528      0.007812     Successful Poll
    16          45     0.00384528      0.003906     Refine Mesh
    17          49     0.00384528      0.001953     Refine Mesh
    18          50     0.00231702      0.003906     Successful Poll
    19          54     0.00231702      0.001953     Refine Mesh
    20          56    0.000861762      0.003906     Successful Poll
    21          60    0.000861762      0.001953     Refine Mesh
    22          64    0.000861762     0.0009766     Refine Mesh
    23          67    0.000533813      0.001953     Successful Poll
    24          71    0.000533813     0.0009766     Refine Mesh
    25          75    0.000193662      0.001953     Successful Poll
    26          79    0.000193662     0.0009766     Refine Mesh
    27          83    0.000193662     0.0004883     Refine Mesh
    28          84    0.000131131     0.0009766     Successful Poll
    29          88    0.000131131     0.0004883     Refine Mesh
    30          90    6.93021e-05     0.0009766     Successful Poll

Iter     Func-count        f(x)       MeshSize      Method
    31          94    6.93021e-05     0.0004883     Refine Mesh
    32          98    6.93021e-05     0.0002441     Refine Mesh
    33         101    3.82887e-05     0.0004883     Successful Poll
    34         105    3.82887e-05     0.0002441     Refine Mesh
    35         109    6.99466e-06     0.0004883     Successful Poll
    36         113    6.99466e-06     0.0002441     Refine Mesh
    37         117    6.99466e-06     0.0001221     Refine Mesh
    38         121    6.99466e-06     6.104e-05     Refine Mesh
    39         122    3.50173e-06     0.0001221     Successful Poll
    40         126    3.50173e-06     6.104e-05     Refine Mesh
    41         128    1.58688e-08     0.0001221     Successful Poll
    42         132    1.58688e-08     6.104e-05     Refine Mesh
    43         136    1.58688e-08     3.052e-05     Refine Mesh
    44         140    1.58688e-08     1.526e-05     Refine Mesh
    45         144    1.58688e-08     7.629e-06     Refine Mesh
    46         148    1.58688e-08     3.815e-06     Refine Mesh
    47         151    9.02274e-09     7.629e-06     Successful Poll
    48         155    9.02274e-09     3.815e-06     Refine Mesh
    49         159    2.17577e-09     7.629e-06     Successful Poll
    50         163    2.17577e-09     3.815e-06     Refine Mesh
    51         167    2.17577e-09     1.907e-06     Refine Mesh
    52         168    1.87484e-09     3.815e-06     Successful Poll
    53         172    1.87484e-09     1.907e-06     Refine Mesh
    54         174    1.57389e-09     3.815e-06     Successful Poll
    55         178    1.57389e-09     1.907e-06     Refine Mesh
    56         182    1.57389e-09     9.537e-07     Refine Mesh
Optimization terminated: mesh size less than options.MeshTolerance.
```




```
% Clear variables
clearvars options5
```

```
disp(['Solution = ',num2str(solution4)])
```

```
Solution = 31.416       31.416
```

```
disp(['Function value = ', num2str(objectiveValue4)])
```

```
Function value = 1.5739e-09
```

```
% Set nondefault solver options
options6 = optimoptions("surrogateopt","Display","iter","PlotFcn",...
    ["surrogateoptplot","optimplotfvalconstr","optimplotfval","optimplotx"]);

% Solve
[solution5,objectiveValue5] = surrogateopt(fun,repmat(-35,nvar,1),repmat(35,...
    nvar,1),[],[],[],[],[],options6);
```

```
Scalar objective function
Number of variables: 2
Number of integer constraints: 0
Number of linear inequality constraints: 0
Number of linear equality constraints: 0
Number of nonlinear inequality constraints: 0

F-count       Time        Best          Current         Trial
             (seconds)    Fval          Fval            type
   1         0.26       7.9556e+01      7.9556e+01    random
   2         0.65       0.0000e+00      0.0000e+00    random
   3         0.85       0.0000e+00      6.4741e+00    random
```

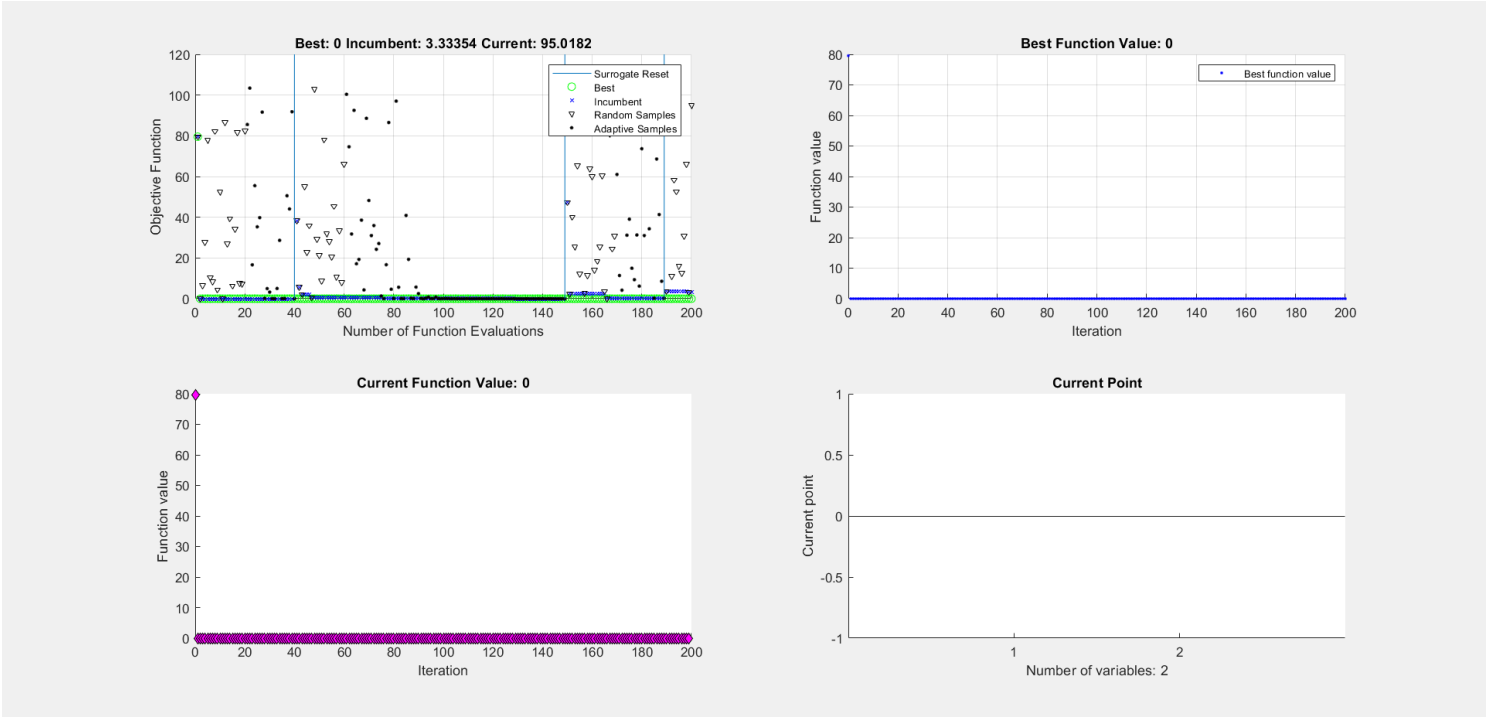
```
    4         1.03       0.0000e+00      2.7797e+01   random
    5         1.45       0.0000e+00      7.7841e+01   random
    6         1.84       0.0000e+00      1.0518e+01   random
    7         2.05       0.0000e+00      8.4979e+00   random
    8         2.24       0.0000e+00      8.2291e+01   random
    9         2.48       0.0000e+00      4.3535e+00   random
   10         2.71       0.0000e+00      5.2486e+01   random
   11         2.89       0.0000e+00      5.0858e-02   random
   12         3.09       0.0000e+00      8.6504e+01   random
   13         3.28       0.0000e+00      2.6977e+01   random
   14         3.47       0.0000e+00      3.9315e+01   random
   15         3.64       0.0000e+00      6.3427e+00   random
   16         3.83       0.0000e+00      3.4336e+01   random
   17         4.02       0.0000e+00      8.1637e+01   random
   18         4.22       0.0000e+00      7.6260e+00   random
   19         4.42       0.0000e+00      7.2884e+00   random
   20         4.62       0.0000e+00      8.2357e+01   random
   21         4.93       0.0000e+00      8.5535e+01   adaptive
   22         5.19       0.0000e+00      1.0340e+02   adaptive
   23         5.40       0.0000e+00      1.6648e+01   adaptive
   24         5.58       0.0000e+00      5.5512e+01   adaptive
   25         5.77       0.0000e+00      3.5293e+01   adaptive
   26         5.96       0.0000e+00      3.9813e+01   adaptive
   27         6.14       0.0000e+00      9.1597e+01   adaptive
   28         6.32       0.0000e+00      1.2827e-01   adaptive
   29         6.52       0.0000e+00      4.9502e+00   adaptive
   30         6.84       0.0000e+00      3.2479e+00   adaptive

F-count       Time         Best          Current         Trial
             (seconds)     Fval          Fval            type
   31         7.10       0.0000e+00      3.2990e-02   adaptive
   32         7.33       0.0000e+00      2.0053e-02   adaptive
   33         7.52       0.0000e+00      4.9979e+00   adaptive
   34         7.72       0.0000e+00      2.8658e+01   adaptive
   35         7.94       0.0000e+00      3.9725e-02   adaptive
   36         8.16       0.0000e+00      4.2677e-02   adaptive
   37         8.37       0.0000e+00      5.0548e+01   adaptive
   38         8.61       0.0000e+00      4.4063e+01   adaptive
   39         8.81       0.0000e+00      9.1813e+01   adaptive
   40         9.00       0.0000e+00      2.8944e-02   adaptive
   41         9.38       0.0000e+00      3.8333e+01   random
   42         9.57       0.0000e+00      5.6437e+00   random
   43         9.77       0.0000e+00      2.1451e+00   random
   44         9.98       0.0000e+00      5.5157e+01   random
   45        10.20       0.0000e+00      2.2740e+01   random
   46        10.45       0.0000e+00      3.5988e+01   random
   47        10.70       0.0000e+00      5.5139e-01   random
   48        10.92       0.0000e+00      1.0297e+02   random
   49        11.14       0.0000e+00      2.9362e+01   random
   50        11.36       0.0000e+00      2.1235e+01   random
   51        11.58       0.0000e+00      8.6510e+00   random
   52        11.79       0.0000e+00      7.8033e+01   random
   53        11.99       0.0000e+00      3.1875e+01   random
   54        12.18       0.0000e+00      2.8068e+01   random
   55        12.36       0.0000e+00      2.0666e+01   random
   56        12.55       0.0000e+00      4.5376e+01   random
   57        12.74       0.0000e+00      1.0629e+01   random
   58        12.93       0.0000e+00      3.3511e+01   random
   59        13.11       0.0000e+00      7.9472e+00   random
   60        13.30       0.0000e+00      6.6077e+01   random

F-count       Time         Best          Current         Trial
             (seconds)     Fval          Fval            type
   61        13.50       0.0000e+00      1.0038e+02   adaptive
```

```
  62         13.68      0.0000e+00      7.4606e+01   adaptive
  63         13.87      0.0000e+00      3.1782e+01   adaptive
  64         14.07      0.0000e+00      9.2496e+01   adaptive
  65         14.26      0.0000e+00      1.7142e+01   adaptive
  66         14.47      0.0000e+00      1.9285e+01   adaptive
  67         14.69      0.0000e+00      3.8585e+01   adaptive
  68         14.87      0.0000e+00      4.3041e+00   adaptive
  69         15.07      0.0000e+00      8.8574e+01   adaptive
  70         15.26      0.0000e+00      4.8220e+01   adaptive
  71         15.44      0.0000e+00      3.0997e+01   adaptive
  72         15.64      0.0000e+00      3.5899e+01   adaptive
  73         15.83      0.0000e+00      2.4247e+01   adaptive
  74         16.02      0.0000e+00      2.7083e+01   adaptive
  75         16.21      0.0000e+00      1.2988e+00   adaptive
  76         16.41      0.0000e+00      1.4032e-02   adaptive
  77         16.60      0.0000e+00      1.6673e+01   adaptive
  78         16.79      0.0000e+00      8.6530e+01   adaptive
  79         16.98      0.0000e+00      4.6186e+00   adaptive
  80         17.18      0.0000e+00      8.2133e-02   adaptive
  81         17.37      0.0000e+00      9.7040e+01   adaptive
  82         17.57      0.0000e+00      5.6289e+00   adaptive
  83         17.79      0.0000e+00      5.0311e-02   adaptive
  84         17.99      0.0000e+00      2.7353e-02   adaptive
  85         18.19      0.0000e+00      4.0893e+01   adaptive
  86         18.39      0.0000e+00      1.9295e+01   adaptive
  87         18.60      0.0000e+00      2.5077e-01   adaptive
  88         18.81      0.0000e+00      5.2154e-02   adaptive
  89         19.01      0.0000e+00      5.7030e+00   adaptive
  90         19.23      0.0000e+00      2.5041e+00   adaptive

F-count       Time        Best          Current         Trial
             (seconds)    Fval          Fval            type
  91         19.43      0.0000e+00      1.1745e-01   adaptive
  92         19.65      0.0000e+00      4.9633e-03   adaptive
  93         19.86      0.0000e+00      2.9946e-01   adaptive
  94         20.07      0.0000e+00      7.7131e-01   adaptive
  95         20.28      0.0000e+00      2.4653e-02   adaptive
  96         20.49      0.0000e+00      3.7757e-02   adaptive
  97         20.70      0.0000e+00      7.4037e-01   adaptive
  98         20.92      0.0000e+00      4.6458e-02   adaptive
  99         21.13      0.0000e+00      1.2909e-02   adaptive
 100         21.34      0.0000e+00      1.7134e-02   adaptive
 101         21.59      0.0000e+00      8.9934e-02   adaptive
 102         21.81      0.0000e+00      5.1369e-02   adaptive
 103         22.02      0.0000e+00      1.5152e-02   adaptive
 104         22.23      0.0000e+00      2.1399e-02   adaptive
 105         22.44      0.0000e+00      9.7798e-03   adaptive
 106         22.65      0.0000e+00      2.4969e-02   adaptive
 107         22.87      0.0000e+00      1.0072e-02   adaptive
 108         23.08      0.0000e+00      9.9016e-03   adaptive
 109         23.29      0.0000e+00      4.0846e-03   adaptive
 110         23.50      0.0000e+00      1.1340e-02   adaptive
 111         23.72      0.0000e+00      1.0170e-02   adaptive
 112         23.93      0.0000e+00      1.0025e-02   adaptive
 113         24.15      0.0000e+00      3.3247e-03   adaptive
 114         24.37      0.0000e+00      4.3940e-04   adaptive
 115         24.58      0.0000e+00      5.5978e-03   adaptive
 116         24.79      0.0000e+00      8.1727e-03   adaptive
 117         25.01      0.0000e+00      6.7556e-03   adaptive
 118         25.22      0.0000e+00      3.5865e-03   adaptive
 119         25.44      0.0000e+00      8.4678e-03   adaptive
 120         25.66      0.0000e+00      3.0395e-03   adaptive

F-count       Time        Best          Current         Trial
```

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
121	25.87	0.0000e+00	6.8207e-04	adaptive
122	26.09	0.0000e+00	2.3302e-03	adaptive
123	26.31	0.0000e+00	3.7578e-03	adaptive
124	26.53	0.0000e+00	3.4658e-03	adaptive
125	26.75	0.0000e+00	1.3133e-03	adaptive
126	26.97	0.0000e+00	1.2785e-03	adaptive
127	27.19	0.0000e+00	1.5325e-03	adaptive
128	27.41	0.0000e+00	1.1360e-03	adaptive
129	27.67	0.0000e+00	3.5557e-05	adaptive
130	27.89	0.0000e+00	4.7603e-04	adaptive
131	28.14	0.0000e+00	7.6187e-04	adaptive
132	28.37	0.0000e+00	9.0723e-04	adaptive
133	28.59	0.0000e+00	7.8644e-05	adaptive
134	28.82	0.0000e+00	1.0055e-03	adaptive
135	29.06	0.0000e+00	2.6622e-04	adaptive
136	29.28	0.0000e+00	3.5288e-04	adaptive
137	29.50	0.0000e+00	7.1074e-05	adaptive
138	29.72	0.0000e+00	2.1652e-04	adaptive
139	29.94	0.0000e+00	2.4007e-04	adaptive
140	30.17	0.0000e+00	1.0499e-04	adaptive
141	30.40	0.0000e+00	9.8367e-05	adaptive
142	30.62	0.0000e+00	3.8025e-05	adaptive
143	30.84	0.0000e+00	1.3462e-04	adaptive
144	31.07	0.0000e+00	9.8577e-05	adaptive
145	31.29	0.0000e+00	4.8282e-05	adaptive
146	31.52	0.0000e+00	6.8903e-05	adaptive
147	31.74	0.0000e+00	5.9869e-05	adaptive
148	31.96	0.0000e+00	5.4995e-05	adaptive
149	32.19	0.0000e+00	6.1292e-05	adaptive
150	32.47	0.0000e+00	4.7346e+01	random

F-count	Time (seconds)	Best Fval	Current Fval	Trial type
151	32.66	0.0000e+00	2.3660e+00	random
152	32.85	0.0000e+00	4.0050e+01	random
153	33.07	0.0000e+00	2.5401e+01	random
154	33.28	0.0000e+00	6.5344e+01	random
155	33.47	0.0000e+00	1.2166e+01	random
156	33.67	0.0000e+00	8.7118e+01	random
157	33.86	0.0000e+00	2.5838e+00	random
158	34.05	0.0000e+00	1.1320e+01	random
159	34.26	0.0000e+00	6.3714e+01	random
160	34.47	0.0000e+00	5.9918e+01	random
161	34.66	0.0000e+00	1.4154e+01	random
162	34.85	0.0000e+00	1.8468e+01	random
163	35.06	0.0000e+00	2.5445e+01	random
164	35.26	0.0000e+00	6.0517e+01	random
165	35.46	0.0000e+00	3.5902e+00	random
166	35.68	0.0000e+00	2.9601e-02	random
167	35.87	0.0000e+00	8.1013e+01	random
168	36.07	0.0000e+00	2.4571e+01	random
169	36.26	0.0000e+00	3.0883e+01	random
170	36.46	0.0000e+00	6.1000e+01	adaptive
171	36.67	0.0000e+00	1.1373e+01	adaptive
172	36.87	0.0000e+00	4.1604e+00	adaptive
173	37.05	0.0000e+00	9.2364e+01	adaptive
174	37.25	0.0000e+00	3.1154e+01	adaptive
175	37.45	0.0000e+00	3.9062e+01	adaptive
176	37.64	0.0000e+00	1.4941e+01	adaptive
177	37.82	0.0000e+00	9.3248e+00	adaptive
178	38.03	0.0000e+00	3.1263e+01	adaptive
179	38.24	0.0000e+00	6.1543e+00	adaptive
180	38.43	0.0000e+00	7.3657e+01	adaptive

```
F-count        Time          Best          Current         Trial
              (seconds)     Fval          Fval            type
  181          38.63       0.0000e+00      3.1003e+01    adaptive
  182          38.83       0.0000e+00      1.0390e+02    adaptive
  183          39.02       0.0000e+00      3.4317e+01    adaptive
  184          39.22       0.0000e+00      8.1635e+01    adaptive
  185          39.42       0.0000e+00      2.2333e-01    adaptive
  186          39.62       0.0000e+00      6.8603e+01    adaptive
  187          39.82       0.0000e+00      4.1322e+01    adaptive
  188          40.02       0.0000e+00      8.5465e+00    adaptive
  189          40.22       0.0000e+00      2.8370e-01    adaptive
  190          40.53       0.0000e+00      3.6003e+00    random
  191          40.81       0.0000e+00      9.0207e+01    random
  192          41.06       0.0000e+00      1.1106e+01    random
  193          41.27       0.0000e+00      5.8287e+01    random
  194          41.47       0.0000e+00      5.2622e+01    random
  195          41.70       0.0000e+00      1.5873e+01    random
  196          41.90       0.0000e+00      1.2481e+01    random
  197          42.09       0.0000e+00      3.0792e+01    random
  198          42.28       0.0000e+00      6.6127e+01    random
  199          42.47       0.0000e+00      3.3335e+00    random
  200          42.66       0.0000e+00      9.5018e+01    random
```




```
surrogateopt stopped because it exceeded the function evaluation limit set by
'options.MaxFunctionEvaluations'.
```

```
% Clear variables
clearvars options6
```

```
disp(['Solution = ',num2str(solution5)])
```

```
Solution = 0  0
```

```
disp(['Function value = ', num2str(objectiveValue5)])
```

```
Function value = 0
```