TABLE I
ERROR VALUES OF THE ORIGINAL DE ALGORITHMS AND THEIR CORRESPONDING EIGENVECTOR-BASED VARIANTS OVER THE 30-DIMENSIONAL BBOB 2012 AND CEC 2013 BENCHMARK SETS

	DE/best/1/bin		DE/best/1/eig			DE/rand/1/bin		DE/rand/1/eig		
	Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.	
bf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	7.69E−06	2.63E−06	**5.92E−09**	8.19E−09	+
bf_3	**1.08E+02**	1.12E+01	1.28E+02	1.15E+01	−	**1.41E+02**	8.54E+00	1.52E+02	8.31E+00	=
bf_4	**8.57E+01**	1.71E+01	1.20E+02	1.59E+01	−	**1.53E+02**	5.50E+00	1.72E+02	1.55E+01	=
bf_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_6	1.26E+01	1.11E+01	**8.40E−03**	4.36E−03	+	4.13E+02	6.10E+01	**2.84E+01**	1.20E+01	+
bf_7	5.81E+00	2.14E+00	**2.80E−01**	2.65E−01	+	1.35E+02	1.83E+01	**3.77E−02**	8.98E−03	+
bf_8	1.47E+01	5.37E−01	**0.00E+00**	0.00E+00	+	2.43E+01	3.15E−01	**1.22E+01**	3.96E−01	+
bf_9	3.80E+01	2.97E+01	**1.06E−08**	1.62E−08	+	2.68E+01	2.14E−01	**1.50E+01**	4.53E−01	+
bf_{10}	5.24E+05	2.37E+05	**2.04E+02**	1.98E+02	+	1.71E+06	1.83E+05	**1.05E−04**	2.95E−05	+
bf_{11}	3.30E+02	3.18E+01	**0.00E+00**	0.00E+00	+	5.23E+02	7.92E+01	**2.12E−07**	6.23E−08	+
bf_{12}	1.85E+01	2.40E+01	**4.16E−04**	8.81E−04	+	1.04E+02	5.40E+01	**8.86E−02**	3.01E−02	+
bf_{13}	8.63E−01	9.56E−01	**1.65E−05**	1.75E−05	+	9.98E+00	5.29E+00	**1.59E−02**	2.41E−03	+
bf_{14}	7.65E−03	1.12E−03	**2.74E−05**	1.79E−05	+	6.17E−02	4.64E−03	**1.06E−06**	2.01E−07	+
bf_{15}	1.95E+02	5.12E+00	**1.90E+02**	1.52E+01	=	2.24E+02	1.30E+01	**2.09E+02**	1.98E+00	=
bf_{16}	2.79E+01	2.64E+00	**2.76E+01**	2.82E+00	=	**2.90E+01**	2.69E+00	2.98E+01	1.97E+00	=
bf_{17}	5.97E−03	3.98E−03	**1.33E−04**	4.60E−05	+	3.60E−01	1.27E−02	**1.26E−01**	2.89E−02	+
bf_{18}	3.78E−01	2.79E−01	**4.32E−02**	3.28E−02	+	3.14E+00	3.68E−01	**5.01E−01**	7.14E−02	+
bf_{19}	5.70E+00	1.18E−01	**5.41E+00**	2.55E−01	=	6.11E+00	3.53E−01	**5.81E+00**	2.57E−01	=
bf_{20}	**2.04E+00**	2.95E−01	2.07E+00	4.88E−01	=	**2.71E+00**	7.15E−02	2.79E+00	8.89E−02	=
bf_{21}	**5.48E+00**	3.93E+00	1.02E+01	3.02E+00	=	1.77E+01	4.53E+00	**6.04E+00**	2.86E+00	+
bf_{22}	2.11E+01	8.47E+00	**1.40E+01**	7.63E+00	=	1.83E+01	3.76E−07	1.83E+01	1.53E−11	+
bf_{23}	3.32E+00	2.82E−01	**2.97E+00**	3.43E−01	=	3.44E+00	4.05E−01	**3.33E+00**	5.31E−01	=
bf_{24}	2.30E+02	1.31E+01	**2.23E+02**	6.58E+00	=	2.55E+02	4.64E+00	**2.39E+02**	7.47E+00	+
cf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	5.99E−08	1.06E−08	**0.00E+00**	0.00E+00	+
cf_2	4.83E+07	1.85E+07	**1.42E+04**	1.39E+04	+	1.18E+08	1.95E+07	**6.92E−02**	1.76E−02	+
cf_3	4.47E+06	1.25E+07	**1.13E−02**	2.39E−02	+	4.90E+08	1.08E+08	**5.60E+07**	2.76E+07	+
cf_4	2.24E+04	2.74E+03	**0.00E+00**	0.00E+00	+	5.47E+04	6.84E+03	**1.30E−04**	5.50E−05	+
cf_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	7.01E−05	8.29E−06	**7.87E−07**	1.56E−07	+
cf_6	1.77E+01	4.60E+00	**5.28E+00**	1.11E+01	+	2.78E+01	2.36E+00	**3.73E+00**	5.56E−01	+
cf_7	2.39E+01	1.83E+01	**4.07E+00**	3.08E+00	+	5.36E+01	3.14E+00	**3.58E+01**	4.17E+00	+
cf_8	2.10E+01	5.47E−02	2.10E+01	4.22E−02	=	2.10E+01	2.70E−02	**2.09E+01**	2.51E−02	=
cf_9	3.64E+01	3.72E+00	**2.52E+01**	1.23E+01	+	**3.89E+01**	1.29E+00	3.99E+01	7.60E−01	=
cf_{10}	**8.13E−03**	4.79E−03	9.35E−03	1.17E−02	=	1.03E+02	2.60E+01	**1.38E−04**	1.17E−04	+
cf_{11}	**1.04E+02**	1.01E+01	1.25E+02	9.33E+00	−	**1.36E+02**	6.70E+00	1.46E+02	4.47E+00	−
cf_{12}	**1.90E+02**	9.78E+00	1.93E+02	6.83E+00	=	2.13E+02	1.16E+01	**2.02E+02**	1.32E+01	=
cf_{13}	1.92E+02	1.39E+01	**1.81E+02**	1.18E+01	=	2.11E+02	1.09E+01	**2.03E+02**	9.32E+00	=
cf_{14}	**3.79E+03**	5.74E+02	4.68E+03	2.55E+02	−	**4.76E+03**	2.35E+02	5.25E+03	2.80E+02	−
cf_{15}	**7.07E+03**	2.28E+02	7.10E+03	2.61E+02	=	**7.16E+03**	2.44E+02	7.25E+03	1.34E+02	=
cf_{16}	**2.49E+00**	3.52E−01	2.54E+00	1.85E−01	=	2.41E+00	2.12E−01	**2.39E+00**	1.83E−01	=
cf_{17}	**1.48E+02**	6.18E+00	1.68E+02	1.37E+01	−	**1.76E+02**	4.60E+00	1.83E+02	1.30E+01	=
cf_{18}	**2.21E+02**	8.73E+00	2.24E+02	1.22E+01	=	2.43E+02	9.00E+00	**2.29E+02**	1.01E+01	+
cf_{19}	**1.33E+01**	8.85E−01	1.40E+01	1.33E+00	=	**1.51E+01**	1.01E+00	1.61E+01	7.87E−01	−
cf_{20}	1.50E+01	1.80E−13	1.50E+01	0.00E+00	=	1.50E+01	5.72E−13	1.50E+01	0.00E+00	=
cf_{21}	3.33E+02	8.22E+01	**3.09E+02**	8.20E+01	=	**2.52E+02**	3.96E+01	3.42E+02	1.13E+02	=
cf_{22}	**3.98E+03**	4.31E+02	4.67E+03	3.80E+02	−	**5.23E+03**	2.04E+02	5.66E+03	2.34E+02	−
cf_{23}	7.33E+03	3.47E+02	**7.10E+03**	2.48E+02	=	**7.37E+03**	2.64E+02	7.38E+03	2.37E+02	=
cf_{24}	2.23E+02	1.79E+01	**2.12E+02**	1.57E+01	=	2.72E+02	5.30E+00	**2.39E+02**	4.58E+00	+
cf_{25}	2.53E+02	8.37E+00	**2.46E+02**	3.45E+00	=	3.07E+02	4.06E+00	**3.05E+02**	1.07E+01	=
cf_{26}	**2.41E+02**	6.18E+01	2.49E+02	6.43E+01	=	2.09E+02	1.86E+00	**2.00E+02**	2.41E−08	+
cf_{27}	8.54E+02	2.43E+02	**4.66E+02**	8.61E+01	+	1.27E+03	2.65E+01	**1.19E+03**	7.28E+01	+
cf_{28}	**4.05E+02**	3.32E+02	5.04E+02	4.31E+02	=	3.00E+02	4.33E−03	3.00E+02	1.57E−04	+
Total number of (+/=/−): 18/28/6						Total number of (+/=/−): 28/20/4				

TABLE II

ERROR VALUES OF THE ORIGINAL DE ALGORITHMS AND THEIR CORRESPONDING EIGENVECTOR-BASED VARIANTS OVER THE 50-DIMENSIONAL BBOB 2012, CEC 2013 BENCHMARK SETS, AND TWO REAL WORLD FUNCTIONS IN CEC 2011

	DE/best/1/bin		DE/best/1/eig			DE/rand/1/bin		DE/rand/1/eig		
	Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.	
bf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	5.03E–03	7.84E–04	**4.45E–04**	9.68E–05	+
bf_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	1.29E+00	1.87E–01	**8.66E–02**	1.22E–02	+
bf_3	**2.74E+02**	1.62E+01	3.04E+02	1.95E+01	–	**3.22E+02**	7.03E+00	3.38E+02	8.64E+00	–
bf_4	**2.75E+02**	2.49E+01	3.37E+02	2.01E+01	–	**3.67E+02**	1.10E+01	4.11E+02	1.94E+01	–
bf_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	**1.67E–06**	1.86E–07	3.25E–03	3.50E–04	–
bf_6	8.83E+01	1.92E+01	**1.96E+00**	6.69E–01	+	3.31E+02	3.60E+01	**1.08E+02**	6.41E+00	+
bf_7	1.99E+01	4.38E+00	**6.08E+00**	3.20E+00	+	1.94E+02	1.99E+01	**4.71E+00**	8.83E–01	+
bf_8	3.76E+01	1.72E+00	**9.37E+00**	1.13E+00	+	7.71E+01	4.19E+00	**4.87E+01**	6.54E–01	+
bf_9	4.60E+01	1.05E+00	**2.43E+01**	1.34E+00	+	1.07E+02	1.02E+01	**5.28E+01**	1.45E+00	+
bf_{10}	4.85E+05	9.84E+04	**7.11E+02**	2.98E+02	+	1.25E+06	7.01E+04	**1.88E+02**	3.30E+01	+
bf_{11}	1.34E+02	1.16E+01	**5.87E–08**	9.87E–08	+	2.58E+02	2.66E+01	**4.08E–01**	8.38E–02	+
bf_{12}	2.85E+00	3.42E+00	**3.86E–02**	6.54E–02	+	1.49E+04	3.44E+03	**2.92E+03**	5.11E+02	+
bf_{13}	1.54E+00	2.43E+00	**1.00E–03**	1.01E–03	+	1.42E+02	1.24E+01	**1.24E+01**	7.28E–01	+
bf_{14}	2.02E–02	2.58E–03	**3.60E–04**	8.36E–05	+	2.80E–01	5.17E–02	**1.46E–02**	2.18E–03	+
bf_{15}	4.07E+02	1.37E+01	**3.95E+02**	1.83E+01	=	4.48E+02	1.89E+01	**4.28E+02**	2.02E+01	+
bf_{16}	3.13E+01	1.68E+00	3.10E+01	1.40E+00	=	**3.07E+01**	2.47E+00	3.09E+01	1.79E+00	=
bf_{17}	7.09E–02	2.50E–02	**1.57E–02**	4.92E–03	+	1.40E+00	1.36E–01	**8.15E–01**	4.86E–02	+
bf_{18}	2.34E+00	7.79E–01	**8.80E–01**	4.73E–01	+	9.17E+00	5.64E–01	**3.34E+00**	3.33E–01	+
bf_{19}	7.01E+00	2.80E–01	**6.71E+00**	2.22E–01	+	7.60E+00	2.98E–01	**7.53E+00**	3.28E–01	=
bf_{20}	**2.67E+00**	3.04E–01	3.01E+00	9.30E–02	–	**3.24E+00**	6.85E–02	3.28E+00	5.18E–02	=
bf_{21}	**1.74E+00**	4.29E–01	1.81E+00	3.94E–01	=	1.94E+00	1.24E–04	1.94E+00	1.19E–05	+
bf_{22}	6.43E+00	8.09E+00	**4.51E+00**	6.07E+00	=	2.59E+00	1.62E–04	2.59E+00	1.83E–05	+
bf_{23}	**3.28E+00**	2.16E–01	3.42E+00	1.48E–01	=	**3.38E+00**	3.17E–01	3.42E+00	1.85E–01	=
bf_{24}	4.40E+02	3.17E+01	**4.28E+02**	2.09E+01	=	5.00E+02	2.11E+01	**4.90E+02**	1.96E+01	=
cf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	2.11E+00	2.39E–01	**2.04E–01**	3.54E–02	+
cf_2	2.05E+08	3.59E+07	**2.53E+05**	1.11E+05	+	4.90E+08	6.51E+07	**1.24E+05**	1.75E+04	+
cf_3	5.90E+09	3.47E+09	**2.46E+06**	3.01E+06	+	3.28E+10	2.54E+09	**2.23E+10**	1.41E+09	+
cf_4	5.50E+04	6.97E+03	**6.08E–06**	5.76E–06	+	9.81E+04	1.85E+04	**1.91E+02**	4.01E+01	+
cf_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	3.31E+00	2.42E–01	**4.98E–01**	8.51E–02	+
cf_6	4.51E+01	8.62E–01	**4.34E+01**	4.48E–13	+	4.92E+01	2.54E–01	**4.41E+01**	1.63E–01	+
cf_7	8.68E+01	1.23E+01	**3.03E+01**	1.85E+01	+	1.32E+02	4.04E+00	**1.10E+02**	5.65E+00	+
cf_8	2.11E+01	3.01E–02	2.11E+01	4.43E–02	=	2.11E+01	2.71E–02	2.11E+01	4.63E–02	=
cf_9	**6.94E+01**	3.05E+00	6.95E+01	2.64E+00	=	7.32E+01	1.03E+00	**7.24E+01**	1.36E+00	=
cf_{10}	2.54E+00	1.28E+00	**1.75E–02**	1.30E–02	+	1.30E+03	8.97E+01	**1.24E+00**	4.53E–02	+
cf_{11}	**2.82E+02**	1.89E+01	3.18E+02	1.09E+01	–	**3.38E+02**	1.32E+01	3.48E+02	2.20E+01	=
cf_{12}	**3.99E+02**	1.96E+01	4.00E+02	1.28E+01	=	4.66E+02	2.35E+01	**4.27E+02**	1.29E+01	+
cf_{13}	4.02E+02	1.44E+01	**3.87E+02**	1.35E+01	+	4.65E+02	1.26E+01	**4.30E+02**	1.25E+01	+
cf_{14}	**1.00E+04**	2.67E+02	1.07E+04	6.30E+02	–	**1.06E+04**	2.99E+02	1.11E+04	3.18E+02	–
cf_{15}	1.38E+04	4.79E+02	**1.35E+04**	6.65E+02	=	**1.38E+04**	5.51E+02	1.40E+04	7.09E+02	=
cf_{16}	**3.26E+00**	2.76E–01	3.35E+00	2.33E–01	=	3.31E+00	2.54E–01	**3.24E+00**	4.62E–01	=
cf_{17}	**3.59E+02**	1.39E+01	3.84E+02	1.77E+01	–	**4.10E+02**	7.90E+00	4.33E+02	1.48E+01	–
cf_{18}	4.59E+02	1.45E+01	**4.43E+02**	2.01E+01	+	5.08E+02	2.46E+01	**4.93E+02**	1.58E+01	+
cf_{19}	**3.10E+01**	1.51E+00	3.14E+01	1.05E+00	=	3.74E+01	2.33E+00	**3.71E+01**	1.62E+00	=
cf_{20}	2.40E+01	1.35E+00	**2.37E+01**	1.40E+00	=	2.45E+01	9.83E–01	2.45E+01	9.74E–01	=
cf_{21}	**6.61E+02**	4.86E+02	9.44E+02	2.94E+02	=	6.17E+02	3.70E+02	**2.08E+02**	4.79E–01	+
cf_{22}	**9.72E+03**	3.56E+02	1.06E+04	3.95E+02	–	**1.09E+04**	2.19E+02	1.14E+04	1.86E+02	–
cf_{23}	**1.40E+04**	4.02E+02	1.42E+04	3.25E+02	=	1.43E+04	3.60E+02	**1.41E+04**	3.33E+02	=
cf_{24}	3.08E+02	3.85E+01	**2.46E+02**	1.13E+01	+	3.72E+02	2.29E+00	**3.46E+02**	5.54E+00	+
cf_{25}	3.21E+02	2.08E+01	**2.88E+02**	8.08E+00	+	**4.12E+02**	2.51E+00	4.13E+02	6.34E+00	=
cf_{26}	4.60E+02	1.77E+01	**3.68E+02**	7.54E+01	+	3.46E+02	3.72E+01	**2.66E+02**	9.89E+01	+
cf_{27}	1.80E+03	1.85E+02	**8.61E+02**	1.69E+02	+	2.15E+03	2.56E+01	**2.10E+03**	3.41E+01	+
cf_{28}	1.04E+03	1.36E+03	**7.01E+02**	9.53E+02	+	4.13E+02	1.25E+00	**4.03E+02**	2.52E–01	+
rf_1	**5.77E+00**	6.24E+00	8.83E+00	6.22E+00	=	**2.28E–01**	1.60E+00	1.41E+00	3.29E+00	=
rf_2	**1.71E+00**	9.67E–02	1.74E+00	1.09E–01	=	**1.71E+00**	9.02E–02	1.76E+00	1.04E–01	=
Total number of (+/=/–): 25/22/7								Total number of (+/=/–): 32/16/6		

TABLE III
ERROR VALUES OF THE ORIGINAL DCMA-EA, DFDE, DEGL ALGORITHMS, AND THEIR CORRESPONDING EIGENVECTOR-BASED VARIANTS OVER THE 30-DIMENSIONAL BBOB 2012 AND CEC 2013 BENCHMARK SETS

	DCMA-EA		DCMA-EA/eig			DFDE		DFDE/eig			DEGL		DEGL/eig		
	Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.	
bf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	6.57E−04	1.40E−04	**1.56E−04**	1.61E−05	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	8.35E−02	3.20E−02	**1.01E−02**	1.58E−03	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_3	**1.25E+02**	6.44E+00	1.30E+02	1.19E+01	=	1.63E+02	4.72E+01	**8.58E+01**	6.69E+00	+	**5.37E+01**	2.03E+01	7.50E+01	2.72E+01	=
bf_4	**7.93E+01**	2.36E+01	8.07E+01	4.31E+01	=	1.96E+02	4.07E+01	**1.24E+02**	9.66E+00	+	**2.99E+01**	5.43E+00	5.81E+01	2.81E+01	−
bf_5	4.52E−06	1.75E−06	**4.04E−07**	3.62E−07	+	2.96E+01	1.98E+01	**1.12E+00**	2.00E−01	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	4.98E−01	1.71E−01	**1.60E−01**	1.47E−02	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_7	1.55E+00	1.12E+00	**1.11E+00**	1.17E+00	=	2.21E+01	1.06E+01	**2.25E+00**	1.26E+00	+	4.58E+00	2.89E+00	**3.35E+00**	2.04E+00	=
bf_8	2.22E+00	5.90E−01	**8.55E−01**	4.10E−01	+	2.56E+01	1.79E+01	**2.02E+01**	7.01E+00	=	1.04E+01	1.66E+00	**3.19E+00**	1.78E+00	+
bf_9	6.75E+00	5.07E−01	**2.64E+00**	3.20E−01	+	**1.68E+01**	8.33E+00	2.19E+01	7.32E−01	−	2.30E+01	1.41E+00	**1.67E+00**	2.11E+00	+
bf_{10}	6.94E+01	3.10E+01	**1.38E−05**	2.76E−05	+	1.37E+01	1.74E+01	**1.69E−01**	1.04E−01	+	1.10E+04	2.78E+03	**1.82E+02**	1.24E+02	+
bf_{11}	1.89E−01	1.48E−01	**0.00E+00**	0.00E+00	+	4.79E−03	6.82E−03	**3.34E−03**	1.01E−03	=	4.12E+01	2.97E+01	**4.70E−09**	1.05E−08	+
bf_{12}	6.65E−02	7.73E−02	**2.01E−04**	1.57E−04	+	1.86E+02	3.78E+02	**8.07E+00**	2.94E+00	+	1.37E+01	1.70E+01	**1.37E−01**	1.89E−01	+
bf_{13}	3.59E−02	2.64E−02	**4.40E−06**	9.82E−06	+	1.05E+00	6.26E−01	**6.24E−01**	8.09E−02	=	4.34E+00	4.52E+00	**2.24E−02**	3.03E−02	+
bf_{14}	1.22E−05	6.76E−06	**0.00E+00**	0.00E+00	+	8.95E−04	3.46E−04	**1.97E−04**	3.54E−05	+	5.20E−04	7.53E−05	**2.23E−05**	5.29E−06	+
bf_{15}	**1.39E+02**	1.20E+01	1.42E+02	1.04E+01	=	1.33E+02	1.60E+01	**9.86E+01**	1.32E+01	+	1.58E+02	1.11E+01	**1.52E+02**	5.43E+00	=
bf_{16}	2.28E+01	2.17E+00	**2.25E+01**	1.34E+00	=	1.76E+01	1.65E+00	**1.49E+01**	1.90E+00	+	**2.35E+01**	1.69E+00	2.46E+01	8.01E−01	=
bf_{17}	**5.70E−05**	1.44E−04	5.94E−05	8.86E−05	=	1.13E+00	3.62E−01	**3.27E−01**	1.29E−01	+	1.40E−02	2.25E−02	**1.12E−02**	1.11E−02	=
bf_{18}	**7.49E−03**	7.10E−03	2.58E−02	3.78E−02	=	4.53E+00	1.23E+00	**1.40E+00**	4.63E−01	+	**1.73E−01**	1.40E−01	1.75E−01	5.50E−02	=
bf_{19}	4.53E+00	2.84E−01	**4.31E+00**	3.35E−01	=	**3.90E+00**	4.68E−01	4.55E+00	2.61E−01	−	**4.48E+00**	2.16E−01	4.70E+00	3.10E−01	=
bf_{20}	2.74E+00	1.26E−01	**2.73E+00**	1.15E−01	=	**1.79E+00**	1.05E−01	2.26E+00	6.42E−02	−	**8.45E−01**	6.31E−01	9.27E−01	6.10E−01	=
bf_{21}	1.04E+01	9.63E+00	**8.96E+00**	7.36E+00	=	1.16E+00	3.47E−01	**6.74E−01**	2.97E−01	+	9.86E+00	1.27E+00	**4.50E+00**	3.71E+00	+
bf_{22}	2.59E+00	4.07E−13	2.59E+00	2.98E−13	=	2.59E+00	8.56E−05	**2.02E+00**	7.52E−01	+	**1.83E+01**	0.00E+00	2.18E+01	7.90E+00	=
bf_{23}	2.46E+00	1.86E−01	**2.38E+00**	1.70E−01	=	2.47E+00	2.39E−01	**2.27E+00**	2.36E−01	=	**2.36E+00**	3.28E−01	2.66E+00	1.74E−01	=
bf_{24}	1.76E+02	1.18E+01	1.76E+02	9.17E+00	=	**1.58E+02**	1.81E+01	1.74E+02	9.86E+00	−	1.91E+02	1.01E+01	**1.78E+02**	1.71E+01	=
cf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	3.44E−01	9.52E−02	**8.20E−02**	1.08E−02	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_2	1.71E+04	7.03E+03	**2.80E−07**	3.52E−07	+	6.15E+02	9.56E+02	**2.98E+02**	1.85E+02	=	3.76E+06	1.51E+06	**7.89E+04**	8.00E+04	+
cf_3	1.54E−02	4.60E−02	**3.80E−07**	1.00E−06	+	1.19E+08	2.00E+08	**1.43E+07**	6.57E+06	+	2.65E+06	4.40E+06	**3.04E+02**	4.24E+02	+
cf_4	6.42E+01	3.94E+01	**0.00E+00**	0.00E+00	+	**6.90E−01**	3.48E−01	1.39E+00	1.99E−01	−	6.99E+03	1.65E+03	**9.38E−08**	2.33E−07	+
cf_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	3.33E−01	7.27E−02	**9.85E−02**	8.98E−03	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_6	4.93E+00	7.60E+00	**2.65E−01**	1.14E−01	+	**2.34E+01**	1.77E+01	2.76E+01	2.66E+01	=	3.02E+01	2.44E+01	**6.57E−02**	2.06E−01	+
cf_7	2.50E+00	1.96E+00	**2.03E+00**	2.13E+00	=	5.21E+01	2.22E+01	**2.84E+01**	2.85E+00	+	**6.03E+00**	4.28E+00	8.23E+00	1.21E+01	=
cf_8	2.10E+01	6.72E−02	**2.09E+01**	7.42E−02	=	2.09E+01	5.34E−02	2.09E+01	5.39E−02	=	2.09E+01	5.06E−02	2.09E+01	6.06E−02	=
cf_9	**9.27E+00**	2.42E+00	1.04E+01	2.43E+00	=	3.54E+01	1.01E+00	**3.19E+01**	9.92E−01	+	2.56E+01	7.90E+00	**1.39E+01**	7.47E+00	+
cf_{10}	7.40E−04	2.34E−03	7.40E−04	2.34E−03	=	1.02E+00	1.90E−02	**1.00E+00**	1.42E−02	+	9.75E−02	1.59E−01	**4.95E−02**	4.00E−02	=
cf_{11}	**1.22E+02**	1.05E+01	1.23E+02	1.26E+01	=	1.10E+02	3.41E+01	**7.90E+01**	5.86E+00	+	**5.54E+01**	2.99E+01	7.89E+01	3.19E+01	=
cf_{12}	1.48E+02	8.57E+00	**1.43E+02**	6.94E+00	=	1.11E+02	3.26E+01	**1.07E+02**	1.64E+01	=	1.58E+02	9.80E+00	1.65E+02	8.57E+00	=
cf_{13}	1.48E+02	6.23E+00	**1.38E+02**	1.00E+01	+	1.90E+02	2.49E+01	**1.36E+02**	1.80E+01	+	1.61E+02	9.90E+00	**1.49E+02**	2.02E+01	=
cf_{14}	**6.37E+03**	3.28E+02	6.57E+03	3.15E+02	=	6.83E+03	2.05E+02	**5.16E+03**	3.33E+02	+	**4.49E+03**	2.49E+02	5.03E+03	1.60E+02	−
cf_{15}	6.82E+03	2.38E+02	**6.62E+03**	2.58E+02	=	6.79E+03	2.13E+02	**6.45E+03**	2.97E+02	+	7.15E+03	3.53E+02	**7.12E+03**	2.97E+02	=
cf_{16}	**2.48E+00**	3.74E−01	2.56E+00	2.94E−01	=	2.42E+00	2.11E−01	**2.24E+00**	2.67E−01	=	**2.29E+00**	3.11E−01	2.47E+00	3.10E−01	=
cf_{17}	**1.55E+02**	7.87E+00	1.65E+02	1.14E+01	=	2.19E+02	3.64E+01	**1.41E+02**	1.00E+01	+	**1.23E+02**	5.54E+00	1.36E+02	6.43E+00	−
cf_{18}	1.80E+02	5.30E+00	1.80E+02	7.69E+00	=	2.23E+02	2.95E+01	**1.84E+02**	7.75E+00	+	1.91E+02	1.16E+01	**1.87E+02**	1.30E+01	=
cf_{19}	1.24E+01	6.57E−01	**1.23E+01**	4.76E−01	=	1.90E+01	3.92E+00	**1.04E+01**	8.75E−01	+	**8.92E+00**	1.37E+00	1.05E+01	1.28E+00	−
cf_{20}	**1.46E+01**	1.18E+00	1.47E+01	1.05E+00	=	1.50E+01	9.49E−14	**1.44E+01**	1.19E+00	=	1.50E+01	6.30E−13	1.50E+01	0.00E+00	=
cf_{21}	**2.94E+02**	6.69E+01	3.04E+02	5.81E+01	=	3.59E+02	7.45E+01	**2.80E+02**	4.87E+01	=	**2.90E+02**	3.16E+01	3.29E+02	6.05E+01	=
cf_{22}	**5.54E+03**	6.29E+02	5.63E+03	4.71E+02	=	6.82E+03	1.56E+02	**5.57E+03**	2.88E+02	+	**4.26E+03**	3.81E+02	4.82E+03	4.84E+02	−
cf_{23}	6.64E+03	2.19E+02	**6.48E+03**	4.43E+02	=	6.88E+03	3.00E+02	**6.84E+03**	2.54E+02	=	**6.86E+03**	3.52E+02	6.99E+03	2.95E+02	=
cf_{24}	2.02E+02	2.82E+00	**2.01E+02**	1.47E+00	=	2.42E+02	7.61E+00	**2.41E+02**	5.77E+00	=	2.11E+02	8.09E+00	**2.10E+02**	9.17E+00	=
cf_{25}	2.51E+02	7.17E+00	**2.46E+02**	7.05E+00	=	3.10E+02	5.45E+00	**3.03E+02**	2.88E+00	+	2.48E+02	3.78E+00	**2.43E+02**	2.10E+01	=
cf_{26}	2.01E+02	3.67E+00	**2.00E+02**	5.81E−01	+	**2.00E+02**	1.57E−04	2.00E+02	5.26E−02	−	2.11E+02	3.48E+01	**2.10E+02**	3.17E+01	+
cf_{27}	3.22E+02	2.81E+01	**3.10E+02**	8.82E+00	=	**7.36E+02**	5.00E+01	9.83E+02	5.62E+01	−	**3.85E+02**	1.01E+02	4.12E+02	9.03E+01	=
cf_{28}	3.00E+02	3.14E−12	**3.00E+02**	3.71E−12	+	6.16E+02	4.76E+02	**3.10E+02**	9.78E−01	+	**3.00E+02**	3.70E−12	3.00E+02	4.07E−12	=
	Total number of (+/=/−): 15/37/0					Total number of (+/=/−): 32/13/7					Total number of (+/=/−): 14/32/6				

TABLE IV
ERROR VALUES OF THE ORIGINAL RBDE, SaDE, JADE ALGORITHMS, AND THEIR CORRESPONDING EIGENVECTOR-BASED VARIANTS OVER THE 30-DIMENSIONAL BBOB 2012 AND CEC 2013 BENCHMARK SETS

	RBDE		RBDE/eig			SaDE		SaDE/eig			JADE		JADE/eig		
	Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.	
bf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_3	**1.21E+02**	7.17E+00	1.36E+02	1.05E+01	−	**4.44E−01**	9.91E−01	2.62E+01	3.41E+00	−	**0.00E+00**	0.00E+00	9.57E−09	1.41E−08	=
bf_4	**1.30E+02**	8.60E+00	1.53E+02	7.62E+00	−	**1.24E+01**	1.45E+00	3.64E+01	4.06E+00	−	**0.00E+00**	0.00E+00	1.10E−03	6.15E−04	−
bf_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_6	1.96E+00	3.86E−01	**8.39E−03**	1.64E−03	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_7	1.80E+01	2.95E+00	**0.00E+00**	0.00E+00	+	5.89E+00	8.99E−01	**4.11E+00**	1.81E+00	=	3.59E+00	1.80E+00	**1.12E+00**	1.02E+00	+
bf_8	1.86E+01	3.60E−01	**1.66E−03**	1.89E−03	+	2.30E+00	1.79E+00	**8.41E−01**	1.76E+00	=	7.97E−01	1.78E+00	**0.00E+00**	0.00E+00	=
bf_9	2.42E+01	3.58E−01	**2.88E+00**	7.06E−01	+	2.14E+01	2.84E+00	**8.39E+00**	2.08E+00	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_{10}	2.37E+05	4.67E+04	**0.00E+00**	0.00E+00	+	1.02E+03	2.59E+02	**1.10E+02**	7.03E+01	+	8.48E+00	4.45E+00	**2.60E−01**	5.81E−01	+
bf_{11}	1.06E+02	1.88E+01	**0.00E+00**	0.00E+00	+	4.44E+00	2.70E+00	**6.44E−05**	8.48E−05	+	4.33E−07	9.09E−07	**0.00E+00**	0.00E+00	=
bf_{12}	3.99E−01	5.23E−01	**4.35E−04**	3.55E−04	+	9.30E+00	5.19E+00	**1.16E+00**	4.35E−01	+	3.57E−04	5.69E−04	**1.34E−04**	2.23E−04	=
bf_{13}	1.64E−01	6.03E−02	**2.04E−07**	7.43E−08	+	9.44E−01	1.13E+00	**4.95E−03**	7.06E−03	=	9.00E−01	1.19E+00	**7.34E−06**	8.77E−06	+
bf_{14}	2.38E−02	2.48E−03	**0.00E+00**	0.00E+00	+	1.36E−04	3.39E−05	**4.48E−05**	1.29E−05	+	6.96E−06	3.06E−06	**1.61E−07**	1.28E−07	+
bf_{15}	2.01E+02	1.20E+01	**1.96E+02**	9.47E+00	=	**5.22E+01**	3.28E+01	5.93E+01	4.09E+01	=	**4.17E+01**	3.97E+00	4.24E+01	7.21E+00	=
bf_{16}	**2.24E+01**	1.79E+00	2.35E+01	1.32E+00	=	1.65E+01	1.84E+00	**1.58E+01**	1.57E+00	=	8.44E+00	1.66E+00	**7.61E+00**	5.71E−01	=
bf_{17}	5.16E−02	1.21E−02	**5.30E−03**	9.62E−04	+	**9.04E−03**	1.50E−02	1.73E−02	1.04E−02	=	3.55E−04	4.68E−04	**2.66E−04**	3.82E−04	=
bf_{18}	1.18E+00	1.97E−01	**7.93E−03**	1.90E−03	+	**2.16E−01**	7.66E−02	2.18E−01	8.68E−02	=	3.86E−02	3.89E−02	**6.14E−03**	4.71E−03	+
bf_{19}	6.09E+00	3.24E−01	**5.66E+00**	3.03E−01	+	**4.51E+00**	2.54E−01	4.61E+00	2.69E−01	=	3.63E+00	7.29E−01	**3.08E+00**	8.29E−01	=
bf_{20}	2.75E+00	4.28E−02	2.75E+00	9.55E−02	=	**2.00E+00**	1.33E−01	2.27E+00	9.36E−02	−	**6.54E−01**	8.32E−02	8.69E−01	7.23E−02	−
bf_{21}	1.02E+01	8.05E+00	**3.18E+00**	6.33E+00	+	3.73E+00	3.91E+00	**2.52E+00**	3.06E+00	=	**6.96E+00**	3.65E+00	7.08E+00	4.66E+00	=
bf_{22}	2.59E+00	2.72E−13	2.59E+00	5.23E−13	=	**1.83E+01**	0.00E+00	1.83E+01	0.00E+00	=	2.18E+01	7.90E+00	**2.04E+01**	9.24E+00	=
bf_{23}	**2.48E+00**	3.09E−01	2.53E+00	2.64E−01	=	**2.62E+00**	2.48E−01	2.69E+00	1.37E−01	=	**1.13E+00**	1.02E−01	1.17E+00	1.04E−01	=
bf_{24}	2.37E+02	1.48E+01	**2.28E+02**	1.64E+01	=	**1.71E+02**	1.34E+01	1.78E+02	9.94E+00	=	9.59E+01	3.24E+00	**9.13E+01**	4.75E+00	=
cf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_2	1.06E+08	1.64E+07	**0.00E+00**	0.00E+00	+	2.63E+05	1.50E+05	**4.52E+04**	3.11E+04	+	5.74E+03	6.69E+03	**2.18E−05**	3.81E−05	+
cf_3	8.79E+06	9.29E+06	**9.57E+03**	7.52E+03	+	7.95E+05	1.56E+06	**5.95E−01**	1.79E+00	+	**2.82E−01**	5.24E−01	8.67E+01	2.70E+02	=
cf_4	4.01E+04	8.83E+03	**0.00E+00**	0.00E+00	+	2.35E+00	1.67E+00	**7.68E−04**	1.34E−03	+	1.49E+04	2.00E+04	**0.00E+00**	0.00E+00	+
cf_5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_6	1.62E+01	1.97E−01	**3.83E−04**	8.93E−04	+	1.24E+01	1.06E+00	**4.20E+00**	7.87E+00	+	**0.00E+00**	0.00E+00	5.28E+00	1.11E+01	=
cf_7	3.11E+01	4.37E+00	**1.09E+01**	2.01E+00	+	1.52E+00	1.40E+00	**1.19E+00**	1.18E+00	=	1.58E+00	2.53E+00	**1.03E+00**	7.59E−01	=
cf_8	2.10E+01	2.58E−02	**2.09E+01**	5.72E−02	=	2.10E+01	4.32E−02	**2.09E+01**	8.07E−02	=	2.09E+01	1.96E−01	2.09E+01	3.64E−02	=
cf_9	3.96E+01	1.15E+00	**3.93E+01**	9.51E−01	=	2.59E+01	8.35E+00	**2.41E+01**	1.04E+01	=	2.75E+01	1.67E+00	**2.67E+01**	1.41E+00	=
cf_{10}	2.15E+01	6.90E+00	**0.00E+00**	0.00E+00	+	7.32E−02	3.85E−02	**3.17E−02**	2.39E−02	+	4.29E−02	2.75E−02	**1.55E−02**	8.21E−03	+
cf_{11}	**1.26E+02**	5.97E+00	1.43E+02	5.09E+00	−	**1.12E+01**	3.88E+00	3.30E+01	5.30E+00	−	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_{12}	2.03E+02	1.75E+01	**1.96E+02**	7.77E+00	+	**8.86E+01**	3.07E+01	9.02E+01	3.21E+01	=	**3.12E+01**	6.43E+00	3.40E+01	6.17E+00	=
cf_{13}	1.98E+02	1.40E+01	**1.93E+02**	1.38E+01	=	1.16E+02	3.36E+01	**1.11E+02**	2.35E+01	=	5.03E+01	1.02E+01	**4.74E+01**	1.24E+01	=
cf_{14}	**4.58E+03**	2.86E+02	5.23E+03	3.19E+02	−	**2.28E+03**	3.51E+02	3.58E+03	2.21E+02	−	**1.22E−01**	4.30E−02	4.92E+01	6.55E+00	−
cf_{15}	7.30E+03	2.24E+02	**7.14E+03**	2.44E+02	=	**6.75E+03**	2.99E+02	6.77E+03	3.21E+02	=	4.19E+03	2.62E+02	**4.04E+03**	3.52E+02	=
cf_{16}	**2.34E+00**	3.27E−01	2.37E+00	2.48E−01	=	**2.35E+00**	3.68E−01	2.39E+00	2.60E−01	=	**1.73E+00**	9.07E−01	1.85E+00	1.10E+00	=
cf_{17}	**1.69E+02**	1.49E+01	1.85E+02	1.17E+01	−	**9.08E+01**	5.51E+00	1.15E+02	6.81E+00	−	**3.04E+01**	6.73E−07	3.13E+01	1.18E−01	−
cf_{18}	2.33E+02	9.26E+00	**2.28E+02**	9.71E+00	=	1.79E+02	7.51E+00	**1.75E+02**	1.19E+01	=	9.51E+01	7.29E+00	**9.42E+01**	8.50E+00	=
cf_{19}	**1.51E+01**	1.20E+00	1.61E+01	5.22E−01	−	**9.42E+00**	4.87E−01	9.97E+00	7.63E−01	=	**1.91E+00**	1.78E−01	2.29E+00	7.98E−02	−
cf_{20}	1.50E+01	1.62E−13	1.50E+01	1.44E−13	=	1.50E+01	9.49E−14	1.50E+01	7.19E−14	=	1.46E+01	1.32E+00	1.46E+01	1.31E+00	=
cf_{21}	**3.00E+02**	4.03E−07	3.23E+02	9.22E+01	=	**3.09E+02**	8.20E+01	3.76E+02	9.17E+01	−	**2.80E+02**	4.22E+01	3.09E+02	8.20E+01	=
cf_{22}	**4.77E+03**	1.64E+02	5.17E+03	2.09E+02	−	**2.31E+03**	3.73E+02	3.81E+03	3.14E+02	−	**1.16E+02**	1.60E+01	2.95E+02	8.37E+01	−
cf_{23}	7.48E+03	1.45E+02	**7.26E+03**	1.77E+02	+	6.69E+03	3.54E+02	**6.54E+03**	4.02E+02	=	4.22E+03	5.49E+02	**4.13E+03**	3.99E+02	=
cf_{24}	2.20E+02	5.97E+00	**2.07E+02**	1.29E+00	+	2.09E+02	3.75E+00	**2.06E+02**	7.18E+00	+	2.43E+02	2.15E+01	**2.17E+02**	1.64E+01	+
cf_{25}	2.95E+02	1.49E+01	**2.63E+02**	2.72E+01	+	2.47E+02	2.83E+00	**2.37E+02**	2.00E+01	=	2.85E+02	2.94E+00	**2.84E+02**	5.18E+00	=
cf_{26}	2.08E+02	1.40E+00	**2.00E+02**	2.84E−12	+	2.00E+02	4.93E−03	**2.00E+02**	2.11E−03	+	**2.01E+02**	8.34E−01	2.16E+02	5.20E+01	+
cf_{27}	1.17E+03	1.16E+02	**6.98E+02**	1.49E+02	+	3.81E+02	3.97E+01	**3.48E+02**	3.16E+01	=	9.39E+02	1.69E+02	**8.26E+02**	2.16E+02	+
cf_{28}	3.00E+02	1.99E−07	3.00E+02	4.55E−10	+	3.00E+02	3.60E−12	3.00E+02	7.07E−12	=	3.00E+02	3.43E−12	3.00E+02	3.28E−12	=
	Total number of (+/=/−): 26/19/7					Total number of (+/=/−): 12/32/8					Total number of (+/=/−): 11/35/6				

TABLE V
ERROR VALUES OF THE ORIGINAL DCMA-EA, DFDE, DEGL ALGORITHMS, AND THEIR CORRESPONDING EIGENVECTOR-BASED VARIANTS OVER THE 50-DIMENSIONAL BBOB 2012, CEC 2013 BENCHMARK SETS, AND TWO REAL WORLD FUNCTIONS IN CEC 2011

	DCMA-EA		DCMA-EA/eig			DFDE		DFDE/eig			DEGL		DEGL/eig		
	Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.	
bf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	9.31E−01	6.71E−01	**2.19E−03**	2.72E−04	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_2	**1.81E−09**	5.73E−09	4.11E−09	8.87E−09	=	3.86E+02	2.75E+02	**1.08E−01**	1.25E−02	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_3	**2.76E+02**	7.54E+00	2.80E+02	1.05E+01	=	2.50E+02	7.21E+01	**2.28E+02**	1.11E+01	=	**1.18E+02**	7.66E+01	1.95E+02	5.22E+01	−
bf_4	**2.16E+02**	8.62E+01	2.26E+02	1.11E+02	=	3.68E+02	9.06E+01	**3.09E+02**	1.96E+01	=	**6.53E+01**	8.95E+00	1.01E+02	5.75E+01	−
bf_5	9.82E−02	3.07E−02	3.23E−01	8.71E−02	−	1.20E+02	3.81E+01	**1.51E+01**	5.44E−01	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_6	3.79E−04	2.66E−04	**3.27E−04**	1.28E−04	=	4.83E+01	3.39E+01	**1.25E+00**	1.35E−01	+	2.85E−08	6.33E−08	**0.00E+00**	0.00E+00	+
bf_7	2.19E+00	8.43E−01	**1.66E+00**	1.34E+00	=	4.64E+01	1.00E+01	**8.74E+00**	1.81E+00	+	1.15E+01	4.83E+00	9.76E+00	4.52E+00	=
bf_8	3.01E+01	3.34E−01	**2.90E+01**	7.12E−01	+	3.57E+02	4.77E+02	**4.90E+01**	1.30E+01	+	3.48E+01	1.63E+01	**5.50E−01**	1.24E+00	+
bf_9	3.29E+01	5.15E−01	**3.02E+01**	8.05E−01	+	9.84E+01	3.26E+01	**4.38E+01**	1.50E+00	+	4.27E+01	7.32E−01	**2.71E+01**	3.51E+00	+
bf_{10}	6.00E+02	1.65E+02	**8.52E−01**	9.55E−01	+	1.51E+03	6.69E+02	**2.29E+02**	1.65E+02	+	1.24E+04	9.98E+03	**9.08E+02**	3.13E+02	+
bf_{11}	1.22E+00	5.53E−01	**0.00E+00**	0.00E+00	+	1.34E+01	1.13E+01	**6.90E−02**	2.80E−02	+	3.76E+01	7.87E+00	**2.30E−07**	2.90E−07	+
bf_{12}	7.04E−02	1.15E−01	**8.96E−03**	1.27E−02	=	1.14E+06	1.66E+06	**2.50E+03**	1.89E+02	+	1.40E+00	1.82E+00	**3.09E−01**	8.24E−01	+
bf_{13}	2.22E−01	2.34E−01	**6.06E−03**	3.89E−03	+	1.71E+02	7.66E+01	**5.54E+00**	1.70E+00	+	1.13E+01	8.71E+00	**7.02E−01**	1.71E+00	+
bf_{14}	8.90E−05	3.01E−05	**1.67E−08**	1.50E−08	+	9.07E−01	6.11E−01	**2.04E−03**	3.74E−04	+	9.93E−04	1.22E−04	**7.13E−05**	1.53E−05	+
bf_{15}	3.03E+02	1.34E+01	**2.99E+02**	1.57E+01	=	2.82E+02	7.62E+01	**2.65E+02**	1.48E+01	=	3.34E+02	1.20E+01	3.34E+02	2.13E+01	=
bf_{16}	**3.07E+01**	1.29E+00	3.09E+01	1.58E+00	=	2.43E+01	1.61E+00	**2.24E+01**	1.73E+00	+	3.16E+01	1.38E+00	**3.13E+01**	1.84E+00	=
bf_{17}	3.03E−05	1.08E−05	**2.71E−05**	1.36E−05	=	2.54E+00	6.12E−01	**5.47E−01**	1.08E−01	+	5.08E−02	3.67E−02	**4.51E−02**	4.37E−02	=
bf_{18}	**1.95E−03**	9.41E−04	2.12E−03	2.42E−03	=	8.05E+00	1.38E+00	**2.33E+00**	6.64E−01	+	5.12E−01	1.65E−01	**4.05E−01**	2.12E−01	=
bf_{19}	**5.52E+00**	3.76E−01	5.65E+00	1.62E−01	=	**4.80E+00**	2.22E−01	5.47E+00	2.49E−01	−	5.90E+00	1.54E−01	**5.87E+00**	2.56E−01	=
bf_{20}	3.17E+00	4.26E−02	**3.15E+00**	8.85E−02	=	**2.02E+00**	1.49E−01	2.44E+00	1.10E−01	−	**1.13E+00**	3.87E−01	1.92E+00	6.31E−01	−
bf_{21}	1.94E+00	3.23E−12	1.94E+00	3.85E−12	=	1.98E+00	2.87E−02	**1.26E+00**	6.60E−01	+	1.94E+00	4.27E−12	1.94E+00	3.68E−11	=
bf_{22}	2.59E+00	3.95E−13	2.59E+00	2.13E−13	+	2.68E+00	8.13E−02	**2.59E+00**	4.67E−05	+	2.59E+00	5.10E−13	2.59E+00	2.03E−12	−
bf_{23}	**3.25E+00**	2.84E−01	3.34E+00	3.60E−01	=	3.34E+00	2.57E−01	**3.30E+00**	1.46E−01	=	3.37E+00	3.27E−01	3.34E+00	3.96E−01	=
bf_{24}	**3.42E+02**	1.89E+01	3.50E+02	8.88E+00	=	**3.26E+02**	3.66E+01	3.60E+02	1.71E+01	−	3.69E+02	1.91E+01	3.72E+02	9.65E+00	=
cf_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	3.14E+02	2.52E+02	**7.92E−01**	9.20E−02	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_2	2.34E+05	8.63E+04	**1.09E+02**	2.78E+02	+	4.85E+05	3.08E+05	**4.79E+04**	2.39E+04	+	5.33E+06	2.37E+06	**2.83E+05**	1.06E+05	+
cf_3	1.42E+03	3.20E+03	**1.69E+01**	4.39E+01	+	3.85E+09	2.69E+09	**3.01E+07**	1.30E+07	+	2.95E+07	3.55E+07	**3.91E+05**	6.81E+05	+
cf_4	4.58E+02	1.81E+02	**7.14E−07**	9.51E−07	+	3.78E+03	3.69E+03	**1.86E+01**	6.06E+00	+	1.37E+04	2.71E+03	**2.35E−06**	2.28E−06	+
cf_5	**3.26E−08**	2.94E−08	6.61E−08	7.90E−08	=	1.09E+02	2.58E+01	**4.81E−01**	3.25E−02	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_6	4.34E+01	1.97E−08	4.34E+01	1.17E−08	+	1.04E+02	3.17E+01	**4.56E+01**	1.80E+00	+	4.85E+01	1.61E+01	**4.03E+01**	9.80E+00	+
cf_7	**3.48E+00**	3.48E+00	3.73E+00	2.69E+00	=	7.45E+01	1.24E+01	**3.69E+01**	7.74E+00	+	1.31E+01	8.53E+00	1.34E+01	9.40E+00	=
cf_8	2.11E+01	2.65E−02	2.11E+01	4.31E−02	=	2.11E+01	4.62E−02	2.11E+01	3.19E−02	=	2.11E+01	2.46E−02	2.11E+01	3.36E−02	=
cf_9	**1.62E+01**	3.54E+00	1.74E+01	3.31E+00	=	**5.00E+01**	1.13E+01	6.25E+01	1.62E+00	−	6.35E+01	5.16E+00	**5.01E+01**	1.71E+01	+
cf_{10}	3.45E−03	4.53E−03	**0.00E+00**	0.00E+00	+	6.43E+01	5.67E+01	**1.13E+00**	2.13E−02	+	6.36E−02	7.04E−02	**3.89E−02**	2.97E−02	=
cf_{11}	2.85E+02	9.81E+00	**2.84E+02**	1.75E+01	=	2.53E+02	6.91E+01	**2.39E+02**	1.75E+01	=	1.81E+02	5.79E+01	2.28E+02	2.50E+01	=
cf_{12}	**3.03E+02**	1.68E+01	3.06E+02	1.53E+01	=	**2.18E+02**	5.14E+01	2.79E+02	1.15E+01	−	3.41E+02	9.96E+00	3.42E+02	1.32E+01	=
cf_{13}	3.09E+02	1.04E+01	**3.03E+02**	1.47E+01	=	3.83E+02	4.47E+01	**3.36E+02**	2.30E+01	+	3.31E+02	1.05E+01	3.32E+02	1.07E+01	=
cf_{14}	**1.24E+04**	3.94E+02	1.28E+04	3.98E+02	−	1.27E+04	5.25E+02	**1.09E+04**	3.02E+02	+	1.02E+04	3.79E+02	1.07E+04	2.44E+02	−
cf_{15}	1.36E+04	3.82E+02	1.36E+04	3.77E+02	=	1.32E+04	2.95E+02	1.32E+04	3.54E+02	=	1.38E+04	4.35E+02	1.38E+04	2.21E+02	=
cf_{16}	3.29E+00	3.98E−01	**3.17E+00**	3.74E−01	=	**3.08E+00**	1.77E−01	3.09E+00	1.86E−01	=	3.26E+00	2.78E−01	3.47E+00	2.47E−01	=
cf_{17}	**3.31E+02**	8.67E+00	3.41E+02	8.49E+00	−	5.04E+02	8.26E+01	**3.24E+02**	2.44E+01	+	2.79E+02	1.21E+01	3.01E+02	1.20E+01	−
cf_{18}	3.60E+02	9.13E+00	**3.51E+02**	2.17E+01	=	5.11E+02	5.26E+01	**3.73E+02**	1.50E+01	+	3.69E+02	1.41E+01	3.80E+02	1.87E+01	=
cf_{19}	2.68E+01	9.05E−01	**2.62E+01**	9.02E−01	=	7.62E+01	3.11E+01	**2.73E+01**	1.38E+00	+	2.12E+01	3.01E+00	2.37E+01	1.96E+00	=
cf_{20}	2.20E+01	2.06E+00	**2.16E+01**	1.24E+00	=	2.46E+01	1.17E+00	**2.41E+01**	1.44E+00	=	2.33E+01	1.81E+00	2.50E+01	1.10E−12	=
cf_{21}	1.01E+03	1.48E+02	**9.44E+02**	2.94E+02	=	1.32E+03	4.44E+02	**6.84E+02**	3.99E+02	+	9.44E+02	2.94E+02	1.00E+03	2.96E+02	=
cf_{22}	**1.17E+04**	2.51E+02	1.21E+04	4.33E+02	=	1.30E+04	5.17E+02	**1.17E+04**	2.13E+02	+	9.65E+03	3.70E+02	1.02E+04	2.61E+02	−
cf_{23}	1.30E+04	2.16E+02	**1.28E+04**	4.01E+02	=	1.37E+04	2.93E+02	**1.34E+04**	3.93E+02	=	1.38E+04	3.65E+02	**1.35E+04**	3.49E+02	=
cf_{24}	**2.03E+02**	3.03E+00	2.03E+02	5.53E+00	=	3.17E+02	1.49E+01	**2.87E+02**	1.36E+01	+	2.29E+02	1.10E+01	2.43E+02	7.98E+00	−
cf_{25}	**2.86E+02**	9.15E+00	2.90E+02	7.20E+00	=	4.10E+02	6.58E+00	**3.99E+02**	6.86E+00	+	2.93E+02	6.53E+00	2.96E+02	1.12E+01	=
cf_{26}	3.05E+02	2.56E+00	**2.66E+02**	5.52E+01	=	**2.00E+02**	2.62E−02	2.11E+02	3.74E+00	−	2.81E+02	7.04E+01	3.23E+02	4.49E+01	=
cf_{27}	**3.83E+02**	7.51E+01	5.03E+02	1.27E+02	−	**1.38E+03**	9.82E+01	1.72E+03	1.01E+02	−	7.17E+02	1.08E+02	7.81E+02	1.33E+02	=
cf_{28}	4.00E+02	2.62E−07	4.00E+02	7.24E−07	=	1.12E+03	4.83E+02	**4.07E+02**	2.68E−01	+	**4.00E+02**	3.89E−12	9.87E+02	1.24E+03	−
rf_1	**1.46E+01**	3.96E+00	1.75E+01	3.96E+00	=	**7.27E+00**	6.48E+00	7.40E+00	3.84E+00	=	6.69E+00	6.00E+00	**4.98E+00**	6.02E+00	=
rf_2	1.74E+00	1.16E−01	**1.68E+00**	9.26E−02	=	1.45E+00	9.48E−02	**1.36E+00**	7.36E−02	=	1.71E+00	1.02E−01	1.74E+00	1.03E−01	=
	Total number of (+/=/−): 12/38/4					Total number of (+/=/−): 35/12/7					Total number of (+/=/−): 13/32/9				

TABLE VI
ERROR VALUES OF THE ORIGINAL RBDE, SaDE, JADE ALGORITHMS, AND THEIR CORRESPONDING EIGENVECTOR-BASED VARIANTS OVER THE 50-DIMENSIONAL BBOB 2012, CEC 2013 BENCHMARK SETS, AND TWO REAL WORLD FUNCTIONS IN CEC 2011

	RBDE		RBDE/eig			SaDE		SaDE/eig			JADE		JADE/eig		
	Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.		Mean	St.D.	Mean	St.D.	
bf_1	3.50E–05	1.19E–05	**1.28E–07**	2.81E–08	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_2	8.86E–03	2.27E–03	**1.26E–05**	2.11E–06	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_3	**3.10E+02**	1.70E+01	3.38E+02	8.23E+00	–	**4.84E+01**	3.48E+00	1.01E+02	7.69E+00	–	**1.92E–06**	8.95E–07	7.20E+00	9.69E–01	–
bf_4	**3.68E+02**	1.98E+01	3.91E+02	1.55E+01	–	**6.73E+01**	6.41E+00	1.20E+02	1.04E+01	–	**4.99E–03**	1.01E–03	1.91E+01	1.05E+00	–
bf_5	**0.00E+00**	0.00E+00	1.85E–07	3.68E–08	–	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_6	2.01E+02	1.42E+01	**3.29E+01**	4.37E+00	+	8.61E–06	2.40E–06	**2.45E–07**	2.46E–07	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
bf_7	1.73E+02	2.61E+01	**1.33E–01**	2.42E–02	+	1.15E+01	2.41E+00	**9.26E+00**	2.93E+00	=	6.13E+00	1.79E+00	**2.05E+00**	9.69E–01	+
bf_8	5.14E+01	1.14E+00	**3.60E+01**	6.11E–01	+	2.28E+01	2.16E+01	**2.13E+01**	1.82E+01	=	**0.00E+00**	0.00E+00	1.61E–07	4.31E–07	–
bf_9	5.25E+01	1.73E+00	**3.92E+01**	4.65E–01	+	4.40E+01	1.02E+00	**3.22E+01**	8.08E–01	+	2.10E+01	1.30E+00	**1.39E+01**	1.15E+00	+
bf_{10}	1.10E+06	8.43E+04	**8.02E–02**	9.82E–02	+	2.17E+03	5.28E+02	**8.21E+02**	3.12E+02	+	1.76E+02	9.23E+01	**8.16E+01**	6.41E+01	+
bf_{11}	2.17E+02	2.33E+01	**9.47E–05**	4.36E–05	+	5.53E–02	3.73E–02	**8.68E–04**	1.12E–03	+	8.52E+01	1.12E+02	**0.00E+00**	0.00E+00	+
bf_{12}	4.94E+02	1.37E+02	**1.09E+00**	2.36E–01	+	4.21E–01	4.88E–01	**2.99E–01**	5.32E–01	=	1.75E–02	5.11E–02	**1.18E–03**	2.47E–03	=
bf_{13}	8.94E+01	7.98E+00	**1.06E–01**	1.11E–02	+	9.38E+00	3.51E+00	**2.12E+00**	2.95E+00	+	2.96E+00	3.22E+00	**6.87E–01**	9.78E–01	+
bf_{14}	1.68E–01	1.95E–02	**2.33E–05**	7.34E–06	+	3.14E–04	4.36E–05	**1.67E–04**	4.82E–05	+	**3.62E–05**	7.81E–06	4.26E–05	1.25E–05	=
bf_{15}	4.52E+02	8.40E+00	**4.12E+02**	2.02E+01	+	2.49E+02	1.78E+01	**2.29E+02**	7.12E+01	=	**8.97E+01**	9.71E+00	1.05E+02	9.65E+00	–
bf_{16}	3.16E+01	1.47E+00	**3.10E+01**	1.81E+00	=	**2.44E+01**	2.57E+00	2.52E+01	2.16E+00	=	1.46E+01	9.90E–01	**1.40E+01**	8.56E–01	=
bf_{17}	1.12E+00	6.86E–02	**4.04E–01**	4.32E–02	+	7.32E–02	3.53E–02	**5.01E–02**	4.99E–02	=	1.22E–03	8.28E–04	**1.15E–03**	9.80E–04	=
bf_{18}	7.42E+00	2.32E–01	**6.14E–01**	7.29E–02	+	8.07E–01	2.28E–01	**5.36E–01**	1.80E–01	+	1.30E–01	5.55E–02	**6.29E–02**	2.83E–02	+
bf_{19}	7.74E+00	3.89E–01	**7.44E+00**	2.10E–01	+	5.64E+00	3.81E–01	**5.58E+00**	2.20E–01	=	**4.67E+00**	5.93E–01	4.74E+00	4.42E–01	=
bf_{20}	3.34E+00	8.19E–02	**3.23E+00**	7.79E–02	+	**2.67E+00**	6.14E–02	2.75E+00	7.07E–02	–	**1.07E+00**	5.65E–02	1.33E+00	1.11E–01	–
bf_{21}	1.94E+00	6.96E–06	1.94E+00	5.43E–09	+	1.94E+00	2.66E–12	1.94E+00	3.87E–12	=	1.94E+00	2.63E–12	1.94E+00	1.87E–12	=
bf_{22}	2.59E+00	1.56E–06	2.59E+00	6.18E–09	+	2.59E+00	3.09E–13	2.59E+00	4.43E–13	–	2.59E+00	1.48E–13	2.59E+00	3.94E–13	=
bf_{23}	**3.34E+00**	3.18E–01	3.35E+00	2.64E–01	=	**3.09E+00**	2.29E–01	3.14E+00	3.51E–01	=	2.76E+00	6.84E–01	**2.73E+00**	5.80E–01	=
bf_{24}	5.13E+02	7.89E+00	**4.84E+02**	2.17E+01	+	3.56E+02	1.57E+01	**3.55E+02**	7.86E+00	=	2.29E+02	1.75E+01	**2.22E+02**	1.13E+01	=
cf_1	1.82E–02	3.08E–03	**5.98E–05**	9.09E–06	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_2	4.55E+08	4.32E+07	**2.66E+01**	4.47E+01	+	7.96E+05	3.79E+05	**3.46E+05**	1.53E+05	+	5.22E+04	2.73E+04	**2.35E+04**	2.10E+04	+
cf_3	2.18E+10	2.63E+09	**9.67E+09**	1.52E+09	+	1.27E+06	1.51E+06	**9.08E+03**	1.52E+04	+	1.36E+06	4.25E+06	**5.47E+04**	1.58E+05	=
cf_4	8.45E+04	5.92E+03	**3.21E–02**	9.88E–03	+	8.58E+00	6.65E+00	**2.86E–02**	1.36E–02	+	1.47E+04	3.11E+04	**3.90E–09**	8.27E–09	+
cf_5	4.82E–01	7.18E–02	**3.83E–03**	6.63E–04	+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=	0.00E+00	0.00E+00	0.00E+00	0.00E+00	=
cf_6	4.66E+01	2.29E–01	**4.34E+01**	8.41E–05	+	4.46E+01	6.96E–01	**4.34E+01**	6.91E–13	+	4.34E+01	2.34E–12	4.34E+01	1.56E–12	+
cf_7	1.14E+02	4.92E+00	**8.19E+01**	5.50E+00	+	8.72E+00	3.84E+00	**6.66E+00**	5.14E+00	=	5.65E+00	2.88E+00	**2.66E+00**	2.45E+00	+
cf_8	2.11E+01	2.61E–02	2.11E+01	4.94E–02	=	2.11E+01	3.44E–02	2.11E+01	2.29E–02	=	**2.10E+01**	2.24E–01	2.11E+01	4.83E–02	=
cf_9	**7.26E+01**	1.45E+00	7.31E+01	9.86E–01	=	4.14E+01	1.80E+01	**3.41E+01**	1.66E+01	=	5.57E+01	1.35E+00	**5.53E+01**	1.45E+00	=
cf_{10}	1.21E+03	1.35E+02	**6.10E–03**	3.76E–03	+	8.03E–02	3.42E–02	**3.00E–02**	1.54E–02	+	4.29E–02	3.21E–02	**3.35E–02**	1.88E–02	=
cf_{11}	**3.29E+02**	1.50E+01	3.55E+02	1.08E+01	–	**5.34E+01**	4.51E+00	9.85E+01	1.23E+01	–	**9.50E–07**	2.29E–07	6.65E+00	8.41E–01	–
cf_{12}	4.54E+02	1.70E+01	**4.10E+02**	1.78E+01	+	2.44E+02	1.18E+01	**2.11E+02**	8.27E+01	=	**9.58E+01**	1.04E+01	9.82E+01	7.48E+00	=
cf_{13}	4.56E+02	2.55E+01	**4.17E+02**	1.08E+01	+	3.05E+02	1.21E+01	**2.97E+02**	1.70E+01	=	**1.31E+02**	1.35E+01	1.38E+02	1.22E+01	=
cf_{14}	**1.06E+04**	2.22E+02	1.11E+04	2.80E+02	–	**6.53E+03**	3.77E+02	8.49E+03	3.48E+02	–	**6.96E+01**	8.52E+00	9.02E+02	1.04E+02	–
cf_{15}	**1.38E+04**	2.57E+02	1.40E+04	1.90E+02	=	**1.34E+04**	2.71E+02	1.35E+04	3.91E+02	=	1.01E+04	4.61E+02	**9.79E+03**	5.01E+02	=
cf_{16}	**3.18E+00**	3.14E–01	3.35E+00	2.73E–01	=	**3.22E+00**	3.04E–01	3.31E+00	2.29E–01	=	3.22E+00	3.58E–01	**2.48E+00**	6.90E–01	+
cf_{17}	**4.16E+02**	1.44E+01	4.40E+02	1.19E+01	–	**2.07E+02**	6.03E+00	2.53E+02	9.78E+00	–	**5.17E+01**	1.02E–01	6.78E+01	1.05E+00	–
cf_{18}	5.19E+02	1.65E+01	**4.84E+02**	1.50E+01	+	**3.65E+02**	1.31E+01	3.69E+02	1.31E+01	=	2.30E+02	1.60E+01	**2.20E+02**	2.24E+01	=
cf_{19}	3.91E+01	1.18E+00	**3.62E+01**	1.21E+00	+	**2.16E+01**	1.32E+00	2.31E+01	1.23E+00	=	**4.49E+00**	2.50E–01	6.13E+00	2.13E–01	=
cf_{20}	2.43E+01	1.13E+00	**2.42E+01**	1.30E+00	=	2.41E+01	1.53E+00	2.41E+01	1.51E+00	=	2.28E+01	2.89E+00	**2.22E+01**	2.39E+00	=
cf_{21}	2.03E+02	1.97E–01	**2.00E+02**	1.11E–02	+	6.04E+02	4.38E+02	**3.84E+02**	3.89E+02	=	7.53E+02	4.76E+02	**3.56E+02**	3.35E+02	=
cf_{22}	**1.04E+04**	3.93E+02	1.10E+04	4.52E+02	–	**6.75E+03**	5.32E+02	8.75E+03	4.18E+02	–	**2.75E+02**	1.55E+02	1.25E+03	2.64E+02	–
cf_{23}	1.42E+04	3.55E+02	**1.37E+04**	3.62E+02	+	1.32E+04	5.09E+02	1.33E+04	3.57E+02	=	1.02E+04	3.91E+02	**9.80E+03**	5.92E+02	=
cf_{24}	3.55E+02	6.55E+00	**3.20E+02**	6.67E+00	+	2.26E+02	6.69E+00	**2.23E+02**	7.27E+00	=	2.81E+02	4.43E+01	**2.27E+02**	3.01E+01	+
cf_{25}	4.02E+02	4.75E+00	**3.95E+02**	1.51E+01	=	2.92E+02	8.44E+00	**2.91E+02**	7.01E+00	=	3.74E+02	5.25E+00	**3.71E+02**	7.14E+00	=
cf_{26}	4.06E+02	7.85E+01	**3.12E+02**	1.38E+02	=	2.26E+02	5.46E+01	**2.12E+02**	3.81E+01	+	**2.58E+02**	9.70E+01	3.70E+02	1.12E+02	=
cf_{27}	2.12E+03	3.00E+01	**1.94E+03**	7.07E+01	+	7.24E+02	5.19E+01	**6.40E+02**	1.13E+02	+	1.75E+03	4.72E+01	**1.61E+03**	1.78E+02	+
cf_{28}	4.01E+02	1.44E–01	**4.00E+02**	8.99E–03	+	4.00E+02	6.44E–12	4.00E+02	5.40E–12	=	4.00E+02	6.50E–12	4.00E+02	4.62E–12	=
rf_1	**3.21E+00**	5.19E+00	3.40E+00	5.56E+00	=	**8.65E–01**	2.97E+00	1.30E+00	3.55E+00	=	4.88E+00	6.35E+00	8.17E+00	5.65E+00	=
rf_2	**1.69E+00**	8.97E–02	1.77E+00	8.51E–02	=	**1.55E+00**	5.83E–02	1.56E+00	9.04E–02	=	1.16E+00	2.07E–01	**9.39E–01**	3.01E–01	=
	Total number of (+/=/–): 36/11/7					Total number of (+/=/–): 14/31/9					Total number of (+/=/–): 13/31/10				