Subsections

Non-linear Continuous Multi-Extremal Optimization

The test programs below are all run via one CE program: CEoptima.m

The following is a batchfile to run the programs: runTHIS.m

Rosenbrock function

$$S(\mathbf{x}) = \sum_{i=1}^{n-1} 100\,(x_{i+1} - x_i^2)^2 + (x_i - 1)^2 \tag{1}$$

Rosen.m

Trigonometric function

$$S(\mathbf{x}) = 1 + \sum_{i=1}^{n} 8\sin^2(\eta(x_i - x_i^*)^2) + 6\sin^2(2\eta(x_i - x_i^*)^2) + \mu(x_i - x_i^*)^2\ . \tag{2}$$

Paviani's function

$$\sum_{i=1}^{n}\left(\ln^2(x_i - 2) + \ln^2(10 - x_i)\right) - \left(\prod_{i=1}^{n} x_i\right)^{0.2}. \tag{3}$$

UniformPaviani.m

Paviani.m

Sphere model, first De Jong's function

$$\sum_{i=1}^{n} x_i^2 \tag{4}$$

FirstJong.m

Third De Jong's function

$$\sum_{i=1}^{n} |x_i| \ , \quad -2.048 \le x_i \le 2.048 \tag{5}$$

ThirdJong.m

Fourth De Jong's function, Quartic function with noise, Quartic Gaussian function

$$\sum_{i=1}^{n} i x_i^4 \ , \quad -1.28 \leqslant x_i \leqslant 1.28 \tag{6}$$

FourthJong.m

Rastrigin's function

$$n * 10 + \sum_{i=1}^{n} (x_i^2 - 10\cos(2\pi x_i)) \ , \quad -5.12 \leqslant x_i \leqslant 5.12 \tag{7}$$

[Rastrigin.m]

Schwefel's function

$$\sum_{i=1}^{n} -x_i \sin(\sqrt{|x_i|}) \ , \quad -512 \leqslant x_i \leqslant 512 \tag{8}$$

[Schwefel.m]

Griewangk's function

$$-\prod_{i=1}^{n} \cos\left(\frac{x_i}{\sqrt{i}}\right) + \sum_{i=1}^{n} \frac{x_i^2}{4000} + 1 \ , \quad -600 \leqslant x_i \leqslant 600 \tag{9}$$

[Griewangk.m]

Sine envelope sine wave function

$$-\sum_{i=1}^{n-1}\left(\frac{\sin^2(\sqrt{x_{i+1}^2+x_i^2}-0.5)}{(0.001(x_{i+1}^2+x_i^2)+1)^2}+0.5\right),\quad -100\leqslant x_i\leqslant 100 \tag{10}$$

Stretch V sine wave function (Ackley)

$$\sum_{i=1}^{n-1}(x_{i+1}^2+x_i^2)^{0.25}(\sin^2(50(x_{i+1}^2+x_i^2)^{0.1})+1),\quad -10\leqslant x_i\leqslant 10 \tag{11}$$

[AckleySine.m]()

Test function (Ackley)

$$\sum_{i=1}^{n-1}\left(3(\cos(2x_i)+\sin(2x_{i+1}))+\frac{\sqrt{x_{i+1}^2+x_i^2}}{e^{0.2}}\right),\quad -30\leqslant x_i\leqslant 30 \tag{12}$$

[Ackleyfunction.m]()

Ackley's function

$$\sum_{i=1}^{n-1}\left(20+e^{-20}e^{-0.2\sqrt{0.5(x_{i+1}^2+x_i^2)}}-e^{0.5(\cos(2\pi x_{i+1})+\cos(2\pi x_i))}\right)\ ,\quad -30\leqslant x_i\leqslant 30 \tag{13}$$

Egg Holder

$$\sum_{i=1}^{n-1}\left(-(x_{i+1}+47)\sin\left(\sqrt{\left|x_{i+1}+\frac{x_i}{2}+47\right|}\right)+\sin\left(\sqrt{\left|x_i-(x_{i+1}+47)\right|}\right)(-x_i)\right) \tag{14}$$
$$-512\leqslant x_i\leqslant 512$$

[EggHolder.m]

Rana's function

$$\sum_{i=1}^{n-1}\left((x_{i+1}+1)\cos\left(\sqrt{|x_{i+1}-x_i+1|}\right)\sin\left(\sqrt{|x_{i+1}+x_i+1|}\right)\right. \tag{15}$$
$$\left.+x_i\cos\left(\sqrt{|x_{i+1}+x_i+1|}\right)\sin\left(\sqrt{|x_{i+1}-x_i+1|}\right)\right)\ ,-500\leqslant x_i\leqslant 500$$

[Rana.m]

Pathological test function

Notice: Possibly not OK.

$$\sum_{i=1}^{n-1}\left(\frac{\sin^2\left(\sqrt{x_{i+1}^2+100x_i^2}\right)-0.5}{0.001(x_{i+1}^2-2x_{i+1}x_i+x_i^2)^2+1.0}+0.5\right)\ ,\quad -100\leqslant x_i\leqslant 100 \qquad (16)$$

Pathology.m

Michalewicz's function

$$\sum_{i=1}^{n-1}\left(\sin(x_{i+1})\sin^{20}\left(\frac{2x_{i+1}^2}{\pi}\right)+\sin(x_i)\sin^{20}\left(\frac{x_{i+1}^2}{\pi}\right)\right)\ ,\quad 0\leqslant x_i\leqslant \pi \qquad (17)$$

Michalewicz.m

Master's cosine wave function

$$-\sum_{i=1}^{n-1}e^{-\frac{1}{8}\left(x_{i+1}^2+0.5x_ix_{i+1}+x_i^2\right)}\cos\left(4\sqrt{x_{i+1}^2+0.5x_ix_{i+1}+x_i^2}\right)\ ,\quad -5\leqslant x_i\leqslant 5 \qquad (18)$$

Keane's function

$$\left| \frac{\left(\sum_{i=1}^{n} \cos^4(x_i) - 2\prod_{i=1}^{n} \cos^2(x_i)\right)}{\sqrt{\sum_{i=1}^{n} i x_i^2}} \right| \tag{19}$$

Constraints: $\prod_{i=1}^{n} x_i \geq 0.75, \ \sum_{i=1}^{n} x_i \leqslant 7.5n, \ 0 \leq x_i \leq 10$.

Hougen function (non-linear regression)

Hougen function is typical complex test for classical non-linear regression problems. The Hougen-Watson model for reaction kinetics is an example of this a non-linear regression problem. The form of the model is

$$\text{rate} = \frac{\beta_1 x_2 - x_3/\beta_5}{1 + \beta_2 x_1 + \beta_3 x_2 + \beta_4 x_3},$$

where the betas are the unknown parameters, and the xs are the input variables. The parameters are estimated via the least squares criterion. That is, the parameters are such that the sum of the squared differences between the observed responses and their fitted values of rate is minimized. The following input data are used:

Table 1: Input data for the Hougen function

x(1)	x(2)	x(3)	rate
470	300	10	8.55
285	80	10	3.79
470	300	120	4.82

470	80	120	0.02
470	80	10	2.75
100	190	10	14.39
100	80	65	2.54
470	190	65	4.35
100	300	54	13.00
100	300	120	8.50
100	80	120	0.05
285	300	10	11.32
285	190	120	3.13

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cetoolbox www user
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