TABLE I: Description of unimodal benchmark functions.

Function	V_no	Range	$f_{\min}$
$F_1(x) = \sum_{i=1}^{n} x_i^2$	30	[−100,100]	0
$F_2(x) = \sum_{i=1}^{n} \lvert x_i \rvert + \prod_{i=1}^{n} \lvert x_i \rvert$	30	[−10,10]	0
$F_3(x) = \sum_{i=1}^{n} \left(\sum_{j-1}^{i} x_j \right)^2$	30	[−100,100]	0
$F_4(x) = \max_i \{ \lvert x_i \rvert, 1 \le i \le n \}$	30	[−100,100]	0
$F_5(x) = \sum_{i=1}^{n-1} \left[100 \left(x_{i+1} - x_i^2 \right)^2 + (x_i - 1)^2 \right]$	30	[−30,30]	0
$F_6(x) = \sum_{i=1}^{n} (\lvert x_i + 0.5 \rvert)^2$	30	[−100,100]	0
$F_7(x) = \sum_{i=1}^{n} i x_i^4 + random[0,1)$	30	[−128,128]	0

TABLE II: Description of multimodal benchmark functions.

Function	V_no	Range	$f_{\min}$
$F_8(x) = \sum_{i=1}^{n} -x_i \sin\left(\sqrt{\lvert x_i \rvert} \right)$	30	[−500,500]	−418.9829 × 5
$F_9(x) = \sum_{i=1}^{n} \left[x_i^2 - 10\cos(2\pi x_i) + 10 \right]$	30	[−5.12,5.12]	0
$F_{10}(x) = -20\exp(-0.2\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2}) - \exp\left(\frac{1}{n}\sum_{i=1}^{n} cos(2\pi x_i)\right) + 20 + e$	30	[−32,32]	0
$F_{11}(x) = \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n} \cos\left(\frac{x_i}{\sqrt{i}}\right) + 1$	30	[−600,600]	
$F_{12}(x) = \frac{\pi}{n}\left\{ 10\sin(\pi y_1) + \sum_{i=1}^{n-1}(y_i - 1)^2 \left[1 + 10\sin^2(\pi y_{i+1})\right] + (y_n - 1)^2 \right\} + \sum_{i=1}^{n} u(x_i, 10, 100, 4)$ $y_i = 1 + \frac{x_i + 1}{4}$ $u(x_i, a, k, m) = \begin{cases} k(x_i - a)^m & x_i > a \\ 0 - a & < x_i < a \\ k(-x_i - a)^m & x_i < -a \end{cases}$	30	[−50,50]	0
$F_{13}(x) =$ $0.1\left\{ \sin^2(3\pi x_1) + \sum_{i=1}^{n} (x_i - 1)^2 \left[1 + \sin^2(3\pi x_i + 1)\right] + (x_n - 1)^2 \left[1 + \sin^2(2\pi x_n)\right] \right\} + \sum_{i=1}^{n} u(x_i, 5, 100, 4)$	30	[−50,50]	0

TABLE III: Description of fixed-dimenstion multimodal benchmark functions.

Function	V_no	Range	$f_{\min}$
$F_{14}(x) = \left(\frac{1}{500} + \sum_{j=1}^{25} \frac{1}{j + \sum_{i=1}^{2} (x_i - a_{ij})^6} \right)^{-1}$	2	$[-65, 65]$	1
$F_{15}(x) = \sum_{i=1}^{11} \left[a_i - \frac{x_1 (b_i^2 + b_i x_2)}{b_i^2 + b_i x_3 + x_4} \right]^2$	4	$[-5, 5]$	0.00030
$F_{16}(x) = 4x_1^2 - 2.1x_1^4 + \frac{1}{3}x_1^6 + x_1 x_2 - 4x_2^2 + 4x_2^4$	2	$[-5, 5]$	−1.0316
$F_{17}(x) = \left(x_2 - \frac{5.1}{4\pi^2} x_1^2 + \frac{5}{\pi} x_1 - 6 \right)^2 + 10\left(1 - \frac{1}{8\pi}\right)\cos x_1 + 10$	2	$[-5, 5]$	0.398
$F_{18}(x) = \left[1 + (x_1 + x_2 + 1)^2 \left(19 - 14x_1 + 3x_1^2 - 14x_2 + 6x_1 x_2 + 3x_2^2 \right) \right]$ $\times \left[30 + (2x_1 - 3x_2)^2 \times \left(18 - 32x_1 + 12x_1^2 + 48x_2 - 36x_1 x_2 + 27x_2^2 \right) \right]$	2	$[-2, 2]$	3
$F_{19}(x) = -\sum_{i=1}^{4} c_i \exp\left(-\sum_{j=1}^{3} a_{ij} (x_j - p_{ij})^2 \right)$	3	$[1, 3]$	−3.86
$F_{20}(x) = -\sum_{i=1}^{4} c_i \exp\left(-\sum_{j=1}^{6} a_{ij} (x_j - p_{ij})^2 \right)$	6	$[0, 1]$	−3.32
$F_{21}(x) = -\sum_{i=1}^{5} \left[(X - a_i)(X - a_i)^T + c_i \right]^{-1}$	4	$[0, 10]$	−10.1532
$F_{22}(x) = -\sum_{i=1}^{7} \left[(X - a_i)(X - a_i)^T + c_i \right]^{-1}$	4	$[0, 10]$	−10.4028
$F_{23}(x) = -\sum_{i=1}^{10} \left[(X - a_i)(X - a_i)^T + c_i \right]^{-1}$	4	[0.10]	−10.5363

TABLE IV: Description of composite benchmark functions.

Function	V_no	Range	$f_{\min}$
$F_{24}\,(CF1)$			
$f_{1,}, f_2, f_3, ..., f_{10}$ = Sphere Function $[\sigma_1, \sigma_2, \sigma_3, ..., \sigma_{10}] = [1, 1, 1, .., 1]$ $[\lambda_1, \lambda_2, \lambda_3, ..., \lambda_{10}] = [5/100, 5/100, 5/100, .., 5/100]$	30	$[-5, 5]$	0
$F_{25}\,(CF2)$			
$f_{1,}, f_2, f_3, ..., f_{10}$ = Griewank's Function $[\sigma_1, \sigma_2, \sigma_3, ..., \sigma_{10}] = [1, 1, 1, .., 1]$ $[\lambda_1, \lambda_2, \lambda_3, ..., \lambda_{10}] = [5/100, 5/100, 5/100, .., 5/100]$	30	$[-5, 5]$	0
$F_{26}\,(CF3)$			
$f_{1,}, f_2, f_3, ..., f_{10}$ = Griewank's Function $[\sigma_1, \sigma_2, \sigma_3, ..., \sigma_{10}] = [1, 1, 1, .., 1]$ $[\lambda_1, \lambda_2, \lambda_3, ..., \lambda_{10}] = [1, 1, 1, .., 1]$	30	$[-5, 5]$	0
$F_{27}\,(CF4)$			
f_1, f_2 = Ackley's Function, f_3, f_4 = Rastrigin's Function, f_5, f_6 =Weierstrass Function, f_7, f_8 = Griewank's Function,f_9, f_{10} = Sphere Function $[\sigma_1, \sigma_2, \sigma_3, ..., \sigma_{10}] = [1, 1, 1, .., 1]$ $[\lambda_1, \lambda_2, \lambda_3, ..., \lambda_{10}] = [5/32, 5/32, 1, 1, 5/0.5, 5/0.5, 5/100, 5/100, 5/100, 5/100]$	30	$[-5, 5]$	0
$F_{28}\,(CF5)$			
f_1, f_2 = Rastrigin's Function, f_3, f_4 = Weierstrass Function, f_5, f_6 = Griewank's Function, f_7, f_8 = Ackley's Function, f_9, f_{10} = Sphere Function $[\sigma_1, \sigma_2, \sigma_3, ..., \sigma_{10}] = [1, 1, 1, .., 1]$ $[\lambda_1, \lambda_2, \lambda_3, ..., \lambda_{10}] =$ $[1/5, 1/5, 5/0.5, 5/0.5, 5/100, 5/100, 5/32, 5/32, 5/100, 5/100]$	30	$[-5, 5]$	0
$F_{29}\,(CF6)$			
f_1, f_2 = Rastrigin's Function, f_3, f_4 = Weierstrass Function, f_5, f_6 = Griewank's Function, f_7, f_8 = Ackley's Function, f_9, f_{10} = Sphere Function $[\sigma_1, \sigma_2, \sigma_3, ..., \sigma_{10}] = [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1]$ $[\lambda_1, \lambda_2, \lambda_3, ..., \lambda_{10}] = [0.1 * 1/5, 0.2 * 1/5, 0.3 * 5/0.5, 0.4 * 5/0.5, 0.5 * 5/100,$ $0.6 * 5/100, 0.7 * 5/32, 0.8 * 5/32, 0.9 * 5/100, 1 * 5/100]$	30	$[-5, 5]$	0