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求解全局优化问题的两阶段模式搜索算法

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摘 要: Matlab

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The Method of Two Stage Pattern Search for Bound Constrained Global Optimization

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Abstract: We presented a two stage pattern search method, which combined the cut-peak function and the pattern search solver in Matlab. A simple cut-peak function and choice function were defined at solution returned by pattern search solver. By minimizing the choice function, a global descent of the original objective function was assured. Since the pattern search method did not require the gradient of the choice function, smoothing technique was not employed. The new algorithm was simple to implement and numerical results indicated that the new method improved the efficiency of finding the global minimization.

Keywords: Global optimization toolbox; pattern search solver; cut peak function; global optimization

1 引 言

Matlab 5

(patternsearch)

[1,2]

$$\min f(x) \quad s.t. \ x \in \Omega , \tag{1}$$

$\Omega = \left\{ x \in R^n \,\middle|\, l \le x \le u \right\}, l \le u \in R^n$ $f(x): \Omega \to R$

x_k^* $f(x_k^*)$

$F(x_k^*, x) = \min\left\{ f(x), f(x_k^*) \right\}$ x_k^*

x_{k+1} $f(x_{k+1}) < f(x_k^*)$ $f(x)$

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$$x^*_{k+1} = x_{k+1}$$

$F(x^*_k, x)$ $f(x^*_k)$ $f(x)$

2 两阶段模式搜索算法

2.1 割峰函数

[3]

定义 1 (割峰函数)

r $w(r, x^*_k, x)$

(i) x^*_k $w(r, x^*_k, x)$ $w(r, x^*_k, x^*_k) = f(x^*_k)$

(ii) $d \in R^n$ $w(r, x^*_k, x^*_k + \lambda d)$ λ

$$\lim_{\lambda \to +\infty} w(r, x^*_k, x^*_k + \lambda d) = f(x^*_k) - c(r) > -\infty$$

$w(r, x^*_k, x)$ x^*_k $c(r)$ r

$w(r, x^{(k)}, x)$

1 $f(x)$ $w(r, x^*_k, x)$

$w(r, x^*_k, x)$

定义 2 (选择函数)

x^*_k $\varphi_k(x) = \min\left\{f(x), w(r, x^*_k, x)\right\}$ $\varphi_k(x)$

2.2 新的割峰函数

[3]

Matlab

$$w(x^*_k, x) = f(x^*_k) \tag{2}$$

$F(x^*_k, x) = \min\left\{f(x), f(x^*_k)\right\}$ 1 2

1 (l) (w) (F)

$f(x) = -e^x \sin(2\pi x)$ $w(x^*_k, x) = f(x^*_k) = f(1.275)$

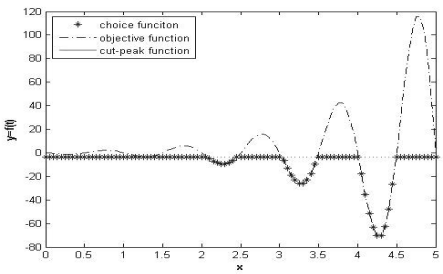

图 1 选择函数、目标函数和割峰函数

Fig.1 Relation of the choice function, objective function and cut peak function

2.3 两阶段模式搜索算法

0 x_0 $k := 0$

1 ( )

x_k (1) x_k^*

2 ( )

x_k^* $w(x_k^*, x) = f(x_k^*)$ $F(x_k^*, x) = \min\{f(x), f(x_k^*)\}$

$F(x_k^*, x)$ x_k $f(x_k) = f(x_k^*)$

$f(x_k) < f(x_k^*)$ $x_{k+1}^* := x_k$ $k := k+1$ 2

$F(x_k^*, x)$ x_k $f(x_k) = f(x_k^*)$

$f(x_k) < f(x_k^*)$

3 数值测试

4

MATLAB 2010a patternsearch solver(PS)

(TSPS)

IT IF IW FP

FF

1 Six-hump Camel-back Function

$$f(x) = 4x_1^2 - 2.1x_1^4 + \frac{x_1^6}{3} + x_1x_2 - 4x_2^2 + 4x_2^4, l = (-3,-3)^T, u = (3,3)^T$$

$(-0.0898,0.7126)^T$ -1.031628.

表 1 算例 1 的测试结果

Table 1 Numerical results of problem 1

Algorithm	Initial point	IT	IF	IW	FP	FF
PS	$(1,1)^T$	54	186	0	$(0.898,-0.7127)^T$	-1.0316
TSPS	$(1,1)^T$	54	199	1	$(0.898,-0.7127)^T$	-1.0316

2 Shubert I Function(n=2)

$$f(x) = \left\{\sum_{i=1}^{5} i\cos(i+1)x_1 + i\right\}\left\{\sum_{i=1}^{5} i\cos((i+1)x_2 + i)\right\}, l = (-10,-10)^T, u = (10,10)^T,$$

$(-1.42513, -0.80032)^T$ $f(x^*) = -186.730909$.

表 2 算例 2 的测试结果

Table 2 Numerical results of problem 2

Algorithm	Initial point	IT	IF	IW	FP	FF
PS	$(2,2)^T$	54	186	0	$(-7.0835, 10.0000)^T$	-48.5068
TSPS	$(2,2)^T$	66	219	1	$(4.8581,-0.8003)^T$	-186.7309

3 Shubert II Function(n=2)

$$f(x)=\left\{\sum_{i=1}^{5} i\cos(i+1)x_1+i\right\}\left\{\sum_{i=1}^{5} i\cos((i+1)x_2+i)\right\}+\frac{1}{2}[(x_1+1.42513)^2+(x_2+0.80032)^2]$$

$l=(-10,10)^T, u=(10,10)^T$. 2.

表 3 算例 3 的测试结果

Table 3 Numerical results of problem 3

Algorithm	Initial point	IT	IF	IW	FP	FF
PS	$(2,2)^T$	54	186	0	$(-7.0835, 10.0000)^T$	-48.5068
TSPS	$(2,2)^T$	66	219	1	$(-0.8005, 4.8568)^T$	-170.5306

4 Shubert III Function(n=2)

$$f(x)=\left\{\sum_{i=1}^{5} i\cos(i+1)x_1+i\right\}\left\{\sum_{i=1}^{5} i\cos((i+1)x_2+i)\right\}+(x_1+1.42513)^2+(x_2+0.80032)^2$$

$l=(-10,10)^T, u=(10,10)^T$. 2.

表 4 算例 4 的测试结果

Table 4 Numerical results of problem 4

Algorithm	Initial point	IT	IF	IW	FP	FF
PS	$(2,2)^T$	54	186	0	$(-7.0809,4.8556)^T$	-122.7247
TSPS	$(2,2)^T$	66	219	1	$(-0.1960, -0.8003)^T$	-122.0653

4 结 论

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