Benchmark Suite for Classic Test Problems

This benchmark suite consists of the most commonly used test problems for testing and validating the performance of metaheuristic search algorithms. In this benchmark suite, there are thirty test problems whose problem size can be changed dynamically. This benchmark suite was used to develop SOTA algorithms in the literature and to compare their performance. Here are a few SOTA algorithms that demonstrate competitive search performance tested in this benchmarking suite.

You can use the links given below to download the source codes of the algorithms.

1. Kahraman, Hamdi Tolga; ARAS, Sefa; GEDIKLI, Eyüp. Fitness-distance balance (FDB): a new selection method for meta-heuristic search algorithms. *Knowledge-Based Systems*, 2020, 190: 105169.

https://se.mathworks.com/matlabcentral/fileexchange/72311-fdb-sos?s_tid=srchtitle

2. Guvenc, U., Duman, S., Kahraman, H. T., Aras, S., & Katı, M. (2021). Fitness–Distance Balance based adaptive guided differential evolution algorithm for security-constrained optimal power flow problem incorporating renewable energy sources. *Applied Soft Computing*, *108*, 107421.

https://se.mathworks.com/matlabcentral/fileexchange/90601-fdb-agde?s_tid=srchtitle

3. Duman, S., Kahraman, H. T., Guvenc, U., & Aras, S. (2021). Development of a Lévy flight and FDB-based coyote optimization algorithm for global optimization and real-world ACOPF problems. *Soft Computing*, *25*(8), 6577-6617.

https://se.mathworks.com/matlabcentral/fileexchange/87864-lrfdb-coa?s_tid=srchtitle

4. Aras, S., Gedikli, E., & Kahraman, H. T. (2021). A novel stochastic fractal search algorithm with fitness-Distance balance for global numerical optimization. *Swarm and Evolutionary Computation*, *61*, 100821.

https://se.mathworks.com/matlabcentral/fileexchange/84405-fdb-sfs?s_tid=srchtitle

5. Duman, S., Kahraman, H. T., Sonmez, Y., Guvenc, U., Kati, M., & Aras, S. (2022). A powerful meta-heuristic search algorithm for solving global optimization and real-world solar photovoltaic parameter estimation problems. *Engineering Applications of Artificial Intelligence*, *111*, 104763.

https://se.mathworks.com/matlabcentral/fileexchange/106920-fdb-tlabc-a-powerful-meta-heuristic-optimization-algorithm?s_tid=srchtitle

6. Sonmez, Y., Duman, S., Kahraman, H. T., Kati, M., Aras, S., & Guvenc, U. (2022). Fitness-distance balance based artificial ecosystem optimisation to solve transient stability constrained optimal power flow problem. *Journal of Experimental & Theoretical Artificial Intelligence*, 1-40.

https://se.mathworks.com/matlabcentral/fileexchange/115785-fdb-aeo?s_tid=srchtitle

7. Kahraman, H. T., Bakir, H., Duman, S., Katı, M., Aras, S., & Guvenc, U. (2022). Dynamic FDB selection method and its application: modeling and optimizing of directional overcurrent relays coordination. *Applied Intelligence*, *52*(5), 4873-4908.

https://se.mathworks.com/matlabcentral/fileexchange/96113-dfdb-mrfo-a-powerful-meta-heuristic-optimization-algorithm?s_tid=srchtitle

Classical test problems.

Name	Function	Type	Range	Min
Ackley	$f_1(x) = 20 - 20exp\left(-0.2\sqrt{\frac{\sum_{i=1}^{D} x_i^2}{D}}\right) - exp\left(\frac{\sum_{i=1}^{D}\cos(2\pi x_i)}{D}\right) + e$	M	$[-100, 100]$	0
Alpine	$f_2(x) = \sum_{i=1}^{D} \mid x_i \sin(x_i) + 0.1x_i \mid$	M	$[-100, 100]$	0
Cigar	$f_3(x) = x_1^2 + 10^6 \sum_{i=2}^{D} x_i^2$	U	$[-100, 100]$	0
DixonPrice	$f_4(x) = (x_1 - 1)^2 + \sum_{i=2}^{D} i(2x_i^2 - x_{i-1})^2$	U	$[-10, 10]$	0
Elliptic	$f_5(x) = \sum_{i=1}^{D}\left((10^6)^{\frac{i-1}{D-1}} x_i^2\right)$	U	$[-100, 100]$	0
Exponential	$f_6(x) = exp\left(0.5 \sum_{i=1}^{D} x_i^2\right)$	M	$[-10, 10]$	0
Griewank	$f_7(x) = 1 + \frac{\sum_{i=1}^{D} x_i^2}{4000} - \prod_{i=1}^{D} \cos\left(\frac{x_i}{\sqrt{i}}\right)$	M	$[-600, 600]$	0
I.C.M.[a]	$f_8(x) = \frac{D}{10} - \left(\frac{\sum_{i=1}^{D}\cos(5\pi x_i)}{10} - \sum_{i=1}^{D} x_i^2\right)$	M	$[-100, 100]$	0
Levy	$f_9(x) = \sin^2(3\pi x_1) + \mid x_D - 1 \mid$ $*(1 + \sin^2(3\pi x_D)) + \sum_{i=1}^{D-1}[(x_i - 1)^2(1 + \sin^2(3\pi x_{i+1}))]$	M	$[-10, 10]$	0
Michalewicz	$f_{10}(x) = D - \sum_{i=1}^{D} \sin(x_i)\sin^{20}\left(\frac{ix_i^2}{\pi}\right)$	M	$[0, \pi]$	0
Penalized-1	$f_{11}(x) = \frac{\pi}{D}\left[10\sin^2(\pi y_1) + \sum_{i=1}^{D-1}[(y_i - 1)^2(1 + 10\sin^2(\pi y_{i+1}))] + \right.$ $\left.(y_D - 1)^2\right] + \sum_{i=1}^{D} u(x_i, 10, 100, 4)$ $y_i(x_i) = 1 + \frac{x_i + 1}{4}$ $u_i(x_i, a, k, m) = \begin{cases} k(x_i - a)^m & x_i > 0 \\ 0 & a \geq x_i \geq -a \\ k(-x_i - a)^m & -a > x_i \end{cases}$	M	$[-50, 50]$	0
Penalized-2	$f_{12}(x) = 0.1\left[\sin^2(3\pi x_1) + \sum_{i=1}^{D}[(x_i - 1)^2(1 + \sin^2(3\pi x_i + 1))] + \right.$ $\left.(x_D - 1)^2(1 + sin^2(2\pi x_D))\right] + \sum_{i=1}^{D} u(x_i, 5, 100, 4)$ $u_i(x_i, a, k, m) = \begin{cases} k(x_i - a)^m & x_i > 0 \\ 0 & a \geq x_i \geq -a \\ k(-x_i - a)^m & -a > x_i \end{cases}$	M	$[-50, 50]$	0

| Penalized-2 | $f_{12}(x) = 0.1\left[\sin^2(3\pi x_1) + \sum_{i=1}^{D}[(x_i - 1)^2(1 + \sin^2(3\pi x_i + 1))] + \right.$
$\left.(x_D - 1)^2(1 + sin^2(2\pi x_D))\right] + \sum_{i=1}^{D} u(x_i, 5, 100, 4)$
$u_i(x_i, a, k, m) = \begin{cases} k(x_i - a)^m & x_i > 0 \\ 0 & a \geq x_i \geq -a \\ k(-x_i - a)^m & -a > x_i \end{cases}$ | M | $[-50, 50]$ | 0 |

Name	Function	Type	Range	Min
Powell	$f_{13}(x) = \sum_{i=1}^{D/4}[(x_{4i-3} - 10x_{4i-2})^2 + 5(x_{4i-1} - x_{4i})^2 + (x_{4i-2} -$ $x_{4i-1})^4 + 10(x_{4i-3} - x_{4i})^2]$	U	$[-4, 5]$	0
Rastrigin	$f_{14}(x) = 10D + \sum_{i=1}^{D} x_i^2 - 10\cos(2\pi x_i)$	M	$[-100, 100]$	0
Rosenbrock	$f_{15}(x) = \sum_{i=1}^{D-1} 100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2$	M	$[-10, 10]$	0
R.H.E. [b]	$f_{16}(x) = \sum_{i=1}^{D}\left(\sum_{j=1}^{i} x_j\right)^2$	U	$[-100, 100]$	0
Salomon	$f_{17}(x) = 1 - \cos\left(2\pi\sqrt{\sum_{i=1}^{D} x_i^2}\right) + 0.1\sqrt{\sum_{i=1}^{D} x_i^2}$	M	$[-100, 100]$	0
Schaffer	$f_{18}(x) = 0.5 + \frac{\sin^2(\sum_{i=1}^{D} x_i^2) - 0.5}{(1 + 0.001\sum_{i=1}^{D} x_i^2)^2}$	M	$[-100, 100]$	0
Schwefel	$f_{19}(x) = 418.982887272434 * D - \sum_{i=1}^{D} x_i \sin(\sqrt{\mid x_i \mid})$	U	$[-500, 500]$	0
Schwefel 1.20	$f_{20}(x) = \sum_{i=1}^{D} \mid x_i \mid$	U	$[-100, 100]$	0
Schwefel 2.21	$f_{21}(x) = \max_{i=1,\dots,D} \mid x_i \mid$	U	$[-100, 100]$	0
Schwefel 2.22	$f_{22}(x) = \sum_{i=1}^{D} \mid x_i \mid + \prod_{i=1}^{D} \mid x_i \mid$	U	$[-10, 10]$	0
Sphere	$f_{23}(x) = \sum_{i=1}^{D} x_i^2$	U	$[-100, 100]$	0
Step	$f_{24}(x) = \sum_{i=1}^{D}(x_i + 0.5)^2$	U	$[-100, 100]$	0
Styblinski–Tang	$f_{25}(x) = 39.1661657037714 * D + 0.5\sum_{i=1}^{D} x_i^4 - 16x_i^2 + 5x_i$	M	$[-5, 5]$	0
SumPower	$f_{26}(x) = \sum_{i=1}^{D} \mid x_i \mid^{i+1}$	M	$[-10, 10]$	0
SumSquares	$f_{27}(x) = \sum_{i=1}^{D} ix_i^2$	U	$[-10, 10]$	0
Quartic	$f_{28}(x) = \sum_{i=1}^{D} ix_i^4$	U	$[-10, 10]$	0

Weierstrass	$f_{29}(x) = \sum_{i=1}^{D}\left[\sum_{j=0}^{k} 0.5^j \cos\left(2\pi\, 3^j (x_i + 0.5)\right)\right] - D\sum_{j=0}^{k} 0.5^j \cos(\pi\, 3^j)$ $k = \begin{cases} 20 & D \geq 20 \\ D & D < 20 \end{cases}$	M	[−1, 1]	0
Zakharov	$f_{30}(x) = \sum_{i=1}^{D} x_i^2 + \left(\sum_{i=1}^{D} 0.5 i x_i\right)^2 + \left(\sum_{i=1}^{D} 0.5 i x_i\right)^4$	M	[−5, 10]	0

M: Multimodal U: Unimodal.

[a] Inverted cosine mixture.

[b] Rotated hyper ellipsoid.