SIGMA technology

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IOSO Global Optimization software benchmarking from Japan

All examples are taken from two public sources (written in Japanese):

1) Global Optimization by Generalized Random Tunneling Algorithm **(2nd Report: Examination on the accuracy of solution and its efficiency) Satoshi KITAYAMA and Koetsu YAMAZAKI Department of Human & Mechanical Systems Engineering, Kanazawa University 2-40-20, Kodatsuno, Kanazawa, Ishikawa, 920-8667, Japan**

2) Global Optimization by Generalized Random Tunneling Algorithm **(5th Report: Approximate Optimization Using RBF Network) Satoshi KITAYAMA, Masao ARAKAWA, Koetsu YAMAZAKI Department of Human & Mechanical Systems Engineering, Kanazawa University Kakuma-machi, Kanazawa, 920-1192, Japan**

Example 1

Task formulation

$$f(\mathbf{x}) = \frac{1}{2}\sum_{i=1}^{2}\left(x_i^4 - 16x_i^2 + 5x_i\right) \rightarrow \min$$

$$g_1(\mathbf{x}) = x_1^{\,2} + x_2^2 - 9 \le 0$$

Position of global optimum is

$$(x_1, x_2)^T = (-2.121, -2.121)^T$$

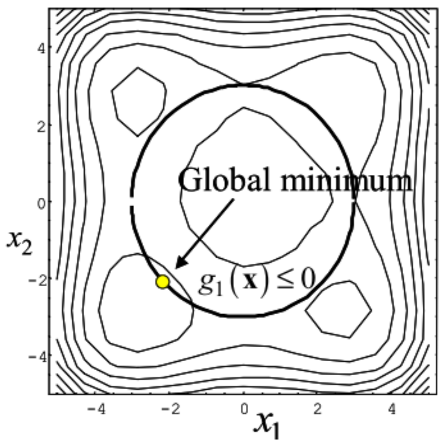
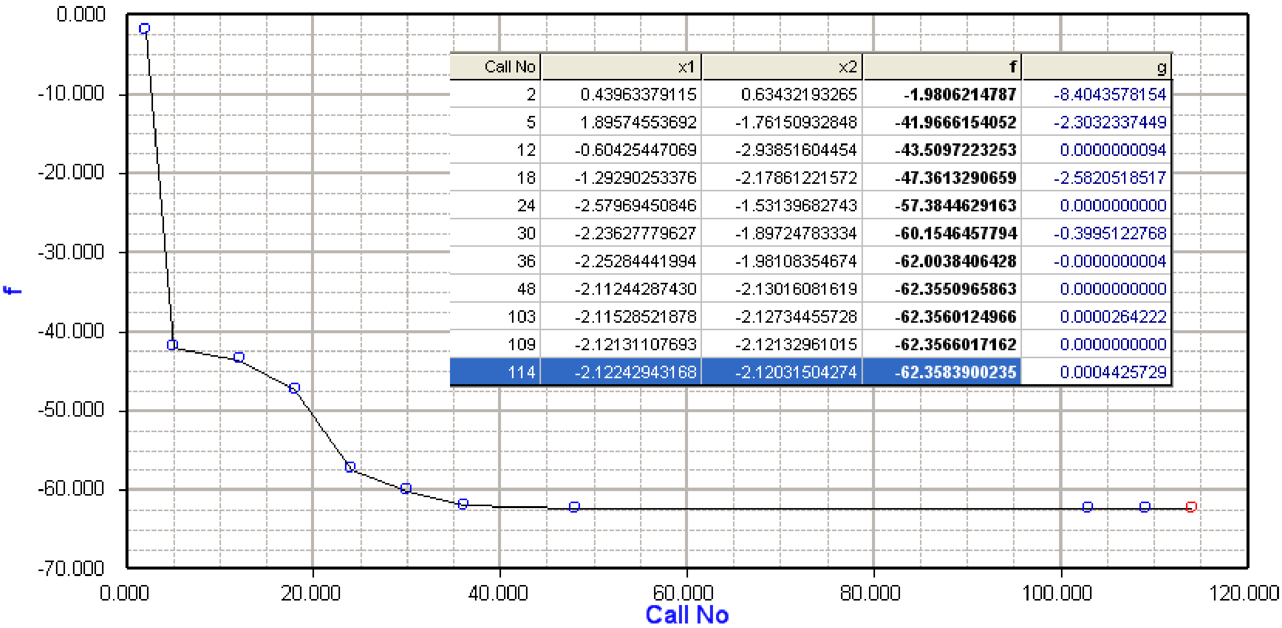


Fig1 Contour of functions and the position of global minimum

Result given by IOSO

IOSO found the global solution easily and quickly



Call No	x1	x2	f	g
2	0.43963379115	0.63432193265	**-1.9806214787**	-8.4043578154
5	1.89574553692	-1.76150932848	**-41.9666154052**	-2.3032337449
12	-0.60425447069	-2.93851604454	**-43.5097223253**	0.0000000094
18	-1.29290253376	-2.17861221572	**-47.3613290659**	-2.5820518517
24	-2.57969450846	-1.53139682743	**-57.3844629163**	0.0000000000
30	-2.23627779627	-1.89724783334	**-60.1546457794**	-0.3995122768
36	-2.25284441994	-1.98108354674	**-62.0038406428**	-0.0000000004
48	-2.11244287430	-2.13016081619	**-62.3550965863**	0.0000000000
103	-2.11528521878	-2.12734455728	**-62.3560124966**	0.0000264222
109	-2.12131107693	-2.12132961015	**-62.3566017162**	0.0000000000
114	-2.12242943168	-2.12031504274	**-62.3583900235**	0.0004425729

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Example 2
Task formulation

$$f(\mathbf{x}) = -x_1 - x_2 \rightarrow \min$$

$$g_1(\mathbf{x}) = -2 - 2x_1^4 + 8x_1^3 - 8x_1^2 + x_2 \leq 0$$

$$g_2(\mathbf{x}) = -36 - 4x_1^4 + 32x_1^3 - 88x_1^2 + 96x_1 + x_2 \leq 0$$

$$0 \leq x_1 \leq 3, \quad 0 \leq x_2 \leq 4$$

Position of global optimum is

$$(x_1, x_2)^T = (2.329, 3.178)^T$$

where $f = -5.508$

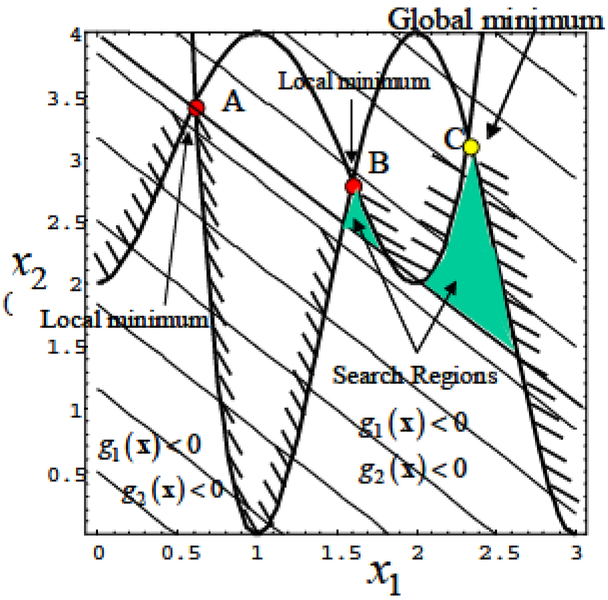
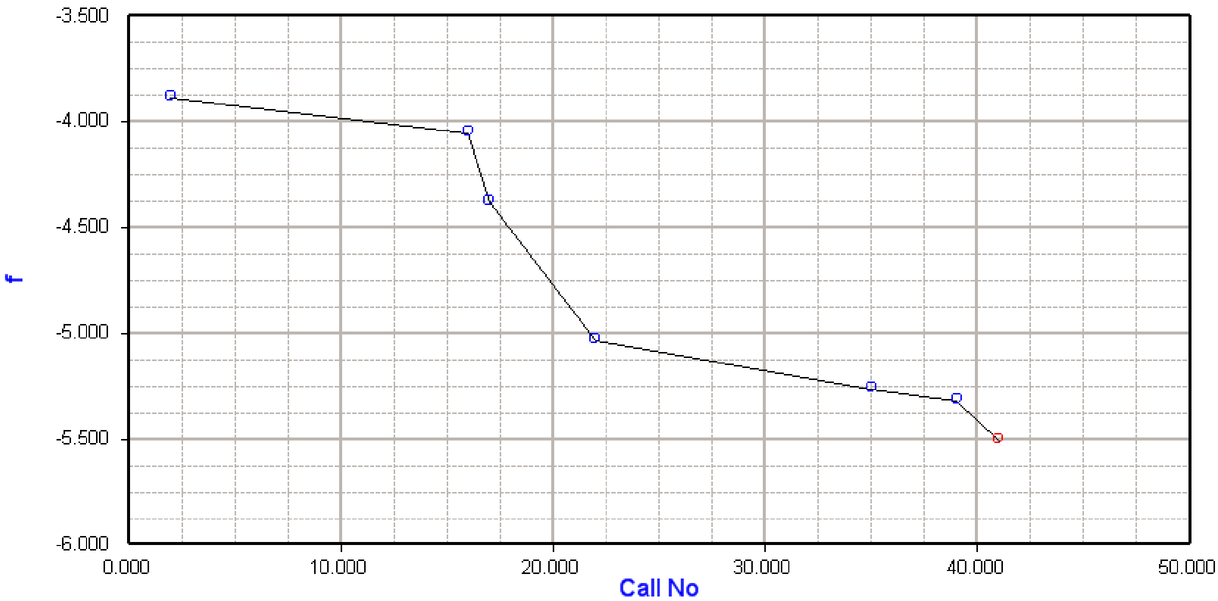


Fig2 Contour of functions and the position of global minimum

Result given by IOSO
IOSO found the global solution easily and quickly



Call No	x1	x2	f	g1	g2
2	1.63189013734	2.25372877306	**-3.8856189104**	-0.4679878994	-0.7356785393
16	1.58154168824	2.47111825405	**-4.0526599423**	-0.4048647520	-0.2506732248
17	1.60668621227	2.77447823339	**-4.3811644457**	-0.0241974670	-0.0836789641
22	2.32289975740	2.70959061478	**-5.0324903722**	-0.4156006977	-0.4997794967
35	2.38958640969	2.87568881098	**-5.2652752207**	-0.8576484463	-0.0022363479
39	2.34775799208	2.97097386686	**-5.3187318589**	-0.3622125805	-0.1200428625
41	2.32949976931	3.17930488005	**-5.5088046494**	0.0009785860	0.0007157992

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Example 3 (Infeasible region)
Task formulation

$$f(\boldsymbol{x}) = -(x_1 - 10)^2 - (x_2 - 15)^2 \rightarrow \min$$

$$g_1(\boldsymbol{x}) = (x_2 - \frac{5.1}{4\pi^2}x_1^2 + \frac{5}{\pi}x_1 - 6)^2$$

$$+10(1 - \frac{1}{8\pi})\cos x_1 + 5 \le 0$$

$$-5 \le x_1 \le 10$$

$$0 \le x_2 \le 15$$

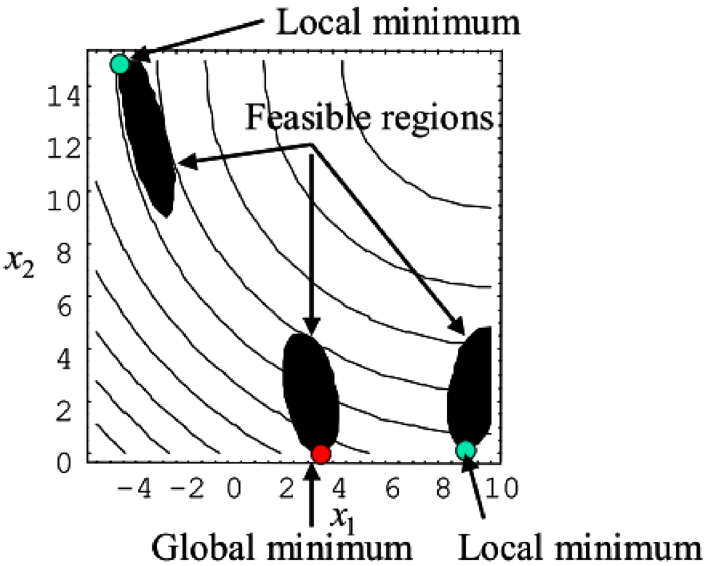


Fig3 Feasible regions and global minimum

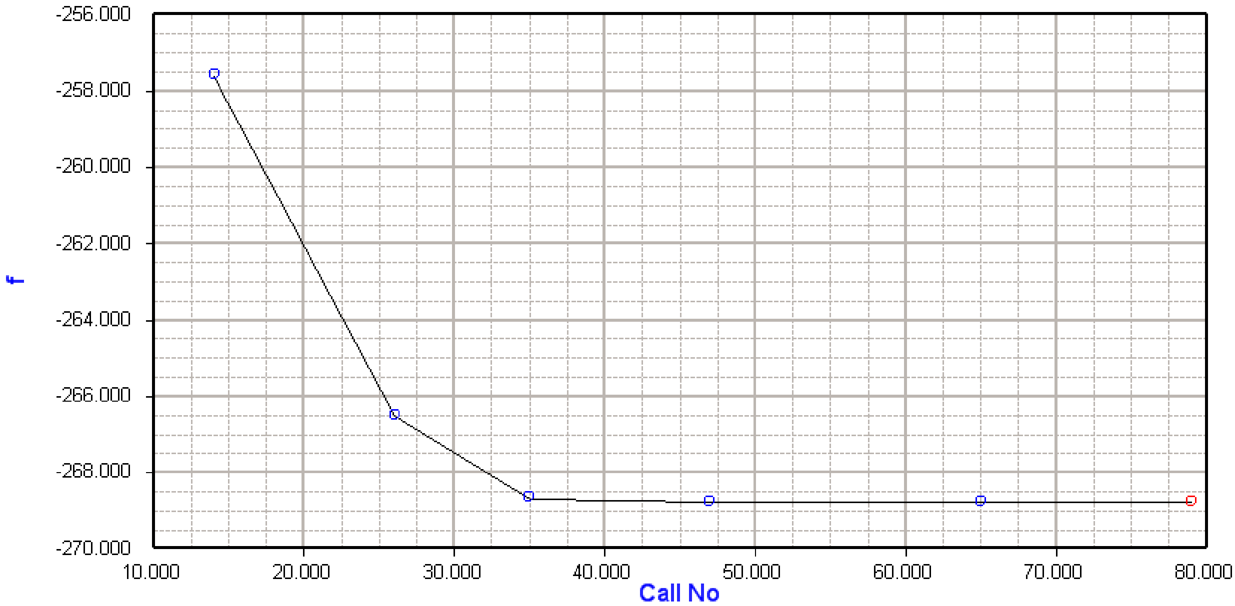
Global solution

$$\boldsymbol{x}_G = (3.271, 0.0496)^T$$

where

$$f(\boldsymbol{x}_G) = -268.788$$

Result given by IOSO
IOSO found the global solution without any problem



Call No	x1	x2	f	g
14	3.55730782652	0.29978728294	**-257.6045363690**	-0.9842157029
26	3.30728610143	0.10928877845	**-266.5257000117**	-0.3088396462
35	3.28327450640	0.04733077926	**-268.6967181812**	-0.0124714240
47	3.27348659581	0.04884416175	**-268.7830434764**	-0.0007753050
65	3.27326731739	0.04874772389	**-268.7888772072**	0.0000532778
79	3.28014793070	0.04559708770	**-268.7905782967**	0.0005596130

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Example 4 (to minimize weight of spring-coil)
Task formulation

$$f(\boldsymbol{x}) = (2 + x_3)x_1^2 x_2 \rightarrow \min$$

$$g_1(\boldsymbol{x}) = 1 - x_2^3 x_3 / (71785 x_1^4) \le 0$$

$$g_2(\boldsymbol{x}) = \frac{4x_2^2 - x_1 x_2}{12566(x_2 x_1^3 - x_1^4)} + \frac{1}{5108 x_1^2} - 1 \le 0$$

$$g_3(\boldsymbol{x}) = 1 - 140.45 x_1 / (x_2^2 x_3) \le 0$$

$$g_4(\boldsymbol{x}) = (x_1 + x_2)/1.5 - 1 \le 0$$

$$0.05 \le x_1 \le 2.00$$

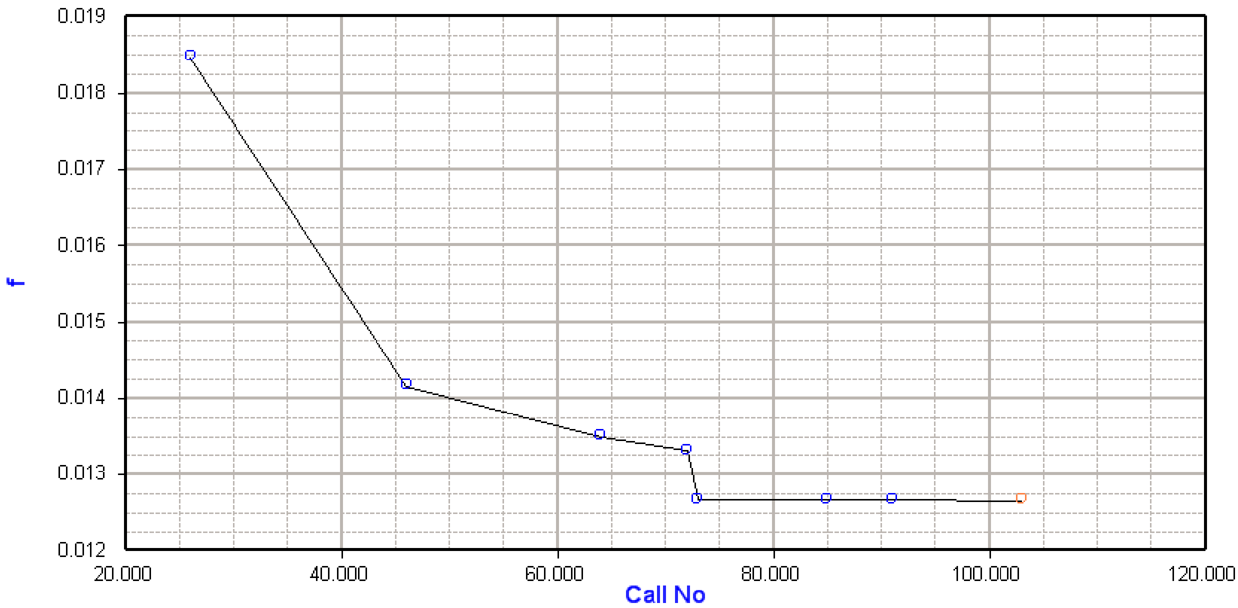
$$0.25 \le x_2 \le 1.30$$

$$2.00 \le x_3 \le 15.0$$

esign Variables	Best solutions found				
	Arora[18]	Coello[19]	Ray[20]	Hu[21]	Kitavama
x_1 (d)	0.053396	0.051480	0.050417	0.051466	0.052062
x_2 (D)	0.399180	0.351661	0.321532	0.351384	0.337205
x_3 (N)	9.185400	11.632201	13.979915	11.608659	13.831074
$g_1(\boldsymbol{x})$	0.000019	-0.002080	-0.001926	-0.003336	-0.005994
$g_2(\boldsymbol{x})$	-0.000018	-0.000110	-0.012944	-0.000110	-0.062925
$g_3(\boldsymbol{x})$	-4.123832	-4.026318	-3.899430	-4.026318	-3.649392
$g_4(\boldsymbol{x})$	-0.698283	-0.731239	-0.752034	-0.731324	-0.740489
$f(\boldsymbol{x})$	0.012730	0.012705	0.013060	0.012667	0.014469

Table 1 Comparison of the results
Various results are presented by various scientists
for comparison (the result found by Hu is the best one)

Result given by IOSO
IOSO easily found the global solution that is the same as given by Hu



Call No	x1	x2	x3	f	g1	g2	g3	g4
26	0.05545031114	0.42362591485	12.1742401773	**0.0184624904**	-0.3637657221	-0.0560678289	-2.5646658541	-0.6806158493
46	0.05264297361	0.37952493235	11.4563264001	**0.0141529721**	-0.1359807090	-0.0012372632	-3.4805997979	-0.7118880627
64	0.05294741587	0.37312485803	10.8986665787	**0.0134923792**	-0.0035133066	-0.0307535768	-3.9010008695	-0.7159518174
72	0.05251494095	0.36905011347	11.0765674546	**0.0133089828**	-0.0197553573	-0.0169347765	-3.8890979932	-0.7189566304
73	0.05192265757	0.36235264488	10.9663050588	**0.0126666420**	0.0000154887	-0.0000241923	-4.0647202528	-0.7238164650
85	0.05188602539	0.36147451989	11.0153413364	**0.0126658418**	0.0000098827	-0.0000004052	-4.0631268582	-0.7244263031
91	0.05186879327	0.36105662636	11.0389265150	**0.0126657073**	0.0000126174	-0.0000009269	-4.0623294574	-0.7247163869
103	0.05168725514	0.35665702794	11.2876222767	**0.0126609123**	0.0004897689	-0.0000389472	-4.0559313987	-0.7277704779