

Novel Optimization Algorithm Based on the Social Aspects of Opinion Formation

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1 Benchmark Functions

Function	Dim (d)	Range	f_{min}
$f_1(x) = \sum_{i=1}^d x_i^2$	30	[-100,100]	0
$f_2(x) = \sum_{i=1}^d x_i + \prod_{i=1}^d x_i $	30	[-10,10]	0
$f_3(x) = \sum_{i=1}^d (\sum_{j=i}^d x_j)^2$	30	[-100,100]	0
$f_4(x) = \max_i \{ x_i , 1 \leq i \leq d\}$	30	[-100,100]	0
$f_5(x) = \sum_{i=1}^{d-1} [100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2]$	30	[-30,30]	0
$f_6(x) = \sum_{i=1}^d ([x_i + 0.5])^2$	30	[-100,100]	0
$f_7(x) = \sum_{i=1}^d ix_i^4 + random[0, 1)$	30	[-1.28,1.28]	0

Table 1: Unimodal benchmark functions

Function	Dim (d)	Range	f_{min}
$f_8(x) = \sum_{i=1}^d -x_i \sin \sqrt{ x_i }$	30	[-500,500]	-12569.5
$f_9(x) = \sum_{i=1}^d [x_i^2 - 10 \cos(2\pi x_i) + 10]$	30	[-5.12,5.12]	0
$f_{10}(x) = -20 \exp(-0.2 \sqrt{\frac{1}{d} \sum_{i=1}^d x_i^2}) - \exp(\frac{1}{d} \sum_{i=1}^d \cos(2\pi x_i)) + 20 + e$	30	[-32,32]	0
$f_{11}(x) = \frac{1}{4000} \sum_{i=1}^d x_i^2 - \prod_{i=1}^d \cos(\frac{x_i}{\sqrt{i}}) + 1$	30	[-600,600]	0
$f_{12}(x) = \frac{\pi}{d} \{10 \sin^2(\pi \mathbf{y}_i) + \sum_{i=1}^{d-1} (\mathbf{y}_i - 1)^2 [1 + 10 \sin^2(\pi \mathbf{y}_{i+1}) + (\mathbf{y}_n - 1)^2]\} + \sum_{i=1}^d \mathbf{u}(x_i, 10, 100, 4)$	30	[-50,50]	0
$f_{13}(x) = 0.1 \{ \sin^2(3\pi x_i) + \sum_{i=1}^d (x_i - 1)^2 [1 + \sin^2(3\pi x_i + 1)] + (\mathbf{x}_n - 1)^2 [1 + \sin^2(2\pi \mathbf{x}_n)] \} + \sum_{i=1}^d \mathbf{u}(x_i, 5, 100, 4)$	30	[-50,50]	0

Table 2: Multimodal benchmark functions

Function	Dim (d)	Range	f_{min}
$f_{14}(x) = (\frac{1}{500} + \sum_{j=1}^{25} \frac{1}{j + \sum_{i=1}^2 (x_i - a_{ij})^6})^{-1}$	2	[-65.536,65.536]	≈ 1
$f_{15}(x) = \sum_{i=1}^{11} [a_i - \frac{x_1(b_i^2 + b_i x_2)}{b_i^2 + b_i x_3 + x_4}]^2$	4	[-5,5]	≈ 0.0003075
$f_{16}(x) = 4x_1^2 - 2.1x_1^4 + \frac{1}{3}x_i^6 + x_1x_2 - 4x_2^2 + 4x_2^4$	2	[-5,5]	-1.0316285
$f_{17}(x) = (x_2 - \frac{5.1}{4\pi^2}x_1^2 + \frac{5}{\pi}x_1 - 6)^2 + 10(1 - \frac{1}{8\pi})\cos(x_1) + 10$	2	[-5,5]	≈ 0.398
$f_{18}(x) = [1 + (x_1 + x_2 + 1)^2(19 - 14x_1 + 3x_1^2 - 14x_2 + 6x_1x_2 + 3x_2^2)] \times [30 + (2x_1 - 3x_2)^2 \times (18 - 32x_1 + 12x_1^2 + 48x_2 - 36x_1x_2 + 27x_2^2)]$	2	[-2,2]	3
$f_{19}(x) = -\sum_{i=1}^4 c_i \exp[-\sum_{j=1}^3 a_{ij}(x_j - p_{ij})^2]$	3	[0,1]	-3.86278
$f_{20}(x) = -\sum_{i=1}^4 c_i \exp[-\sum_{j=1}^6 a_{ij}(x_j - p_{ij})^2]$	6	[0,1]	-3.32237

Table 3: Fixed-dimension multimodal benchmark functions

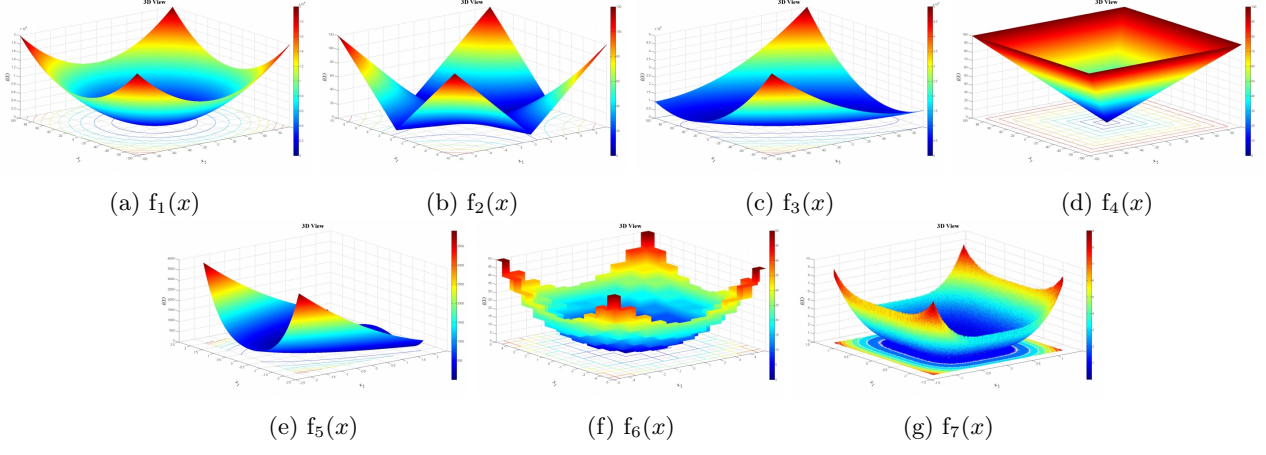


Figure 1: Unimodal benchmark functions 3D plot

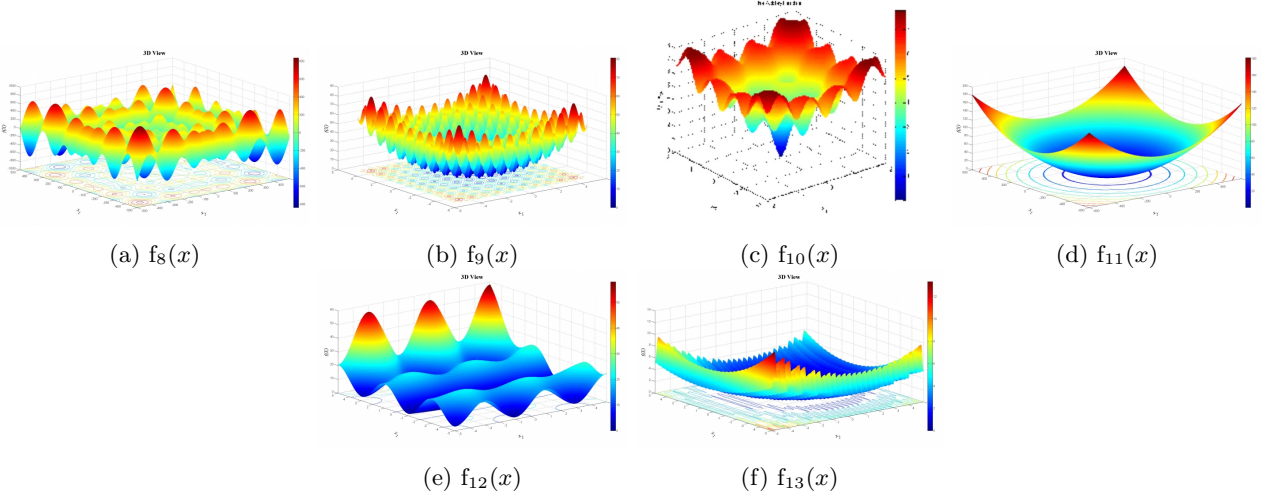


Figure 2: Multimodal benchmark functions 3D plot

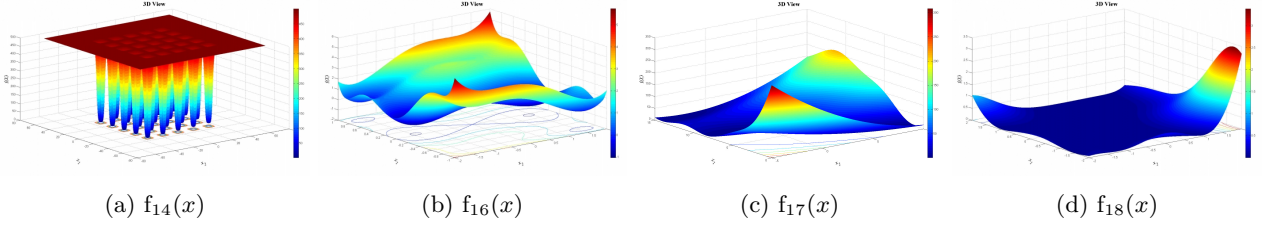


Figure 3: Fixed-size multimodal benchmark functions 3D plot

2 Algorithms Parameters

2.1 Willian

- Population size: 20
- Max number of iterations: 500

2.2 Grey Wolf Optimizer (GWO)

- Population size: 20

- Max number of iterations: 500

2.3 Particle Swarm Optimization (PSO)

- Population size: 20
- Max number of iterations: 500
- Vmax: 6
- wMax: 0.9
- wMin: 0.2
- c1: 2
- c2: 2

3 Results

F	Willian			GWO			PSO		
	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
f_1	2.74E-57	0	$2.00E-58$	$1.30E-23$	$2.08E-30$	$3.48E-22$	0.037	0.005	0.167
f_2	1.91E-25	0	$5.75E-24$	$6.89E-14$	$1.77E-19$	$2.05E-12$	6.608	0.130	30.103
f_3	0	0	$2.88E-45$	$3.53E-14$	$5.06E-25$	$1.06E-12$	218.6	119.2	510.9
f_4	3.27E-18	$1.93E-21$	$9.17E-17$	$1.75E-10$	$8.07E-14$	$3.20E-9$	1.701	1.286	2.486
f_5	1.88	0.003	28.9	2.88	2.81	2.90	3232.3	34.1	90135.2
f_6	0.009	0.000005	0.25	5.64	4.56	6.80	0.025	0.003	0.208
f_7	0.092	0.0006	0.70	0.0019	0.00002	0.008	5.519	0.085	24.357

* values 0 have at least 70 decimal places precision.

Table 4: Unimodal benchmark functions results

F	Willian			GWO			PSO		
	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
f_8	-5613	-7233	-4403	-2510	-3840	-1920	-4732	-8481	-2654
f_9	<u>0</u>	0	0	<u>0</u>	0	0	134.9	73.1	184.9
f_{10}	4.44E-16	$4.44E-16$	$4.44E-16$	$4.38E-14$	$3.99E-15$	$2.66E-13$	0.75	0.04	2.05
f_{11}	<u>0</u>	0	0	<u>0</u>	0	0	0.01	0.0002	0.03
f_{12}	0.19	0.08	0.27	1.09	0.79	1.48	0.37	0.0002	2.19
f_{13}	0.0009	0.00007	0.006	2.63	2.30	2.75	0.02	0.0006	0.11

* values 0 have at least 70 decimal places precision.

Table 5: Multimodal benchmark functions results

F	Willian			GWO			PSO		
	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
f_{14}	4.38	0.99	12.6	6.98	0.99	12.6	4.08	0.99	16.4
f_{15}	0.0003244	0.0003079	0.0004262	0.0217	0.00464	0.0847	0.0448	0.00436	0.1010
f_{16}	<u>-1.0316</u>	-1.0316	-1.0303	<u>-1.0316</u>	-1.03	-1.01	<u>-1.0316</u>	-1.0316	-1.0316
f_{17}	<u>0.398</u>	0.398	0.398	0.542	0.401	1.90	<u>0.398</u>	0.398	0.398
f_{18}	9.24	3.00	30.11	6.78	3.00	84.1	2.99	2.99	2.99
f_{19}	-3.772	-3.862	-3.089	-3.69	-3.86	-3.03	-3.86041	-3.86041	-3.86041
f_{20}	-3.263	-3.32	-2.78	-2.32	-2.96	-1.3	-3.162	-3.321	-2.638

* values 0 have at least 70 decimal places precision.

Table 6: Fixed-dimension benchmark functions results

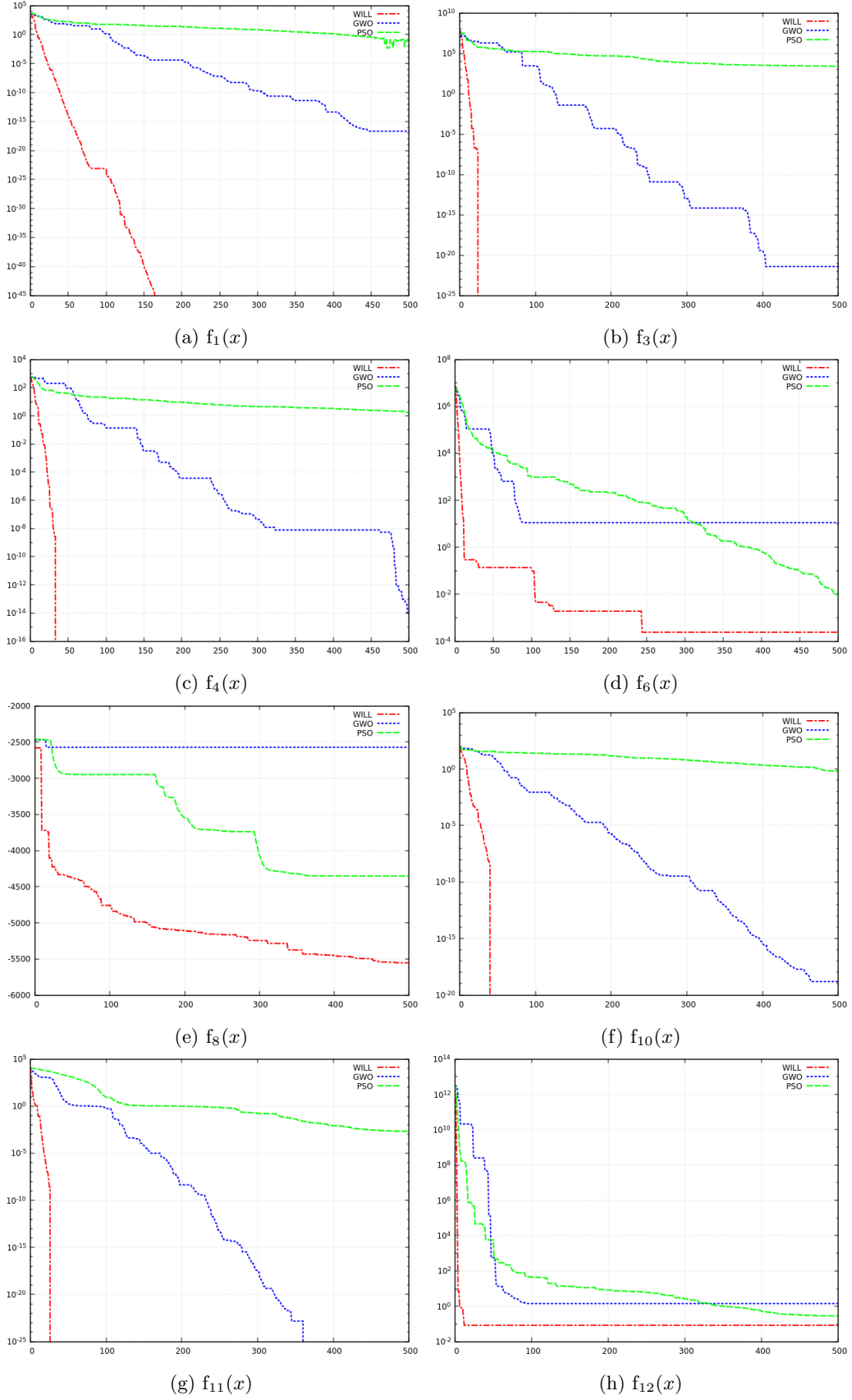


Figure 4: Comparison of the solution progress for eight of the benchmark functions.

References

- [1] Mehdi Moussaïd, Juliane E. Kämmer, Pantelis P. Analytis, and Hansjörg Neth. Social influence and the collective dynamics of opinion formation. *PLOS ONE*, 8(11):1–8, 11 2013.
- [2] Xin Yao, Yong Liu, and Guangming Lin. Evolutionary programming made faster. *Trans. Evol. Comp*, 3(2):82–102, July 1999.
- [3] Seyedali Mirjalili, Seyed Mohammad Mirjalili, and Andrew Lewis. Grey wolf optimizer. *Advances in Engineering Software*, 69:46 – 61, 2014.