TABLE I

DELTAP RESULTS OF SEVEN CMOEAS ON LIRCMOP TEST SUITE. "+", "-", OR "≈" INDICATES THAT THE CORRESPONDING ALGORITHM IS SIGNIFICANTLY BETTER THAN, WORSE THAN, OR COMPARABLE TO DPPCMO. THE BEST AVERAGE DELTAP VALUE ON EACH TEST PROBLEM IS HIGHLIGHTED IN GRAY.

Problem	dpACS	PPS	CMOES	ToP	BiCo	CCMO	DPPCMO
MW1	2.3406e-3 (6.89e-5) −	3.9231e-2 (1.00e-1) −	1.6378e-3 (1.76e-5) −	1.7022e-1 (0.00e+0) ≈	1.8108e-3 (1.08e-3) ≈	1.6241e-3 (3.31e-5) ≈	1.6162e-3 (1.38e-5)
MW2	7.8234e-3 (4.89e-3) +	1.7935e-1 (1.18e-1) −	1.4765e-2 (1.54e-2) +	4.8140e-1 (0.00e+0) ≈	1.4777e-2 (7.07e-3) ≈	2.0447e-2 (8.54e-3) ≈	1.8674e-2 (7.74e-3)
MW3	5.2255e-3 (4.08e-4) −	6.3234e-3 (4.66e-4) −	4.9829e-3 (3.28e-4) −	5.7210e-1 (3.80e-1) −	4.9725e-3 (2.29e-4) −	4.8825e-3 (2.49e-4) −	4.7386e-3 (1.44e-4)
MW4	4.1330e-2 (7.12e-5) −	6.7450e-2 (5.83e-3) −	4.1749e-2 (4.53e-4) −	4.5665e-1 (2.26e-2) −	4.1254e-2 (4.42e-4) −	4.0838e-2 (3.92e-4) ≈	4.0749e-2 (4.17e-4)
MW5	6.7768e-3 (1.72e-3) −	3.9231e-1 (3.53e-1) −	5.4007e-3 (9.43e-4) +	7.4308e-1 (5.91e-2) −	1.3640e-2 (4.16e-2) −	5.1422e-3 (2.29e-3) +	5.7355e-3 (4.38e-4)
MW6	5.7376e-3 (3.08e-3) +	7.0941e-1 (3.69e-1) −	1.3521e-2 (9.88e-3) ≈	7.8408e-1 (3.38e-1) −	8.3889e-3 (4.47e-3) +	2.3128e-2 (1.07e-2) −	1.5245e-2 (7.88e-3)
MW7	6.6212e-3 (9.43e-4) −	5.5509e-3 (4.69e-4) −	4.4123e-3 (2.21e-4) ≈	1.4212e-1 (2.17e-1) −	4.9846e-3 (5.16e-4) −	4.5659e-3 (5.03e-4) ≈	4.2887e-3 (1.95e-4)
MW8	4.7425e-2 (6.21e-4) −	1.9944e-1 (1.22e-1) −	4.4274e-2 (1.84e-3) ≈	6.6642e-1 (3.66e-1) −	4.6066e-2 (3.08e-3) −	4.6124e-2 (3.45e-3) −	4.4219e-2 (1.68e-3)
MW9	2.1747e-2 (8.06e-3) −	3.2408e-1 (2.99e-1) −	3.6609e-2 (1.27e-1) ≈	5.6820e-1 (3.24e-1) −	2.5427e-2 (7.02e-3) −	1.3187e-2 (4.03e-3) ≈	1.2923e-2 (4.24e-3)
MW10	1.6846e-2 (2.02e-2) +	3.5976e-1 (2.05e-1) −	2.0136e-2 (1.27e-2) ≈	NaN (NaN)	3.1904e-2 (2.68e-2) ≈	3.7278e-2 (3.57e-2) ≈	2.4849e-2 (1.89e-2)
MW11	4.4451e-2 (3.54e-2) +	7.3521e-2 (4.03e-3) ≈	7.5061e-2 (4.51e-3) ≈	6.1141e-1 (1.97e-1) −	7.4647e-2 (4.38e-3) ≈	7.5267e-2 (5.87e-3) ≈	7.4740e-2 (4.11e-3)
MW12	7.1129e-3 (2.21e-3) −	2.7949e-1 (2.76e-1) −	5.3741e-3 (2.66e-3) −	8.0501e-1 (1.87e-1) −	4.6921e-3 (9.15e-5) ≈	4.8359e-3 (1.35e-4) −	4.7982e-3 (6.69e-4)
MW13	3.0903e-2 (1.83e-2) +	5.9156e-1 (6.02e-1) −	5.4165e-2 (3.10e-2) ≈	1.0709e+0 (5.90e-1) −	2.5666e-2 (1.84e-2) +	7.0001e-2 (4.94e-2) ≈	5.6165e-2 (2.39e-2)
MW14	1.2702e-1 (2.90e-3) −	1.7908e-1 (4.60e-2) −	1.0066e-1 (2.46e-3) −	4.8693e-1 (4.80e-1) −	9.7997e-2 (1.50e-3) ≈	9.7836e-2 (2.10e-3) ≈	9.7441e-2 (1.55e-3)
LIRCMOP1	1.0113e-1 (2.54e-2) −	7.3558e-3 (1.35e-3) +	1.5426e-2 (4.37e-3) −	1.2197e-1 (9.85e-2) −	1.0727e-2 (2.97e-3) ≈	4.4523e-2 (3.18e-2) −	1.0359e-2 (2.52e-3)
LIRCMOP2	6.4303e-2 (4.46e-2) −	6.0716e-3 (3.80e-4) +	2.1300e-2 (1.14e-2) −	9.3071e-2 (8.76e-2) −	8.3972e-3 (3.26e-3) ≈	8.6452e-2 (3.67e-2) −	8.8771e-3 (2.95e-3)
LIRCMOP3	1.0064e-1 (4.71e-2) −	4.3781e-3 (1.88e-3) +	6.5986e-2 (3.39e-2) −	3.3763e-1 (8.24e-2) −	1.3542e-2 (8.50e-3) ≈	1.3622e-1 (5.82e-2) −	2.0941e-2 (2.28e-2)
LIRCMOP4	1.0094e-1 (5.87e-2) −	3.3243e-3 (2.62e-4) +	5.7520e-2 (2.99e-2) −	3.1319e-1 (4.74e-2) −	1.4149e-2 (1.06e-2) ≈	1.2315e-1 (3.81e-2) −	1.9085e-2 (1.68e-2)
LIRCMOP5	4.5516e-3 (2.72e-4) +	6.5484e-3 (7.14e-4) −	9.7056e-3 (9.26e-3) −	7.6949e-2 (2.11e-1) −	6.0455e-1 (5.42e-1) −	5.1341e-3 (1.84e-4) ≈	5.7684e-3 (2.99e-3)
LIRCMOP6	4.4324e-3 (3.32e-4) +	7.9754e-3 (1.13e-3) −	5.6030e-3 (4.96e-4) −	5.8258e-2 (2.51e-1) −	4.5723e-1 (6.65e-1) −	5.3344e-3 (3.11e-4) ≈	5.2235e-3 (2.51e-4)
LIRCMOP7	8.4923e-3 (6.47e-4) +	2.5697e-2 (3.95e-2) −	1.1681e-2 (1.28e-2) ≈	2.6761e-2 (3.63e-2) −	9.1809e-2 (9.38e-2) −	9.7524e-3 (1.38e-2) ≈	1.1887e-2 (1.39e-2)
LIRCMOP8	8.2769e-3 (5.65e-4) +	1.7886e-2 (2.08e-2) −	8.4192e-3 (4.49e-3) +	4.5520e-2 (7.93e-2) −	4.4630e-2 (6.60e-2) −	7.1944e-3 (1.83e-4) ≈	1.0151e-2 (9.84e-3)
LIRCMOP9	4.2269e-3 (1.87e-4) −	3.2015e-3 (1.05e-4) −	2.6740e-3 (7.27e-5) −	2.3419e-1 (1.79e-1) −	1.0503e-1 (6.37e-2) −	2.6387e-3 (6.07e-5) −	2.5323e-3 (7.66e-5)
LIRCMOP10	5.7131e-3 (1.82e-4) −	5.3026e-3 (1.97e-4) −	4.7280e-3 (1.64e-4) −	5.4938e-3 (2.33e-4) −	4.5539e-2 (8.62e-2) −	4.5640e-3 (1.57e-4) −	4.4563e-3 (1.40e-4)
LIRCMOP11	6.8468e-3 (4.19e-4) +	8.8243e-3 (3.28e-4) +	9.7610e-3 (1.71e-4) −	1.3563e-1 (8.54e-2) −	1.1810e-2 (3.42e-3) −	9.7684e-3 (1.82e-4) −	9.6606e-3 (1.84e-4)
LIRCMOP12	5.4649e-3 (5.54e-4) −	5.3588e-3 (1.70e-4) −	4.5732e-3 (2.44e-4) ≈	3.8014e-2 (5.54e-2) −	9.0985e-3 (7.09e-3) −	4.6235e-3 (2.24e-4) −	4.5665e-3 (1.08e-4)
LIRCMOP13	9.3308e-2 (1.24e-4) ≈	1.2652e-1 (1.26e-2) −	1.0687e-1 (1.60e-3) −	1.2669e-1 (4.38e-3) −	9.3742e-2 (1.10e-3) ≈	1.0754e-1 (1.51e-3) −	9.3316e-2 (1.00e-3)
LIRCMOP14	9.6762e-2 (3.31e-4) −	1.1779e-1 (2.94e-3) −	9.9962e-2 (1.13e-3) −	1.2027e-1 (3.12e-3) −	9.6022e-2 (1.15e-3) −	1.0019e-1 (9.70e-4) −	9.5279e-2 (1.09e-3)
DASCMOP1	5.0438e-3 (9.27e-4) −	1.8937e-1 (2.30e-1) −	3.0449e-3 (2.11e-4) −	7.5376e-1 (1.18e-1) −	7.0083e-1 (3.11e-2) −	3.0979e-3 (2.67e-4) −	2.8083e-3 (1.45e-4)
DASCMOP2	5.9508e-3 (3.77e-4) −	5.0999e-3 (1.83e-4) −	4.3454e-3 (9.90e-5) −	5.3212e-1 (2.67e-1) −	2.3719e-1 (3.14e-2) −	4.3447e-3 (9.61e-5) −	4.1548e-3 (7.62e-5)
DASCMOP3	1.9486e-2 (1.28e-3) −	2.7480e-1 (1.26e-1) −	1.8833e-2 (2.00e-3) +	6.7875e-1 (1.19e-1) −	2.7820e-1 (5.25e-2) −	1.9710e-2 (4.61e-4) −	1.9122e-2 (1.24e-3)
DASCMOP4	3.3641e-2 (1.53e-1) −	1.7909e-1 (6.27e-2) −	3.2742e-2 (1.18e-1) −	NaN (NaN)	1.2257e-3 (8.91e-5) −	1.2470e-3 (5.24e-4) ≈	1.1508e-3 (1.44e-5)
DASCMOP5	8.6845e-3 (1.99e-3) −	4.2813e-3 (2.53e-4) −	3.9205e-3 (6.07e-4) −	NaN (NaN)	2.7224e-3 (6.22e-5) −	2.6962e-3 (4.93e-5) ≈	2.6892e-3 (3.34e-5)
DASCMOP6	4.9323e-2 (1.22e-1) −	1.2144e-1 (2.13e-1) −	2.3936e-2 (2.11e-2) −	NaN (NaN)	4.4628e-2 (9.48e-2) ≈	2.0667e-2 (7.16e-3) ≈	1.9705e-2 (4.31e-3)
DASCMOP7	8.0623e-2 (9.23e-2) −	5.6928e-2 (8.33e-3) −	1.2636e-1 (3.00e-1) −	NaN (NaN)	3.1668e-2 (8.53e-4) −	3.1093e-2 (6.67e-4) ≈	3.0892e-2 (5.54e-4)
DASCMOP8	7.4827e-2 (8.45e-3) −	7.2362e-2 (9.87e-3) −	9.4563e-2 (1.86e-1) −	NaN (NaN)	4.0921e-2 (9.85e-4) ≈	4.0733e-2 (7.86e-4) ≈	4.0582e-2 (7.97e-4)
DASCMOP9	5.0687e-2 (2.45e-3) −	1.0196e-1 (5.39e-2) −	4.1104e-2 (8.76e-4) −	5.9079e-1 (2.46e-1) −	3.1144e-1 (5.88e-2) −	4.1200e-2 (1.34e-3) −	4.0515e-2 (9.83e-4)
DOC1	9.1903e-3 (1.28e-3) −	1.0629e-1 (1.11e-1) −	4.3881e-2 (4.68e-2) −	5.8519e-3 (2.53e-4) −	1.1527e-2 (8.68e-3) −	5.9074e-3 (6.29e-4) −	5.3709e-3 (5.38e-4)
DOC2	3.5812e-1 (1.57e-1) −	4.8332e-1 (1.53e-1) −	NaN (NaN)	4.4378e-1 (8.31e-2) −	NaN (NaN)	2.2389e-2 (8.09e-2) −	4.4037e-3 (1.08e-3)
DOC3	6.7589e+2 (5.66e+2) ≈	2.4608e+2 (1.57e+2) +	6.4570e+2 (4.87e+2) ≈	1.2458e+2 (1.38e+2) +	4.6533e+2 (1.53e+2) ≈	5.5954e+2 (4.80e+2) ≈	6.2577e+2 (4.19e+2)
DOC4	8.0080e-2 (2.01e-2) −	3.9643e-1 (1.35e-1) −	4.7807e-2 (1.47e-2) −	5.1264e-2 (3.96e-2) ≈	2.4274e-1 (1.51e-1) −	4.4668e-2 (1.94e-2) −	3.1785e-2 (1.23e-2)
DOC5	6.6820e+0 (1.46e+1) −	7.2283e+1 (1.31e+2) −	1.8754e+1 (4.69e+1) ≈	3.5142e+1 (5.41e+1) −	NaN (NaN)	6.6037e+0 (2.92e+1) ≈	6.6464e+0 (2.92e+1)
DOC6	7.9510e+0 (4.29e+0) −	7.0405e+0 (7.23e+0) −	9.6052e-1 (1.75e+0) −	1.7921e+1 (1.87e+1) −	1.0290e+0 (8.27e-1) −	6.8781e-2 (1.13e-1) −	7.7160e-3 (1.97e-3)
DOC7	3.3029e-1 (1.45e-1) −	5.5085e-1 (2.15e-1) −	7.3429e-2 (2.17e-1) −	4.7661e-1 (4.51e-1) −	5.0347e+0 (1.73e+0) −	2.6719e-2 (1.06e-1) −	5.6839e-3 (1.34e-3)
DOC8	3.0766e+0 (1.40e+0) −	2.4544e+2 (6.19e+1) −	1.8667e-1 (1.98e-1) −	2.9336e+1 (1.99e+1) −	7.8042e+1 (7.76e+1) −	1.7249e-1 (5.14e-2) −	8.3757e-2 (7.68e-2)
DOC9	3.3388e-1 (6.43e-2) +	8.3483e-1 (4.34e-2) −	6.3903e-1 (2.80e-2) +	7.0232e-1 (5.96e-2) −	7.0241e-1 (3.63e-2) −	6.4745e-1 (2.93e-2) +	6.6334e-1 (2.64e-2)
+/ − / ≈	11/33/2	6/39/1	5/29/11	1/36/3	2/28/14	2/24/20	