Novel Optimization Algorithm Based on the Social Aspects of Opinion Formation

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1 Benchmark Functions

Function	**Dim (d)**	**Range**	$\mathbf{f}_{min}$
$f_1(x) = \sum_{i=1}^{d} x_i^2$	30	[-100,100]	0
$f_2(x) = \sum_{i=1}^{d} \lvert x_i \rvert + \prod_{i=1}^{d} \lvert x_i \rvert$	30	[-10,10]	0
$f_3(x) = \sum_{i=1}^{d} (\sum_{j=i}^{i} x_j)^2$	30	[-100,100]	0
$f_4(x) = \mathbf{max}_i\{\lvert x_i \rvert, 1 \leq i \leq d\}$	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
$f_7(x) = \sum_{i=1}^{d} i x_i^4 + random[0,1)$	30	[-1.28,1.28]	0

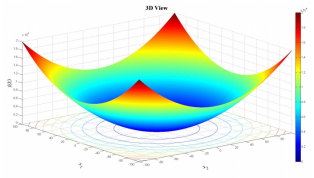
Table 1: Unimodal benchmark functions

Function	**Dim (d)**	**Range**	$\mathbf{f}_{min}$
$f_8(x) = \sum_{i=1}^{d} -x_i \sin \sqrt{\lvert x_i \rvert}$	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
$f_{12}(x) = \frac{\pi}{d}\{10\sin^2(\pi \mathbf{y}_i) + \sum_{i=1}^{d-1}(\mathbf{y}_i - 1)^2[1 + 10\sin^2(\pi \mathbf{y}_{i+1})] + (y_n - 1)^2\} + \sum_{i=1}^{d} \mathbf{u}(x_i, 10, 100, 4)$	30	[-50,50]	0
$f_{13}(x) = 0.1\{\sin^2(3\pi x_i) + \sum_{i=1}^{d}(x_i - 1)^2[1 + \sin^2(3\pi x_i + 1)] + (x_n - 1)^2[1 + \sin^2(2\pi x_n)]\} + \sum_{i=1}^{d} \mathbf{u}(x_i, 5, 100, 4)$	30	[-50,50]	0

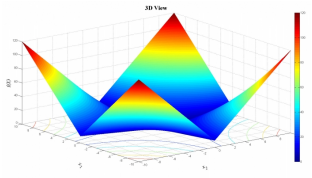
Table 2: Multimodal benchmark functions

Function	**Dim (d)**	**Range**	$\mathbf{f}_{min}$
$f_{14}(x) = (\frac{1}{500} + \sum_{j=1}^{25} \frac{1}{j + \sum_{i=1}^{2}(x_i - a_{ij})^6})^{-1}$	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

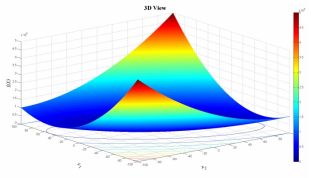
Table 3: Fixed-dimension multimodal benchmark functions



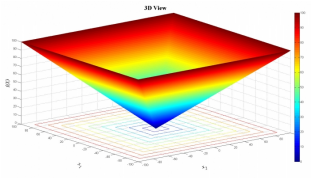
(a) $f_1(x)$



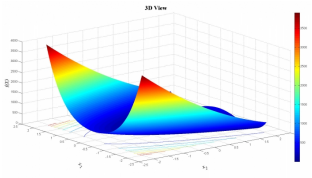
(b) $f_2(x)$



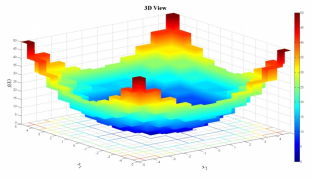
(c) $f_3(x)$



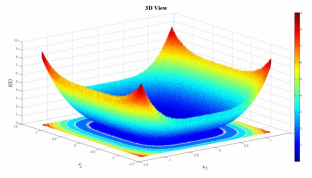
(d) $f_4(x)$



(e) $f_5(x)$

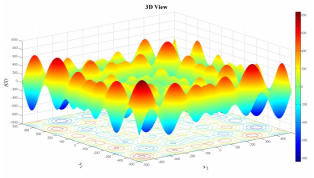


(f) $f_6(x)$

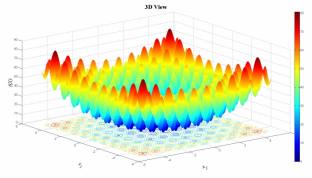


(g) $f_7(x)$

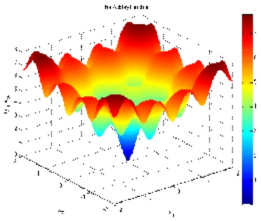
Figure 1: Unimodal benchmark functions 3D plot



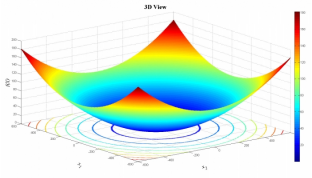
(a) $f_8(x)$



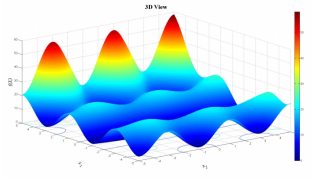
(b) $f_9(x)$



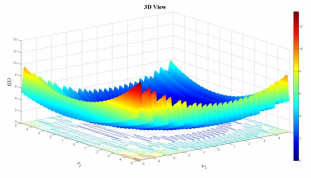
(c) $f_{10}(x)$



(d) $f_{11}(x)$

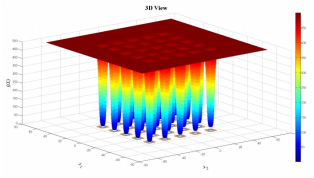


(e) $f_{12}(x)$

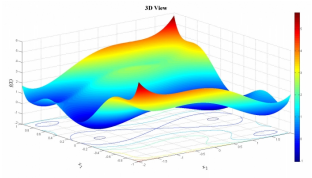


(f) $f_{13}(x)$

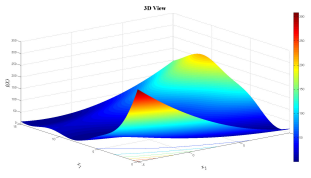
Figure 2: Multimodal benchmark functions 3D plot



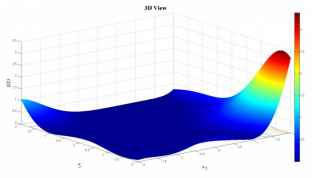
(a) $f_{14}(x)$



(b) $f_{16}(x)$



(c) $f_{17}(x)$



(d) $f_{18}(x)$

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	**1.74E − 51**	**0**	$2.00E-50$	$1.30E{-}23$	$2.08E{-}30$	$3.48E{-}22$	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	$\underline{0}$	0	0	$\underline{0}$	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}	$\underline{0}$	0	0	$\underline{0}$	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

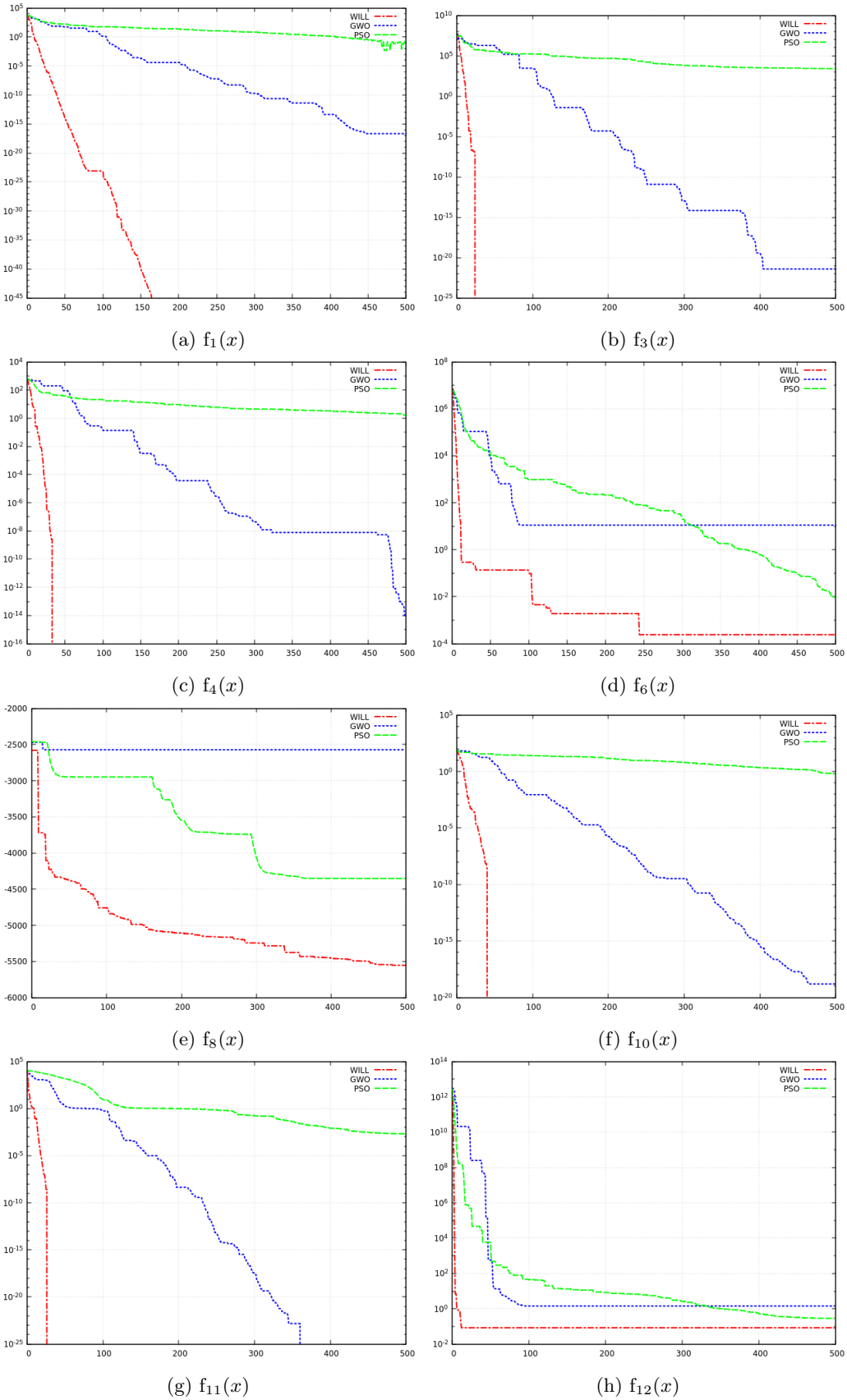
* values 0 have at least 70 decimal places precision.

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}	$\underline{-1.0316}$	-1.0316	-1.0303	$\underline{-1.0316}$	-1.03	-1.01	$\underline{-1.0316}$	-1.0316	-1.0316
f_{17}	$\underline{0.398}$	0.398	0.398	0.542	0.401	1.90	$\underline{0.398}$	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	$\mathbf{-3.86041}$	$\mathbf{-3.86041}$	-3.86041
f_{20}	$\mathbf{-3.263}$	$\mathbf{-3.32}$	-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



(a) $f_1(x)$ (b) $f_3(x)$

(c) $f_4(x)$ (d) $f_6(x)$

(e) $f_8(x)$ (f) $f_{10}(x)$

(g) $f_{11}(x)$ (h) $f_{12}(x)$

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.

[4] James Kennedy and Russell C. Eberhart. Particle swarm optimization. In *Proceedings of the 1995 IEEE International Conference on Neural Networks*, volume 4, pages 1942–1948, Perth, Australia, IEEE Service Center, Piscataway, NJ, 1995.