Supplementary File of “Multiobjective Multitasking Optimization with Decomposition-based

Transfer Selection”

Qiuzhen Lin, Member*, IEEE*, Zhongjian Wu, Lijia Ma, Maoguo Gong, Senior Member*, IEEE*,

Jianqiang Li, and Carlos A. Coello Coello, *Fellow*, IEEE

**TABLE A.I**

THE MEAN VALUES AND STANDARD DEVIATIONS of IGD and MSS RESULTS OBTAINED BY THE COMPARED VARIANTS IN CEC2017

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CEC2017 | NO-KT | | NO-DTS | | KT-1 | | KT-2 | | MMTEA-DTS | |
| IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS |
| CIHS1 | 3.23E-03 +  (1.00E-03) | 2.35 + | 2.18E-04 +  (2.57E-05) | 0.37 + | 1.80E-04 +  (1.04E-05) | -0.02 + | **1.75E-04 ≈**  **(3.80E-06)** | **-0.09 -** | 1.76E-04 (5.08E-06) | -0.05 |
| CIHS2 | 3.04E-03 +  (6.48E-04) | 1.30E-03 +  (2.31E-04) | 5.12E-04 +  (1.15E-04) | **3.69E-04 –**  **(6.53E-05)** | 4.42E-04 (7.70E-05) |
| CIMS1 | 1.53E-02 +  (1.41E-02) | 1.42 + | 1.41E-04 +  (4.03E-07) | 0.71 + | 1.41E-04 ≈  (9.44E-08) | 0.00 + | 1.41E-04 +  (1.21E-07) | -0.19 + | **1.41E-04 (8.60E-08)** | **-0.20** |
| CIMS2 | 1.74E-04 +  (5.22E-07) | 1.75E-04 +  (6.35E-07) | 1.74E-04 +  (3.64E-07) | 1.74E-04 ≈  (1.55E-07) | **1.74E-04 (1.53E-07)** |
| CILS1 | 8.58E-01 +  (6.09E-01) | 2.21 + | 5.10E-04 +  (8.68E-05) | 0.05 + | 1.97E-04 +  (4.74E-05) | -0.01 + | 1.83E-04 ≈  (5.23E-06) | -0.01 + | **1.82E-04 (8.13E-06)** | **-0.02** |
| CILS2 | 3.21E-04 +  (2.35E-05) | 1.71E-04 +  (1.69E-06) | 1.62E-04 ≈  (1.58E-06) | 1.62E-04 ≈  (1.72E-06) | **1.62E-04 (1.52E-06)** |
| PIHS1 | 1.61E-03 +  (3.85E-04) | 2.04 + | 9.91E-04 +  (3.57E-04) | 0.32 + | 1.05E-03 +  (3.46E-04) | 0.25 + | **4.48E-04 –**  **(1.09E-04)** | **-0.35 -** | 5.50E-04 (1.63E-04) | -0.25 |
| PIHS2 | 2.62E+00 +  (5.07E-01) | 2.80E-01 +  (2.13E-01) | 1.03E-02 +  (1.24E-02) | **2.89E-03 ≈**  **(4.15E-03)** | 3.69E-03 (5.41E-03) |
| PIMS1 | 4.45E-03 ≈  (1.50E-03) | 0.28 + | **3.10E-03 –**  **(1.43E-03)** | **-0.28 -** | 6.07E-02 ≈  (8.94E-02) | 0.53 + | 1.43E-02 ≈  (1.69E-02) | -0.22 - | 1.45E-02 (1.70E-02) | -0.08 |
| PIMS2 | 1.77E+01 +  (5.73E+00) | 1.26E+01 ≈  (4.09E+00) | 1.43E+01 ≈ (3.90E+00) | **1.20E+01 ≈**  **(4.06E+00)** | 1.33E+01 (3.76E+00) |
| PILS1 | **3.03E-04 –**  **(1.16E-04)** | 1.16 + | 4.56E-04 ≈  (2.74E-04) | 0.97 + | 4.47E-04 ≈  (2.96E-04) | 0.31 + | 3.92E-04 ≈  (1.53E-04) | 0.18 + | 3.86E-04 (1.46E-04) | **0.17** |
| PILS2 | 6.31E-01 +  (2.96E-03) | 3.42E-01 +  (1.55E-01) | **8.18E-04 ≈**  **(2.52E-04)** | 8.76E-04 ≈  (2.78E-04) | 9.37E-04 (3.50E-04) |
| NIHS1 | 2.02E+01 +  (4.00E+01) | 1.62 + | 1.52E+00 +  (1.26E-02) | 0.14 + | **1.45E+00 ≈**  **(2.32E-02)** | 0.00 + | 1.45E+00 ≈  (2.43E-02) | **-0.11 -** | 1.46E+00 (2.00E-02) | -0.10 |
| NIHS2 | 1.15E-03 +  (2.81E-04) | 3.94E-04 +  (8.97E-05) | 2.86E-04 +  (5.52E-05) | **2.04E-04 ≈**  **(1.33E-05)** | 2.12E-04 (1.72E-05) |
| NIMS1 | 2.13E-01 +  (2.10E-01) | 0.97 + | 1.58E-01 +  (1.07E-01) | 0.34 + | **9.89E-02 ≈**  **(1.01E-02)** | **-0.05 -** | 9.99E-02 ≈  (1.34E-02) | -0.03 + | 1.02E-01 (1.23E-02) | -0.04 |
| NIMS2 | 3.01E-03 +  (4.63E-03) | 9.13E-04 +  (3.09E-03) | 1.96E-04 ≈  (3.07E-05) | 2.49E-04 +  (8.48E-05) | **1.89E-04 (3.81E-05)** |
| NILS1 | 8.75E-04 +  (7.07E-05) | 0.13 + | 8.85E-04 +  (7.49E-05) | **-0.14 -** | 8.42E-04 ≈  (4.52E-05) | -0.04 - | 8.57E-04 ≈  (7.44E-05) | 0.16 + | **8.36E-04 (2.12E-05)** | -0.01 |
| NILS2 | 5.91E-01 –  (1.58E-01) | **5.13E-01 –**  **(2.37E-01)** | 5.89E-01 ≈  (1.62E-01) | 6.42E-01 ≈  (4.00E-04) | 6.42E-01 (1.32E-04) |
| ≈/+/- | 1/15/2 | 0/9/0 | 2/14/2 | 0/7/2 | 11/7/0 | 0/7/2 | 14/2/2 | 0/5/4 | / | **/** |
| Rank | 4.61 | | 3.80 | | 2.39 | | 2.16 | | **2.04** | |

**TABLE A.II**

THE MEAN VALUES AND STANDARD DEVIATIONS of IGD and MSS RESULTS OBTAINED BY THE COMPARED VARIANTS IN CEC2019

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CEC2019 | NO-KT | | NO-DTS | | KT-1 | | KT-2 | | MMTEA-DTS | |
| IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS |
| CPLX1\_1 | 2.41E-04 ≈(2.12E-05) | 0.35 + | 2.51E-04 ≈(2.55E-05) | 1.06 + | **2.38E-04 ≈(1.68E-05)** | **-0.09 -** | 2.51E-04 ≈(2.37E-05) | 0.30 - | 2.50E-04 (2.54E-05) | 0.32 |
| CPLX1\_2 | 3.68E-04 + (3.88E-05) | 4.18E-04 +  (7.12E-05) | **3.32E-04 -(2.00E-05)** | 3.43E-04 ≈(1.74E-05) | 3.46E-04 (2.10E-05) |
| CPLX2\_1 | 2.42E-04 ≈(1.96E-05) | 1.24 + | 2.51E-04 ≈(2.37E-05) | 0.38 + | **2.41E-04 ≈(1.89E-05)** | **0.11 -** | 2.48E-04 ≈(2.51E-05) | 0.28 + | 2.44E-04 ≈(1.96E-05) | 0.19 |
| CPLX2\_2 | 5.86E-03 + (2.49E-03) | 7.94E-04 +  (1.57E-04) | 7.48E-04 ≈(3.07E-04) | **6.70E-04 ≈(2.21E-04)** | 7.17E-04 (2.21E-04) |
| CPLX3\_1 | 2.19E-03 + (5.37E-04) | 0.29 + | 2.02E-03 +  (3.91E-04) | 0.59 + | 1.51E-03 ≈(4.76E-04) | 0.12 + | **1.39E-03 ≈(2.61E-04)** | **-0.11 -** | 1.47E-03 (4.21E-04) | -0.09 |
| CPLX3\_2 | **1.23E-03** -**(1.89E-04)** | 1.42E-03 ≈(2.24E-04) | 1.42E-03 ≈(1.73E-04) | 1.37E-03 ≈(1.89E-04) | 1.35E-03 (1.95E-04) |
| CPLX4\_1 | 2.14E-03 + (7.18E-04) | 1.74 + | 2.06E-03 +  (4.44E-04) | 1.12 + | **1.11E-03 ≈(9.62E-05)** | **-0.12 -** | 1.15E-03 ≈(1.00E-04) | -0.02 + | 1.14E-03 (2.04E-04) | -0.07 |
| CPLX4\_2 | 3.10E-03 + (1.09E-03) | 2.02E-03 +  (4.81E-04) | **1.11E-03 ≈(9.50E-05)** | 1.25E-03 ≈(9.19E-05) | 1.15E-03 (2.35E-04) |
| CPLX5\_1 | 1.50E-03 + (2.13E-04) | 0.16 + | 1.59E-03 +  (2.14E-04) | 0.54 + | 1.26E-03 ≈(1.61E-04) | -0.08 + | 1.25E-03 ≈(1.81E-04) | -0.18 + | **1.25E-03 (1.65E-04)** | **-0.23** |
| CPLX5\_2 | 5.06E-03 ≈(7.79E-04) | 5.35E-03 ≈(7.62E-04) | **5.46E-03 ≈(8.53E-04)** | 5.36E-03 ≈(5.42E-04) | 5.30E-03 (8.13E-04) |
| CPLX6\_1 | 1.51E-03 ≈(2.23E-04) | 0.38 + | 1.59E-03 ≈(2.19E-04) | 0.39 + | 1.57E-03 ≈(1.77E-04) | -0.03 + | 1.52E-03 ≈(1.50E-04) | -0.24 + | **1.49E-03 (1.92E-04)** | **-0.25** |
| CPLX6\_2 | 2.86E-03 + (1.13E-03) | 2.57E-03 +  (5.58E-04) | 2.02E-03 ≈(4.00E-04) | **1.90E-03 ≈(4.16E-04)** | 1.99E-03 (2.90E-04) |
| CPLX7\_1 | 1.23E-03 + (1.46E-04) | 0.57 + | 1.19E-03 +  (1.53E-04) | 0.37 + | 1.06E-03 ≈(1.78E-04) | **-0.27 -** | **9.99E-04 ≈(1.51E-04)** | -0.24 + | 1.02E-03 (1.59E-04) | -0.26 |
| CPLX7\_2 | 1.48E-03 ≈(3.03E-04) | 1.44E-03 ≈(2.99E-04) | **1.27E-03 ≈(2.18E-04)** | 1.38E-03 ≈(2.92E-04) | 1.34E-03 (2.61E-04) |
| CPLX8\_1 | **1.48E-03 -(2.68E-04)** | 0.41 + | 1.54E-03 ≈(3.02E-04) | 0.20 + | 1.63E-03 ≈(3.07E-04) | **-0.09 -** | 1.68E-03 ≈(2.59E-04) | 0.02 + | 1.66E-03 (2.39E-04) | -0.05 |
| CPLX8\_2 | 3.45E-03 + (2.03E-03) | 2.34E-03 +  (1.74E-03) | 8.66E-04 ≈(5.37E-04) | 9.23E-04 ≈(7.11E-04) | **8.15E-04 (8.61E-04)** |
| CPLX9\_1 | 4.97E-03 ≈(6.20E-04) | 0.31 + | 5.06E-03 ≈(5.90E-04) | 0.60 + | 5.18E-03 ≈(5.67E-04) | **-0.07 -** | 5.35E-03 ≈(1.37E-03) | -0.01 - | **5.29E-03 (5.13E-04)** | 0.06 |
| CPLX9\_2 | 2.55E-03 + (7.47E-04) | 2.89E-03 +  (9.34E-04) | 1.82E-03 ≈(2.17E-04) | **1.75E-03** -**(1.89E-04)** | 1.91E-03 (2.82E-04) |
| CPLX10\_1 | 6.27E-03 + (2.80E-03) | 1.73 + | 5.58E-03 +  (2.49E-03) | 1.07 + | 1.74E-03 ≈(9.26E-04) | -0.10 + | 1.50E-03 ≈(9.37E-04) | -0.24 + | **1.39E-03 (7.85E-04)** | **-0.26** |
| CPLX10\_2 | 1.07E-02 + (3.17E-03) | 6.80E-03 +  (1.61E-03) | 3.29E-03 +  (1.13E-03) | 2.57E-03 ≈(1.10E-03) | **2.52E-03 (8.74E-04)** |
| ≈/+/- | 6/12/2 | 0/10/0 | 8/12/0 | 0/10/0 | 18/1/1 | 0/4/6 | 19/0/1 | 0/7/3 | / | / |
| Rank | 4.04 | | 3.83 | | 2.40 | | 2.41 | | **2.32** | |

**TABLE A.III**

THE MEAN VALUES AND STANDARD DEVIATIONS of IGD and MSS RESULTS OBTAINED BY THE COMPARED VARIANTS IN CEC2021

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ETMO2021 | NO-KT | | NO-DTS | | KT-1 | | KT-2 | | MMTEA-DTS | |
| IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS |
| ETMOF1\_1 | 9.73E-04 +  (1.17E-04) | 1.66 + | 7.28E-04 +  (6.91E-05) | 0.20 + | 6.75E-04 ≈  (5.43E-05) | -0.07 + | **6.46E-04 ≈**  **(5.84E-05)** | **-0.20** - | 6.52E-04 (5.95E-05) | -0.17 |
| ETMOF1\_2 | 3.25E-03 +  (2.41E-03) | 1.68E-03 +  (1.75E-04) | 1.45E-03 ≈  (1.24E-04) | **1.38E-03 ≈**  **(1.39E-04)** | 1.41E-03 (1.21E-04) |
| ETMOF2\_1 | 7.89E-04 +  (1.46E-04) | 1.98 + | 6.61E-04 +  (9.54E-05) | 0.94 + | 3.77E-04 ≈  (4.36E-05) | -0.21 + | **3.64E-04 ≈**  **(3.70E-05)** | **-0.35** - | 3.79E-04 (3.56E-05) | -0.23 |
| ETMOF2\_2 | 9.44E-03 +  (4.42E-04) | 8.15E-03 +  (2.37E-04) | 7.38E-03 ≈  (3.06E-04) | **7.18E-03 ≈**  **(3.23E-04)** | 7.34E-03 (3.14E-04) |
| ETMOF3\_1 | 3.18E-03 +  (1.72E-03) | 0.88 + | 2.55E-03 +  (1.26E-03) | 0.22 + | 3.39E-03 +  (3.07E-03) | 0.50 + | 2.02E-03 ≈  (1.22E-03) | -0.01 + | **1.95E-03 (4.05E-04)** | **-0.05** |
| ETMOF3\_2 | 3.74E-03 +  (9.02E-04) | 2.95E-03 ≈  (5.62E-04) | 3.03E-03 ≈  (1.06E-03) | **2.73E-03 ≈**  **(5.24E-04)** | 2.84E-03 (5.18E-04) |
| ETMOF4\_1 | 5.45E+00 + (3.89E+00) | 0.88 + | 3.65E+00 + (1.53E+00) | 0.18 + | 4.52E+00 ≈  (4.17E+00) | 0.31 + | 2.94E+00 ≈  (2.52E+00) | -0.09 + | **2.78E+00 (2.65E+00)** | **-0.19** |
| ETMOF4\_2 | 5.62E-01 +  (3.75E-01) | 3.98E-01 +  (4.00E-02) | 3.96E-01 +  (6.95E-02) | 3.52E-01 ≈  (3.80E-02) | **3.47E-01 (5.89E-02)** |
| ETMOF5\_1 | 2.68E-01 +  (2.11E-03) | 0.78 + | 2.42E-01 ≈  (7.21E-02) | 0.39 + | 2.69E-01 +  (2.05E-03) | -0.04 + | 2.67E-01 ≈  (2.33E-03) | -0.08 + | **2.66E-01 (2.68E-03)** | **-0.12** |
| ETMOF5\_2 | 4.25E-01 +  (9.33E-02) | 4.23E-01 +  (1.12E-01) | 2.42E-01 ≈  (1.57E-02) | 2.37E-01 ≈  (2.33E-02) | **2.34E-01 (2.58E-02)** |
| ETMOF6\_1 | 1.12E+00 +  (1.50E-01) | 0.89 + | 1.25E+00 +  (1.93E-01) | 1.38 + | **6.35E-01 ≈**  **(2.10E-01)** | **-0.31 -** | 6.49E-01 ≈  (1.60E-01) | -0.29 - | 6.65E-01 (2.01E-01) | -0.26 |
| ETMOF6\_2 | 1.58E-01 +  (1.19E-01) | 2.35E-01 +  (2.00E-01) | **4.12E-02 ≈**  **(2.38E-02)** | 4.10E-02 ≈  (2.13E-02) | 4.27E-02 (3.41E-02) |
| ETMOF7\_1 | 5.20E-03 +  (4.08E-03) | 0.65 + | **1.05E-03 –**  **(2.24E-04)** | **-0.04** **-** | 1.83E-03 ≈  (3.80E-03) | 0.30 + | 1.51E-03 ≈  (1.42E-03) | 0.02 - | 1.69E-03 (1.22E-03) | 0.04 |
| ETMOF7\_2 | 1.63E-02 –  (9.75E-04) | **1.59E-02 –**  **(1.35E-03)** | 7.35E-02 ≈  (3.13E-01) | 1.70E-02 ≈  (5.36E-03) | 1.87E-02 (6.44E-03) |
| ETMOF7\_3 | 2.26E-02 ≈  (3.39E-03) | **2.07E-02 ≈**  **(2.32E-03)** | 2.10E-02 ≈  (4.08E-03) | 2.22E-02 ≈  (3.79E-03) | 2.18E-02 (3.33E-03) |
| ETMOF8\_1 | 1.12E-02 +  (5.53E-03) | 0.91 + | 8.85E-03 +  (8.93E-04) | 0.24 + | **7.37E-03 ≈**  **(6.29E-04)** | 0.03 + | 7.47E-03 ≈  (7.22E-04) | 0.17 + | 7.58E-03 (8.01E-04) | **-0.34** |
| ETMOF8\_2 | 4.63E-03 +  (8.49E-04) | 2.75E-03 +  (5.51E-04) | 2.32E-03 +  (6.10E-04) | 2.56E-03 ≈  (1.71E-04) | **1.99E-03 (2.00E-04)** |
| ETMOF8\_3 | 3.37E-03 +  (1.10E-03) | 1.55E-03 +  (1.90E-04) | 1.41E-03 +  (1.55E-04) | 1.45E-03 ≈  (5.33E-05) | **1.29E-03 (8.99E-05)** |
| ≈/+/- | 1/16/1 | 0/8/0 | 3/13/2 | 0/7/1 | 13/5/0 | 0/7/1 | 18/0/0 | 0/4/4 | **/** | **/** |
| Rank | 4.43 | | 3.62 | | 2.50 | | 2.23 | | **1.70** | |

**TABLE A.IV**

THE MEAN VALUES AND STANDARD DEVIATIONS of IGD and MSS RESULTS OBTAINED BY THE COMPARED VARIANTS IN CEC2017

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CEC2017 | *a* = 1 | | *a* = 3 | | *a* = 5 | | *a* = 7 | | *a* = 9 | |
| IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS |
| CIHS1 | 2.18E-04 +  (2.57E-05) | 2.18 + | 1.77E-04 ≈(3.70E-06) | -0.02 + | 1.76E-04 (5.08E-06) | **-0.02** | 1.76E-04 ≈(3.36E-06) | 0.02 + | **1.76E-04 ≈(2.65E-06)** | 0.02 + |
| CIHS2 | 1.30E-03 +  (2.31E-04) | 4.44E-04 ≈(9.05E-05) | **4.42E-04 (7.70E-05)** | 4.69E-04 ≈(8.62E-05) | 4.79E-04 +  (6.99E-05) |
| CIMS1 | 1.41E-04 +  (4.03E-07) | 1.50 + | **1.41E-04 -(4.67E-08)** | **-0.27 -** | 1.41E-04 (8.60E-08) | -0.13 | 1.41E-04 ≈(8.91E-08) | 0.03 + | 1.41E-04 ≈(1.08E-07) | 0.27 + |
| CIMS2 | 1.75E-04 +  (6.35E-07) | **1.73E-04 ≈(1.42E-07)** | 1.74E-04 (1.53E-07) | 1.74E-04 +  (2.21E-07) | 1.74E-04 +  (2.27E-07) |
| CILS1 | 5.10E-04 +  (8.68E-05) | 2.19 + | 1.83E-04 ≈(8.97E-06) | -0.15 + | **1.82E-04 (8.13E-06)** | **-0.17** | 1.86E-04 +  (9.54E-06) | -0.09 + | 1.92E-04 +  (1.08E-05) | -0.10 + |
| CILS2 | 1.71E-04 +  (1.69E-06) | 1.62E-04 ≈(1.64E-06) | 1.62E-04 (1.52E-06) | **1.62E-04 ≈(1.34E-06)** | 1.62E-04 ≈(1.61E-06) |
| PIHS1 | 9.91E-04 +  (3.57E-04) | 1.77 + | 6.13E-04 ≈(1.54E-04) | 0.15 + | 5.50E-04 (1.63E-04) | 0.03 | 4.64E-04 -(1.22E-04) | -0.12 - | **4.48E-04 -(9.49E-05)** | **-0.14 -** |
| PIHS2 | 2.80E-01 +  (2.13E-01) | 4.94E-03 +  (7.38E-03) | **3.69E-03 (5.41E-03)** | 4.53E-03 ≈(6.75E-03) | 4.96E-03 ≈(1.03E-02) |
| PIMS1 | 3.10E-03 -(1.43E-03) | **-0.27 -** | 1.55E-02 ≈(2.30E-02) | 0.01 - | 1.45E-02 (1.70E-02) | 0.20 | 7.79E-03 ≈(1.33E-02) | -0.05 - | **2.58E-03 -(1.18E-03)** | -0.13 - |
| PIMS2 | 1.26E+01 ≈(4.09E+00) | **1.15E+01 ≈(4.05E+00)** | 1.33E+01 (3.76E+00) | 1.31E+01 ≈(4.15E+00) | 1.39E+01 ≈(3.54E+00) |
| PILS1 | 4.56E-04 ≈(2.74E-04) | 1.26 + | 6.72E-04 ≈(1.01E-03) | 0.36 + | 3.86E-04 (1.46E-04) | 0.07 | 3.82E-04 -(2.18E-04) | 0.07 + | **3.75E-04 ≈(1.80E-04)** | **0.06 -** |
| PILS2 | 3.42E-01 +  (1.55E-01) | 1.07E-03 +  (3.37E-04) | **9.37E-04 (3.50E-04)** | 9.51E-04 ≈(3.41E-04) | 1.09E-03 ≈(5.68E-04) |
| NIHS1 | 1.52E+00 +  (1.26E-02) | 1.89 + | **1.46E+00 ≈(1.70E-02)** | -0.21 + | 1.46E+00 (2.00E-02) | **-0.23** | 1.46E+00 ≈(2.14E-02) | -0.20 + | 1.47E+00 +  (1.49E-02) | 0.01 + |
| NIHS2 | 3.94E-04 +  (8.97E-05) | 2.15E-04 ≈(1.53E-05) | **2.12E-04 (1.72E-05)** | 2.16E-04 ≈(1.62E-05) | 2.15E-04 ≈(1.84E-05) |
| NIMS1 | 1.58E-01 +  (1.07E-01) | 0.58 + | 1.18E-01 ≈(1.23E-01) | 0.08 + | **1.02E-01 (1.23E-02)** | **-0.05** | 1.09E-01 ≈(1.45E-02) | -0.01 + | 1.13E-01 +  (8.48E-03) | 0.03 + |
| NIMS2 | 9.13E-04 +  (3.09E-03) | 2.56E-04 +  (1.16E-04) | 1.89E-04 (3.81E-05) | **1.80E-04 ≈(2.72E-05)** | 2.02E-04 ≈(5.69E-05) |
| NILS1 | 8.85E-04 +  (7.49E-05) | **-0.17 -** | **8.35E-04 ≈(3.60E-05)** | -0.15 - | 8.36E-04 (2.12E-05) | 0.00 | 8.66E-04 ≈(1.04E-04) | 0.23 + | 8.41E-04 ≈(2.61E-05) | -0.03 - |
| NILS2 | **5.13E-01 -(2.37E-01)** | 6.02E-01 ≈(1.49E-01) | 6.42E-01 (1.32E-04) | 6.42E-01 ≈(1.88E-06) | 6.23E-01 ≈(1.04E-01) |
| ≈/+/- | 2/14/2 | 0/7/2 | 14/3/1 | 0/6/3 | / | / | 14/2/2 | 0/7/2 | 11/5/2 | 0/5/4 |
| Rank | 4.57 | | 2.41 | | **2.29** | | 2.64 | | 3.09 | |

**TABLE A.V**

THE MEAN VALUES AND STANDARD DEVIATIONS of IGD and MSS RESULTS OBTAINED BY THE COMPARED VARIANTS IN CEC2019

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CEC2019 | *a* = 1 | | *a* = 3 | | *a* = 5 | | *a* = 7 | | *a* = 9 | |
| IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS |
| CPLX1\_1 | 2.51E-04 ≈(2.55E-05) | 1.10 + | 2.51E-04 ≈(2.58E-05) | 0.28 - | 2.50E-04 (2.54E-05) | 0.33 | 2.46E-04 ≈(2.40E-05) | **0.16 +** | **2.45E-04 ≈(2.11E-05)** | 0.19 - |
| CPLX1\_2 | 4.18E-04 +  (7.12E-05) | 3.41E-04 ≈(2.05E-05) | 3.46E-04 (2.10E-05) | **3.39E-04 ≈(1.54E-05)** | 3.43E-04 ≈(2.20E-05) |
| CPLX2\_1 | 2.51E-04 ≈(2.37E-05) | 0.53 + | 2.53E-04 ≈(2.53E-05) | 0.51 + | 2.44E-04 (1.96E-05) | 0.22 | **2.42E-04 ≈(2.42E-05)** | **0.10 -** | 2.51E-04 ≈(2.45E-05) | 0.61 + |
| CPLX2\_2 | 7.94E-04 +  (1.57E-04) | 7.69E-04 +  (3.14E-04) | 7.17E-04 (2.21E-04) | **6.84E-04 ≈(2.25E-04)** | 8.38E-04 ≈(2.54E-04) |
| CPLX3\_1 | 2.02E-03 +  (3.91E-04) | 0.64 + | **1.30E-03 -(1.43E-04)** | **-0.36** - | 1.47E-03 (4.21E-04) | -0.17 | 1.56E-03 ≈(4.15E-04) | 0.08 + | 1.62E-03 +  (4.03E-04) | 0.30 + |
| CPLX3\_2 | 1.42E-03 ≈(2.24E-04) | **1.35E-03 ≈(1.38E-04)** | 1.35E-03 (1.95E-04) | 1.40E-03 ≈(1.78E-04) | 1.46E-03 +  (1.79E-04) |
| CPLX4\_1 | 2.06E-03 +  (4.44E-04) | 1.95 + | 1.15E-03 ≈(1.25E-04) | -0.07 + | **1.14E-03 (2.04E-04)** | **-0.15** | 1.22E-03 +  (1.06E-04) | 0.04 + | 1.25E-03 +  (1.30E-04) | 0.12 + |
| CPLX4\_2 | 2.02E-03 +  (4.81E-04) | 1.19E-03 ≈(1.53E-04) | **1.15E-03 (2.35E-04)** | 1.22E-03 +  (1.15E-04) | 1.26E-03 +  (1.12E-04) |
| CPLX5\_1 | 1.59E-03 +  (2.14E-04) | 0.60 + | **1.25E-03 ≈(1.56E-04)** | **-0.33 -** | 1.25E-03 (1.65E-04) | -0.22 | 1.31E-03 ≈(1.49E-04) | 0.02 + | 1.36E-03 +  (1.11E-04) | 0.08 + |
| CPLX5\_2 | 5.35E-03 ≈(7.62E-04) | 5.47E-03 ≈(8.34E-04) | **5.30E-03 (8.13E-04)** | 5.44E-03 ≈(8.52E-04) | 5.36E-03 ≈(8.11E-04) |
| CPLX6\_1 | 1.59E-03 ≈(2.19E-04) | 0.47 + | 1.53E-03 ≈(1.66E-04) | -0.08 + | **1.49E-03 (1.92E-04)** | **-0.26** | 1.53E-03 ≈(1.72E-04) | -0.05 + | 1.53E-03 ≈(2.18E-04) | 0.13 + |
| CPLX6\_2 | 2.57E-03 +  (5.58E-04) | 2.11E-03 ≈(8.39E-04) | **1.99E-03 (2.90E-04)** | 2.12E-03 +  (3.63E-04) | 2.36E-03 +  (6.46E-04) |
| CPLX7\_1 | 1.19E-03 +  (1.53E-04) | 0.58 + | **1.01E-03 ≈(1.43E-04)** | **-0.12 -** | 1.02E-03 (1.59E-04) | -0.09 | 1.07E-03 ≈(1.64E-04) | 0.03 + | 1.09E-03 ≈(1.59E-04) | 0.17 + |
| CPLX7\_2 | 1.44E-03 ≈(2.99E-04) | 1.34E-03 ≈(3.25E-04) | 1.34E-03 (2.61E-04) | **1.32E-03 ≈(2.64E-04)** | 1.36E-03 ≈(3.08E-04) |
| CPLX8\_1 | **1.54E-03 ≈(3.02E-04)** | 0.36 + | 1.62E-03 ≈(3.07E-04) | **-0.32 -** | 1.66E-03 (2.39E-04) | -0.06 | 1.73E-03 ≈(2.56E-04) | 0.10 + | 1.71E-03 ≈(2.98E-04) | 0.11 + |
| CPLX8\_2 | 2.34E-03 +  (1.74E-03) | **7.66E-04 ≈(7.77E-04)** | 8.15E-04 (8.61E-04) | 9.14E-04 ≈(8.79E-04) | 1.01E-03 ≈(7.93E-04) |
| CPLX9\_1 | **5.06E-03 ≈(5.90E-04)** | 0.52 + | 5.26E-03 ≈(6.18E-04) | **-0.18 -** | 5.29E-03 (5.13E-04) | -0.07 | 5.32E-03 ≈(6.31E-04) | -0.00 + | 5.22E-03 ≈(5.37E-04) | 0.13 + |
| CPLX9\_2 | 2.89E-03 +  (9.34E-04) | **1.80E-03 ≈(2.91E-04)** | 1.91E-03 (2.82E-04) | 1.95E-03 ≈(2.56E-04) | 2.23E-03 +  (3.05E-04) |
| CPLX10\_1 | 5.58E-03 +  (2.49E-03) | 1.88 + | 1.50E-03 ≈(1.03E-03) | -0.10 + | **1.39E-03 (7.85E-04)** | **-0.19** | 1.61E-03 ≈(1.14E-03) | -0.07 + | 1.99E-03 +  (1.06E-03) | 0.16 + |
| CPLX10\_2 | 6.80E-03 +  (1.61E-03) | 2.77E-03 ≈(1.03E-03) | **2.52E-03 (8.74E-04)** | 2.77E-03 ≈(1.05E-03) | 3.33E-03 +  (1.13E-03) |
| ≈/+/- | 8/12/0 | 0/10/0 | 18/1/1 | 0/4/6 | / | / | 17/3/0 | 0/9/1 | 11/9/0 | 0/9/1 |
| Rank | 4.14 | | 2.47 | | **2.37** | | 2.79 | | 3.23 | |

**TABLE A.VI**

THE MEAN VALUES AND STANDARD DEVIATIONS of IGD and MSS RESULTS OBTAINED BY THE COMPARED VARIANTS IN CEC2021

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ETMO2021 | *a* = 1 | | *a* = 3 | | *a* = 5 | | *a* = 7 | | *a* = 9 | |
| IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS | IGD | MSS |
| ETMOF1\_1 | 7.28E-04 +  (6.91E-05) | 1.10 + | **6.52E-04 ≈(4.20E-05)** | 0.38 + | 6.52E-04  (5.95E-05) | 0.33 | 6.52E-04 ≈(7.02E-05) | **0.16 -** | 6.71E-04 ≈  (5.66E-05) | 0.19 - |
| ETMOF1\_2 | 1.68E-03 +  (1.75E-04) | 1.46E-03 ≈(7.43E-05) | 1.41E-03  (1.21E-04) | **1.40E-03 ≈(1.47E-04)** | 1.44E-03 ≈  (1.23E-04) |
| ETMOF2\_1 | 6.61E-04 +  (9.54E-05) | 0.53 + | 6.60E-04 +  (4.32E-05) | 0.51 + | **3.79E-04**  **(3.56E-05)** | 0.22 | 4.07E-04 +  (3.35E-05) | **0.10 -** | 4.11E-04 +  (6.07E-05) | 0.61 + |
| ETMOF2\_2 | 8.15E-03 +  (2.37E-04) | 8.18E-03 ≈(4.32E-04) | 7.34E-03  (3.14E-04) | **7.32E-03 ≈(3.85E-04)** | 7.48E-03 ≈  (4.01E-04) |
| ETMOF3\_1 | 2.55E-03 +  (1.26E-03) | 0.64 + | 2.12E-03 +  (1.71E-03) | -0.06 + | **1.95E-03**  **(4.05E-04)** | **-0.17** | 1.99E-03 ≈(3.00E-04) | 0.08 + | 1.99E-03 ≈(5.58E-04) | 0.30 + |
| ETMOF3\_2 | 2.95E-03 ≈  (5.62E-04) | 2.84E-03 ≈(5.99E-04) | **2.84E-03**  **(5.18E-04)** | 2.88E-03 ≈(5.86E-04) | 2.69E-03 ≈(4.09E-04) |
| ETMOF4\_1 | 3.65E+00 +  (1.53E+00) | 1.95 + | 2.58E+00 ≈(2.00E+00) | **-0.27 -** | 2.78E+00  (2.65E+00) | -0.15 | **2.14E+00 ≈(1.20E+00)** | 0.04 + | 2.80E+00≈(2.04E+00) | 0.12 + |
| ETMOF4\_2 | 3.98E-01 +  (4.00E-02) | **3.39E-01 ≈(4.41E-02)** | 3.47E-01  (5.89E-02) | 3.52E-01 ≈(4.25E-02) | 3.59E-01 ≈(3.44E-02) |
| ETMOF5\_1 | 2.42E-01 ≈(7.21E-02) | 0.60 + | **2.58E-01 ≈(4.58E-02)** | **-0.33 -** | 2.66E-01  (2.68E-03) | -0.22 | 2.66E-01 ≈(2.54E-03) | 0.02 + | 2.67E-01 ≈(2.26E-03) | 0.08 + |
| ETMOF5\_2 | 4.23E-01 +  (1.12E-01) | **2.29E-01 ≈(2.46E-02)** | 2.34E-01  (2.58E-02) | 2.46E-01 ≈(2.95E-02) | 2.60E-01 +  (4.37E-02) |
| ETMOF6\_1 | 1.25E+00 +  (1.93E-01) | 0.47 + | 8.42E-01 +  (2.90E-01) | -0.08 + | 6.65E-01  (2.01E-01) | **-0.26** | **6.59E-01 ≈(2.44E-01)** | -0.05 + | 6.91E-01 ≈(1.64E-01) | 0.13 + |
| ETMOF6\_2 | 2.35E-01 +  (2.00E-01) | **3.90E-02 ≈(1.97E-02)** | 4.27E-02  (3.41E-02) | 5.06E-02 ≈(3.52E-02) | 4.39E-02 ≈(3.61E-02) |
| ETMOF7\_1 | **1.05E-03 -(2.24E-04)** | **-0.58 -** | 1.73E-03 ≈(5.72E-04) | -0.12 - | 1.69E-03  (1.22E-03) | -0.09 | 1.57E-03 ≈(6.53E-04) | 0.03 + | 1.55E-03 ≈(1.00E-03) | 0.17 + |
| ETMOF7\_2 | **1.59E-02 -(1.35E-03)** | 1.89E-02 ≈(3.10E-03) | 1.87E-02  (6.44E-03) | 1.87E-02 ≈(3.90E-03) | 1.92E-02 ≈(5.51E-03) |
| ETMOF7\_3 | **2.07E-02 ≈(2.32E-03)** | 2.19E-02 ≈(3.76E-03) | 2.18E-02  (3.33E-03) | 2.09E-02 ≈(4.64E-03) | 2.05E-02 ≈(5.31E-03) |
| ETMOF8\_1 | 8.85E-03 +  (8.93E-04) | 0.36 + | **7.50E-03 ≈(6.90E-04)** | **-0.32 -** | 7.58E-03  (8.01E-04) | -0.06 | 7.48E-03 ≈(6.64E-04) | 0.10 + | 7.73E-03 ≈(6.97E-04) | 0.11 + |
| ETMOF8\_2 | 2.75E-03 +  (5.51E-04) | 1.96E-03 ≈(2.08E-04) | 1.99E-03  (2.00E-04) | **1.93E-03 ≈(2.22E-04)** | 2.04E-03 ≈(3.19E-04) |
| ETMOF8\_3 | 1.55E-03 +  (1.90E-04) | **1.29E-03 ≈(6.22E-05)** | 1.29E-03  (8.99E-05) | 1.29E-03 ≈(7.82E-05) | 1.33E-03 ≈  (9.04E-05) |
| ≈/+/- | 3/13/2 | 0/7/1 | 15/0/1 | 0/4/4 | / | / | 17/1/0 | 0/6/2 | 16/2/0 | 0/7/1 |
| Rank | 4.17 | | 2.69 | | **2.44** | | 2.76 | | 2.84 | |