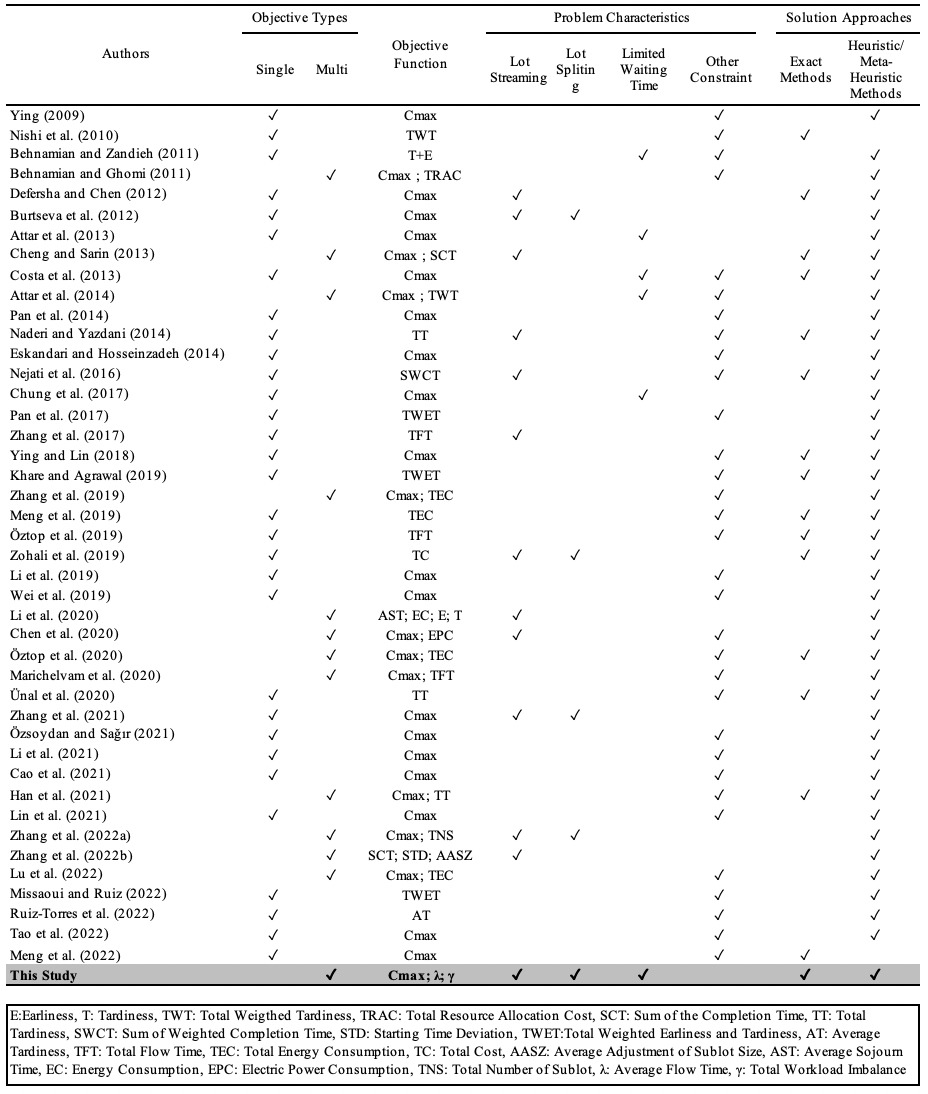
**TABLES**

**Table 1** Summary of single and multi-objective studies on HFSP problem

****

**Table 2** The number of variables and constraints in the optimization model

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Count** | **Constraints** | **Count** | | **Constraints** | **Count** |
|  | BS | **(4)** | LSB | **(14)** | | LSB |
|  | BS | **(5)** | 1 | **(15)** | | LSB |
|  | BSM | **(6)** | 1 | **(16)** | | LSB |
|  | LB | **(7)** | SM | **(17)** | | L(L-1)SB(B-1)M |
|  | S | **(8)** | SM | **(18)** | | LSB |
|  | S | **(9)** | SB | **(19)** | | LB |
|  | BS | **(10)** | LSMB | **(20)** | | LB |
|  | B | **(11)** | L | **(21)** | | L(L-1)SB(B-1)M |
|  | BSM | **(12)** | LSMB | **(22)** | | L(L-1)SB(B-1)M |
|  | B(B-1)SM | **(13)** | SB | **(23)** | | L(L-1)SB(B-1)M |

**Table 3** The controlled factors and parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Factors** | **Levels** | | |
| **1** | **2** | **3** |
| *M* | 4 | 6 | 8 |
| *S* | 2 | 6 | 10 |
| *B* | 2 | 6 | 10 |
| *L* | 10-20-30-40 | | |
| **Parameters** | **Generation pattern** | | |
| *PT* | Uniform [10-20] | | |
| *LS* | Uniform [30-100] | | |
| *WT* | 1000 w.r.t L=10 | | |
|  | 3000 w.r.t L=20 | | |
|  | 6000 w.r.t L=20 | | |
|  | 9000 w.r.t L=30 | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **L=10** | | | | **L=20** | | | | **L=30** | | | | **L=40** | | | |
| **B** | **S** | **M** | **P1** | **P2** | **P3** | **P4** | **P1** | **P2** | **P3** | **P4** | **P1** | **P2** | **P3** | **P4** | **P1** | **P2** | **P3** | **P4** |
| 1 | 1 | 1 | 0.29 | 0.40 | 0.03 | 0.02 | 0.42 | 0.58 | 0.11 | 0.02 | 0.16 | 0.40 | 0.05 | 0.00 | 0.06 | 0.15 | 0.05 | 0.01 |
| 1 | 1 | 2 | 0.32 | 1.12 | 0.20 | 0.00 | 0.10 | 0.24 | 0.02 | 0.02 | 0.38 | 0.85 | 0.06 | 0.00 | 0.38 | 0.69 | 0.08 | 0.01 |
| 1 | 1 | 3 | 0.28 | 2.58 | 0.70 | 0.01 | 0.18 | 0.34 | 0.04 | 0.03 | 0.43 | 0.76 | 0.13 | 0.00 | 0.19 | 0.60 | 0.19 | 0.00 |
| 1 | 2 | 1 | 0.36 | 0.76 | 0.09 | 0.00 | 0.34 | 0.54 | 0.13 | 0.00 | 0.26 | 0.29 | 0.04 | 0.00 | 0.35 | 0.42 | 0.03 | 0.00 |
| 1 | 2 | 2 | 0.05 | 0.06 | 0.02 | 0.00 | 0.09 | 0.29 | 0.05 | 0.00 | 0.05 | 0.11 | 0.01 | 0.00 | 0.06 | 0.18 | 0.02 | 0.03 |
| 1 | 2 | 3 | 0.22 | 0.32 | 0.05 | 0.03 | 0.09 | 0.11 | 0.04 | 0.01 | 0.19 | 0.39 | 0.12 | 0.00 | 0.57 | 0.30 | 0.08 | 0.01 |
| 1 | 3 | 1 | 0.55 | 1.67 | 0.21 | 0.01 | 0.29 | 0.64 | 0.12 | 0.00 | 0.25 | 0.29 | 0.04 | 0.00 | 0.58 | 1.00 | 0.14 | 0.00 |
| 1 | 3 | 2 | 0.19 | 0.59 | 0.12 | 0.02 | 0.16 | 0.22 | 0.00 | 0.03 | 0.61 | 0.67 | 0.14 | 0.01 | 0.13 | 0.29 | 0.01 | 0.00 |
| 1 | 3 | 3 | 0.13 | 0.24 | 0.02 | 0.03 | 0.24 | 0.37 | 0.04 | 0.07 | 0.11 | 0.24 | 0.02 | 0.01 | 0.40 | 0.55 | 0.07 | 0.05 |
| 2 | 1 | 1 | 0.84 | 1.13 | 0.73 | 0.00 | 0.09 | 0.21 | 0.02 | 0.00 | 0.51 | 1.22 | 0.04 | 0.01 | 0.14 | 0.25 | 0.08 | 0.00 |
| 2 | 1 | 2 | 0.25 | 0.20 | 0.09 | 0.00 | 0.51 | 0.91 | 0.20 | 0.00 | 0.09 | 0.20 | 0.01 | 0.02 | 0.17 | 0.37 | 0.08 | 0.02 |
| 2 | 1 | 3 | 0.20 | 0.33 | 0.02 | 0.00 | 0.47 | 0.57 | 0.15 | 0.02 | 0.26 | 1.42 | 0.13 | 0.01 | 1.18 | 2.01 | 0.18 | 0.00 |
| 2 | 2 | 1 | 0.75 | 1.08 | 0.11 | 0.01 | 0.50 | 1.07 | 0.09 | 0.00 | 0.27 | 0.27 | 0.01 | 0.00 | 1.05 | 5.63 | 1.18 | 0.00 |
| 2 | 2 | 2 | 0.26 | 0.45 | 0.08 | 0.00 | 1.10 | 2.17 | 0.07 | 0.03 | 0.35 | 0.50 | 0.05 | 0.00 | 0.29 | 0.60 | 0.05 | 0.00 |
| 2 | 2 | 3 | 0.14 | 0.39 | 0.02 | 0.01 | 0.14 | 0.22 | 0.06 | 0.00 | 0.07 | 0.44 | 0.08 | 0.00 | 0.34 | 0.38 | 0.05 | 0.00 |
| 2 | 3 | 1 | 0.37 | 0.25 | 0.05 | 0.00 | 0.43 | 0.41 | 0.05 | 0.00 | 2.60 | 3.14 | 0.12 | 0.00 | 0.21 | 0.23 | 0.02 | 0.00 |
| 2 | 3 | 2 | 0.07 | 0.16 | 0.04 | 0.01 | 0.03 | 0.23 | 0.02 | 0.02 | 0.23 | 0.22 | 0.03 | 0.00 | 0.21 | 0.34 | 0.03 | 0.00 |
| 2 | 3 | 3 | 0.17 | 0.49 | 0.06 | 0.04 | 0.69 | 0.80 | 0.26 | 0.00 | 0.12 | 0.37 | 0.07 | 0.00 | 0.06 | 0.08 | 0.02 | 0.05 |
| 3 | 1 | 1 | 3.58 | 8.17 | 0.81 | 0.00 | 0.09 | 0.41 | 0.13 | 0.00 | 0.30 | 0.40 | 0.03 | 0.02 | 1.01 | 1.58 | 0.35 | 0.00 |
| 3 | 1 | 2 | 0.66 | 2.22 | 0.11 | 0.00 | 0.39 | 0.52 | 0.07 | 0.00 | 2.30 | 3.95 | 0.08 | 0.10 | 0.49 | 0.78 | 0.10 | 0.04 |
| 3 | 1 | 3 | 0.42 | 0.53 | 0.10 | 0.00 | 0.09 | 0.51 | 0.21 | 0.02 | 0.29 | 0.74 | 0.05 | 0.04 | 0.30 | 0.70 | 0.13 | 0.00 |
| 3 | 2 | 1 | 1.91 | 2.68 | 1.05 | 0.00 | 0.19 | 0.96 | 0.07 | 0.00 | 1.12 | 1.53 | 0.24 | 0.00 | 0.86 | 0.91 | 0.05 | 0.00 |
| 3 | 2 | 2 | 0.22 | 0.29 | 0.19 | 0.01 | 0.65 | 0.82 | 0.17 | 0.00 | 0.31 | 0.37 | 0.05 | 0.00 | 0.09 | 0.40 | 0.05 | 0.00 |
| 3 | 2 | 3 | 0.08 | 0.32 | 0.04 | 0.01 | 0.03 | 0.21 | 0.11 | 0.00 | 0.25 | 0.56 | 0.06 | 0.01 | 0.13 | 0.29 | 0.02 | 0.01 |
| 3 | 3 | 1 | 0.32 | 0.61 | 0.26 | 0.00 | 0.21 | 0.47 | 0.00 | 0.01 | 0.62 | 0.28 | 0.00 | 0.01 | 0.22 | 0.27 | 0.02 | 0.00 |
| 3 | 3 | 2 | 0.68 | 0.92 | 0.08 | 0.03 | 0.33 | 0.64 | 0.07 | 0.01 | 0.49 | 0.80 | 0.03 | 0.00 | 0.38 | 0.94 | 0.04 | 0.02 |
| 3 | 3 | 3 | 0.28 | 0.58 | 0.20 | 0.01 | 0.41 | 0.96 | 0.17 | 0.00 | 0.15 | 0.22 | 0.01 | 0.05 | 0.06 | 0.09 | 0.04 | 0.01 |
| **Average** | | | **0.50** | **1.06** | **0.20** | **0.01** | **0.31** | **0.57** | **0.09** | **0.01** | **0.47** | **0.76** | **0.06** | **0.01** | **0.37** | **0.74** | **0.12** | **0.01** |

**Table 4** The metric values of the proposed algorithms for all levels of *L*

**Table 5** The metric values of the proposed algorithms for *L =* 10

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **L=10** | | | | | | | | | | | |
| **B** | **S** | **M** | **P1-P2** | **P2-P1** | **P1-P3** | **P3-P1** | **P1-P4** | **P4-P1** | **P2-P3** | **P3-P2** | **P2-P4** | **P4-P2** | **P3-P4** | **P4-P3** |
| 1 | 1 | 1 | 0.22 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.02 | 0.67 |
| 1 | 1 | 2 | 1.00 | 0.00 | 0.03 | 0.75 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 1 | 1 | 3 | 1.00 | 0.00 | 0.65 | 0.00 | 0.00 | 1.00 | 0.27 | 0.05 | 0.00 | 1.00 | 0.00 | 0.83 |
| 1 | 2 | 1 | 1.00 | 0.00 | 0.05 | 0.22 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.98 |
| 1 | 2 | 2 | 1.00 | 0.00 | 0.02 | 0.15 | 0.00 | 0.83 | 0.00 | 0.47 | 0.00 | 0.47 | 0.00 | 0.62 |
| 1 | 2 | 3 | 1.00 | 0.00 | 0.03 | 0.70 | 0.42 | 0.92 | 0.00 | 0.53 | 0.00 | 0.53 | 0.00 | 0.50 |
| 1 | 3 | 1 | 1.00 | 0.00 | 0.00 | 0.72 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.70 |
| 1 | 3 | 2 | 1.00 | 0.00 | 0.88 | 0.00 | 0.08 | 0.57 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.22 |
| 1 | 3 | 3 | 0.25 | 0.02 | 0.00 | 1.00 | 0.10 | 0.58 | 0.27 | 0.68 | 0.40 | 0.07 | 0.27 | 0.15 |
| 2 | 1 | 1 | 0.87 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.98 |
| 2 | 1 | 2 | 0.00 | 0.88 | 0.00 | 0.88 | 0.00 | 0.88 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.87 |
| 2 | 1 | 3 | 0.43 | 0.00 | 0.00 | 1.00 | 0.00 | 0.42 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.37 |
| 2 | 2 | 1 | 0.45 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.02 | 0.93 |
| 2 | 2 | 2 | 0.65 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.98 |
| 2 | 2 | 3 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.38 | 0.00 | 1.00 | 0.00 | 1.00 | 0.05 | 0.28 |
| 2 | 3 | 1 | 0.00 | 0.98 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.97 | 0.00 | 1.00 | 0.02 | 0.78 |
| 2 | 3 | 2 | 0.05 | 0.03 | 0.03 | 0.78 | 0.00 | 0.87 | 0.00 | 1.00 | 0.00 | 1.00 | 0.07 | 0.68 |
| 2 | 3 | 3 | 1.00 | 0.00 | 0.00 | 0.40 | 0.53 | 0.40 | 0.00 | 1.00 | 0.00 | 1.00 | 0.10 | 0.02 |
| 3 | 1 | 1 | 0.07 | 0.02 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 3 | 1 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.98 |
| 3 | 1 | 3 | 1.00 | 0.00 | 0.00 | 0.98 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.02 | 0.98 |
| 3 | 2 | 1 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 3 | 2 | 2 | 0.52 | 0.00 | 0.03 | 0.67 | 0.00 | 0.67 | 0.02 | 0.87 | 0.00 | 1.00 | 0.00 | 0.95 |
| 3 | 2 | 3 | 1.00 | 0.00 | 0.10 | 0.10 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.05 | 0.22 |
| 3 | 3 | 1 | 0.32 | 0.02 | 0.00 | 0.05 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.98 |
| 3 | 3 | 2 | 0.03 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.03 | 0.05 |
| 3 | 3 | 3 | 0.00 | 0.00 | 0.55 | 0.88 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.05 | 0.76 |
| **Average** | | | **0.59** | **0.07** | **0.09** | **0.71** | **0.04** | **0.87** | **0.02** | **0.87** | **0.01** | **0.93** | **0.03** | **0.68** |

**Table 5** (continued for *L =* 20)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **L=20** | | | | | | | | | | | |
| **B** | **S** | **M** | **P1-P2** | **P2-P1** | **P1-P3** | **P3-P1** | **P1-P4** | **P4-P1** | **P2-P3** | **P3-P2** | **P2-P4** | **P4-P2** | **P3-P4** | **P4-P3** |
| 1 | 1 | 1 | 1.00 | 0.00 | 0.04 | 0.52 | 0.00 | 1.00 | 0.00 | 0.95 | 0.00 | 1.00 | 0.00 | 0.77 |
| 1 | 1 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.13 | 0.03 |
| 1 | 1 | 3 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.99 | 0.00 | 1.00 | 0.00 | 1.00 | 0.03 | 0.28 |
| 1 | 2 | 1 | 0.61 | 0.00 | 0.22 | 0.84 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.03 | 0.83 |
| 1 | 2 | 2 | 1.00 | 0.00 | 0.00 | 0.57 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.87 |
| 1 | 2 | 3 | 0.02 | 0.00 | 0.37 | 0.49 | 0.03 | 0.49 | 0.00 | 0.92 | 0.00 | 1.00 | 0.00 | 0.63 |
| 1 | 3 | 1 | 1.00 | 0.00 | 0.00 | 0.03 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.99 |
| 1 | 3 | 2 | 0.37 | 0.00 | 0.00 | 1.00 | 0.00 | 0.98 | 0.00 | 1.00 | 0.00 | 0.60 | 0.41 | 0.08 |
| 1 | 3 | 3 | 0.97 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.72 |
| 2 | 1 | 1 | 0.91 | 0.00 | 0.00 | 0.98 | 0.00 | 1.00 | 0.00 | 0.91 | 0.00 | 1.00 | 0.00 | 0.99 |
| 2 | 1 | 2 | 1.00 | 0.00 | 0.00 | 0.99 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.02 | 0.90 |
| 2 | 1 | 3 | 0.99 | 0.00 | 0.47 | 0.89 | 0.00 | 0.93 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 2 | 2 | 1 | 0.99 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 2 | 2 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.66 | 0.51 |
| 2 | 2 | 3 | 0.99 | 0.05 | 0.44 | 0.20 | 0.00 | 1.00 | 0.01 | 0.02 | 0.00 | 1.00 | 0.00 | 0.67 |
| 2 | 3 | 1 | 0.97 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.97 |
| 2 | 3 | 2 | 1.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.06 | 0.00 | 1.00 | 0.00 | 1.00 | 0.04 | 0.90 |
| 2 | 3 | 3 | 0.07 | 0.00 | 0.00 | 0.28 | 0.00 | 1.00 | 0.00 | 0.93 | 0.00 | 1.00 | 0.00 | 1.00 |
| 3 | 1 | 1 | 1.00 | 0.00 | 0.00 | 0.03 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.64 |
| 3 | 1 | 2 | 0.73 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.99 |
| 3 | 1 | 3 | 0.94 | 0.00 | 0.00 | 0.17 | 0.00 | 0.17 | 0.00 | 1.00 | 0.00 | 1.00 | 0.01 | 0.25 |
| 3 | 2 | 1 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.03 | 0.97 |
| 3 | 2 | 2 | 0.99 | 0.00 | 0.00 | 0.40 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 3 | 2 | 3 | 1.00 | 0.00 | 0.73 | 0.00 | 0.18 | 0.21 | 0.00 | 1.00 | 0.00 | 1.00 | 0.06 | 0.77 |
| 3 | 3 | 1 | 0.98 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.86 | 0.48 |
| 3 | 3 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.03 | 0.93 |
| 3 | 3 | 3 | 0.95 | 0.00 | 0.00 | 0.97 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| **Average** | | | **0.87** | **0.00** | **0.08** | **0.68** | **0.01** | **0.88** | **0.00** | **0.95** | **0.00** | **0.99** | **0.09** | **0.75** |

**Table 5** (continued for *L =* 30)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **L=30** | | | | | | | | | | | |
| **B** | **S** | **M** | **P1-P2** | **P2-P1** | **P1-P3** | **P3-P1** | **P1-P4** | **P4-P1** | **P2-P3** | **P3-P2** | **P2-P4** | **P4-P2** | **P3-P4** | **P4-P3** |
| 1 | 1 | 1 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.95 |
| 1 | 1 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.01 | 0.71 |
| 1 | 1 | 3 | 1.00 | 0.00 | 0.06 | 0.04 | 0.00 | 0.99 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 1 | 2 | 1 | 0.67 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.94 |
| 1 | 2 | 2 | 1.00 | 0.00 | 0.46 | 0.09 | 0.00 | 0.42 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.99 |
| 1 | 2 | 3 | 0.26 | 0.00 | 0.03 | 0.08 | 0.00 | 1.00 | 0.01 | 0.78 | 0.00 | 1.00 | 0.00 | 0.95 |
| 1 | 3 | 1 | 0.02 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.99 |
| 1 | 3 | 2 | 0.01 | 0.17 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.05 | 0.96 |
| 1 | 3 | 3 | 1.00 | 0.00 | 0.26 | 0.07 | 0.00 | 0.28 | 0.00 | 0.96 | 0.00 | 1.00 | 0.10 | 0.85 |
| 2 | 1 | 1 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.39 | 0.70 |
| 2 | 1 | 2 | 1.00 | 0.00 | 0.00 | 0.99 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.01 | 0.68 |
| 2 | 1 | 3 | 1.00 | 0.00 | 0.26 | 0.40 | 0.00 | 0.40 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.78 |
| 2 | 2 | 1 | 0.79 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.07 | 0.03 |
| 2 | 2 | 2 | 0.66 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.97 |
| 2 | 2 | 3 | 0.21 | 0.00 | 0.52 | 0.01 | 0.00 | 0.09 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 2 | 3 | 1 | 0.95 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 2 | 3 | 2 | 0.01 | 0.00 | 0.00 | 0.99 | 0.00 | 1.00 | 0.00 | 0.87 | 0.00 | 1.00 | 0.00 | 1.00 |
| 2 | 3 | 3 | 1.00 | 0.00 | 0.94 | 0.83 | 0.12 | 0.83 | 0.00 | 1.00 | 0.00 | 1.00 | 0.07 | 0.62 |
| 3 | 1 | 1 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.28 | 0.04 |
| 3 | 1 | 2 | 0.01 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.02 | 0.01 |
| 3 | 1 | 3 | 0.99 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.54 |
| 3 | 2 | 1 | 0.99 | 0.00 | 0.01 | 0.92 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.01 | 0.99 |
| 3 | 2 | 2 | 0.00 | 0.00 | 0.02 | 0.96 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.99 |
| 3 | 2 | 3 | 1.00 | 0.00 | 0.31 | 0.17 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.91 |
| 3 | 3 | 1 | 0.01 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.26 | 0.16 |
| 3 | 3 | 2 | 0.02 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.94 |
| 3 | 3 | 3 | 0.68 | 0.00 | 0.00 | 0.87 | 0.00 | 0.87 | 0.00 | 1.00 | 0.00 | 1.00 | 0.66 | 0.08 |
| **Average** | | | **0.64** | **0.01** | **0.11** | **0.76** | **0.00** | **0.88** | **0.00** | **0.99** | **0.00** | **1.00** | **0.07** | **0.73** |

**Table 5** (continued for *L =* 40)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **L=40** | | | | | | | | | | | |
| **B** | **S** | **M** | **P1-P2** | **P2-P1** | **P1-P3** | **P3-P1** | **P1-P4** | **P4-P1** | **P2-P3** | **P3-P2** | **P2-P4** | **P4-P2** | **P3-P4** | **P4-P3** |
| 1 | 1 | 1 | 1.00 | 0.00 | 0.49 | 0.09 | 0.03 | 0.13 | 0.00 | 0.15 | 0.00 | 1.00 | 0.00 | 0.61 |
| 1 | 1 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.10 | 0.52 |
| 1 | 1 | 3 | 0.36 | 0.00 | 0.10 | 0.62 | 0.00 | 0.68 | 0.00 | 0.36 | 0.00 | 1.00 | 0.00 | 0.95 |
| 1 | 2 | 1 | 0.05 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.01 | 0.50 |
| 1 | 2 | 2 | 0.87 | 0.00 | 0.28 | 0.01 | 0.02 | 0.23 | 0.00 | 0.97 | 0.00 | 1.00 | 0.71 | 0.67 |
| 1 | 2 | 3 | 0.06 | 0.00 | 0.79 | 0.50 | 0.03 | 0.50 | 0.00 | 1.00 | 0.00 | 1.00 | 0.10 | 0.85 |
| 1 | 3 | 1 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.98 |
| 1 | 3 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.04 | 0.18 |
| 1 | 3 | 3 | 0.04 | 0.00 | 0.00 | 0.05 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.42 |
| 2 | 1 | 1 | 0.57 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.75 |
| 2 | 1 | 2 | 0.54 | 0.00 | 0.04 | 0.92 | 0.00 | 0.92 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.15 |
| 2 | 1 | 3 | 1.00 | 0.00 | 0.05 | 0.70 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.20 | 0.98 |
| 2 | 2 | 1 | 1.00 | 0.00 | 0.00 | 0.98 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 2 | 2 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 2 | 2 | 3 | 1.00 | 0.00 | 0.01 | 0.10 | 0.00 | 1.00 | 0.00 | 0.79 | 0.00 | 1.00 | 0.00 | 0.96 |
| 2 | 3 | 1 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 1.00 | 0.17 | 0.15 | 0.00 | 1.00 | 0.04 | 0.97 |
| 2 | 3 | 2 | 0.26 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.65 |
| 2 | 3 | 3 | 0.91 | 0.00 | 0.00 | 0.17 | 0.00 | 0.64 | 0.00 | 1.00 | 0.00 | 1.00 | 0.44 | 0.49 |
| 3 | 1 | 1 | 0.03 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 3 | 1 | 2 | 0.48 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.04 | 0.28 |
| 3 | 1 | 3 | 1.00 | 0.00 | 0.00 | 1.00 | 0.01 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.01 | 0.99 |
| 3 | 2 | 1 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 3 | 2 | 2 | 1.00 | 0.00 | 0.00 | 0.97 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.99 |
| 3 | 2 | 3 | 0.09 | 0.00 | 0.44 | 0.99 | 0.00 | 1.00 | 0.00 | 0.99 | 0.00 | 1.00 | 0.00 | 0.93 |
| 3 | 3 | 1 | 0.49 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.99 |
| 3 | 3 | 2 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.18 | 0.00 | 1.00 | 0.00 | 1.00 | 0.30 | 0.60 |
| 3 | 3 | 3 | 0.82 | 0.00 | 0.21 | 0.57 | 0.01 | 0.57 | 0.00 | 0.44 | 0.00 | 1.00 | 0.00 | 0.64 |
| **Average** | | | **0.62** | **0.00** | **0.09** | **0.69** | **0.00** | **0.84** | **0.01** | **0.88** | **0.00** | **1.00** | **0.07** | **0.74** |

**Table 6** The metric values of the proposed algorithms for *L =* 10 and = 20

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **L=10** | | | | | | **L=20** | | | | | |
| **B** | **S** | **M** | **P1-P2** | **P1-P3** | **P1-P4** | **P2-P3** | **P2-P4** | **P3-P4** | **P1-P2** | **P1-P3** | **P1-P4** | **P2-P3** | **P2-P4** | **P3-P4** |
| 1 | 1 | 1 | 0.17 | 0.05 | 0.43 | 0.31 | 2.55 | 6.34 | 0.94 | 0.47 | 0.34 | 0.50 | 0.36 | 0.72 |
| 1 | 1 | 2 | 0.07 | 0.05 | 0.09 | 0.61 | 1.21 | 1.97 | 1.41 | 1.67 | 0.21 | 1.19 | 0.15 | 0.12 |
| 1 | 1 | 3 | 0.04 | 0.05 | 0.13 | 1.33 | 3.20 | 2.42 | 0.25 | 0.07 | 0.14 | 0.29 | 0.58 | 2.02 |
| 1 | 2 | 1 | 0.59 | 0.02 | 0.02 | 0.03 | 0.03 | 0.89 | 1.71 | 0.84 | 0.38 | 0.49 | 0.22 | 0.45 |
| 1 | 2 | 2 | 0.45 | 0.11 | 0.03 | 0.23 | 0.06 | 0.28 | 0.05 | 0.06 | 0.07 | 1.21 | 1.47 | 1.22 |
| 1 | 2 | 3 | 6.77 | 0.39 | 0.23 | 0.06 | 0.03 | 0.60 | 1.03 | 0.18 | 2.74 | 0.18 | 2.65 | 2.11 |
| 1 | 3 | 1 | 0.29 | 0.30 | 0.41 | 1.05 | 1.45 | 1.39 | 1.36 | 0.17 | 0.77 | 0.12 | 0.57 | 4.54 |
| 1 | 3 | 2 | 0.22 | 0.03 | 0.20 | 0.13 | 0.94 | 7.26 | 0.01 | 0.00 | 0.01 | 0.26 | 0.86 | 3.27 |
| 1 | 3 | 3 | 2.30 | 0.15 | 0.10 | 0.07 | 0.04 | 0.63 | 2.02 | 0.14 | 0.32 | 0.07 | 0.16 | 2.27 |
| 2 | 1 | 1 | 0.16 | 0.01 | 0.31 | 0.05 | 1.93 | 1.33 | 0.19 | 0.03 | 0.03 | 0.18 | 0.15 | 0.83 |
| 2 | 1 | 2 | 0.28 | 0.42 | 0.22 | 1.48 | 0.77 | 0.52 | 2.84 | 3.79 | 1.65 | 1.34 | 0.58 | 0.44 |
| 2 | 1 | 3 | 1.89 | 0.36 | 0.01 | 0.19 | 0.01 | 0.04 | 0.55 | 0.11 | 0.13 | 0.20 | 0.23 | 1.19 |
| 2 | 2 | 1 | 0.00 | 0.00 | 0.00 | 0.75 | 0.93 | 1.24 | 0.39 | 0.70 | 0.33 | 1.81 | 0.86 | 0.48 |
| 2 | 2 | 2 | 6.80 | 0.86 | 1.23 | 0.13 | 0.18 | 1.43 | 0.18 | 0.71 | 0.33 | 4.02 | 1.86 | 0.46 |
| 2 | 2 | 3 | 0.52 | 0.05 | 0.07 | 0.10 | 0.13 | 1.33 | 0.36 | 0.20 | 0.19 | 0.55 | 0.52 | 0.94 |
| 2 | 3 | 1 | 0.88 | 0.03 | 0.06 | 0.03 | 0.07 | 2.02 | 1.91 | 0.65 | 0.08 | 0.34 | 0.04 | 0.13 |
| 2 | 3 | 2 | 2.90 | 0.71 | 0.28 | 0.25 | 0.10 | 0.39 | 1.00 | 3.52 | 0.68 | 3.52 | 0.68 | 0.19 |
| 2 | 3 | 3 | 2.72 | 0.50 | 0.45 | 0.19 | 0.16 | 0.89 | 0.51 | 0.01 | 0.12 | 0.03 | 0.23 | 8.04 |
| 3 | 1 | 1 | 3.45 | 1.91 | 0.23 | 0.55 | 0.07 | 0.12 | 1.21 | 0.70 | 0.09 | 0.58 | 0.08 | 0.14 |
| 3 | 1 | 2 | 0.82 | 0.14 | 0.32 | 0.17 | 0.39 | 2.23 | 4.08 | 2.30 | 0.85 | 0.56 | 0.21 | 0.37 |
| 3 | 1 | 3 | 3.09 | 0.91 | 0.35 | 0.29 | 0.11 | 0.38 | 1.49 | 1.18 | 0.93 | 0.79 | 0.63 | 0.79 |
| 3 | 2 | 1 | 0.73 | 0.21 | 0.19 | 0.29 | 0.26 | 0.88 | 0.56 | 1.16 | 1.98 | 2.08 | 3.55 | 1.70 |
| 3 | 2 | 2 | 0.81 | 1.47 | 0.25 | 1.81 | 0.31 | 0.17 | 0.70 | 0.06 | 0.06 | 0.09 | 0.08 | 0.89 |
| 3 | 2 | 3 | 5.45 | 0.88 | 0.18 | 0.16 | 0.03 | 0.21 | 4.09 | 0.06 | 0.11 | 0.01 | 0.03 | 1.96 |
| 3 | 3 | 1 | 3.96 | 4.98 | 0.94 | 1.26 | 0.24 | 0.19 | 2.14 | 0.36 | 1.38 | 0.17 | 0.64 | 3.79 |
| 3 | 3 | 2 | 0.01 | 0.00 | 0.01 | 0.16 | 0.61 | 3.71 | 0.80 | 0.78 | 0.14 | 0.97 | 0.18 | 0.19 |
| 3 | 3 | 3 | 2.89 | 6.49 | 6.34 | 2.94 | 2.54 | 0.86 | 0.27 | 0.14 | 0.44 | 0.52 | 1.63 | 3.16 |
| **Average** | | | **1.79** | **0.78** | **0.48** | **0.54** | **0.68** | **1.47** | **1.19** | **0.74** | **0.54** | **0.82** | **0.71** | **1.57** |

**Table 6** (continued for *L =* 30 and = 40)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **L=30** | | | | | | **L=40** | | | | | |
| **B** | **S** | **M** | **P1-P2** | **P1-P3** | **P1-P4** | **P2-P3** | **P2-P4** | **P3-P4** | **P1-P2** | **P1-P3** | **P1-P4** | **P2-P3** | **P2-P4** | **P3-P4** |
| 1 | 1 | 1 | 0.51 | 0.04 | 0.05 | 0.07 | 0.09 | 1.26 | 0.53 | 2.04 | 0.30 | 3.83 | 0.57 | 0.15 |
| 1 | 1 | 2 | 0.05 | 0.07 | 0.04 | 1.40 | 0.81 | 0.58 | 0.09 | 0.07 | 0.03 | 0.77 | 0.37 | 0.48 |
| 1 | 1 | 3 | 8.81 | 0.05 | 0.25 | 0.01 | 0.03 | 5.09 | 5.15 | 0.89 | 1.34 | 0.17 | 0.26 | 1.51 |
| 1 | 2 | 1 | 3.61 | 0.13 | 0.11 | 0.04 | 0.03 | 0.88 | 1.54 | 0.51 | 0.14 | 0.33 | 0.09 | 0.28 |
| 1 | 2 | 2 | 2.79 | 0.14 | 0.03 | 0.05 | 0.01 | 0.21 | 1.72 | 0.09 | 0.21 | 0.05 | 0.12 | 2.36 |
| 1 | 2 | 3 | 0.63 | 0.54 | 0.17 | 0.85 | 0.27 | 0.32 | 8.04 | 2.99 | 7.19 | 0.37 | 0.89 | 2.40 |
| 1 | 3 | 1 | 3.14 | 0.83 | 4.21 | 0.26 | 1.34 | 5.10 | 6.77 | 1.44 | 3.23 | 0.21 | 0.48 | 2.25 |
| 1 | 3 | 2 | 2.91 | 0.26 | 2.12 | 0.09 | 0.73 | 8.05 | 1.53 | 0.11 | 0.05 | 0.07 | 0.03 | 0.47 |
| 1 | 3 | 3 | 0.43 | 0.09 | 0.10 | 0.21 | 0.24 | 1.13 | 1.14 | 0.14 | 1.31 | 0.13 | 1.15 | 8.09 |
| 2 | 1 | 1 | 3.61 | 0.07 | 0.15 | 0.02 | 0.04 | 2.00 | 4.27 | 0.30 | 0.20 | 0.07 | 0.05 | 0.67 |
| 2 | 1 | 2 | 0.38 | 0.09 | 0.12 | 0.23 | 0.31 | 1.37 | 5.45 | 0.35 | 1.11 | 0.06 | 0.20 | 3.13 |
| 2 | 1 | 3 | 0.11 | 0.04 | 0.08 | 0.37 | 0.72 | 1.97 | 4.67 | 0.63 | 0.48 | 0.13 | 0.10 | 0.77 |
| 2 | 2 | 1 | 0.33 | 0.08 | 0.06 | 0.23 | 0.17 | 0.74 | 0.32 | 0.37 | 1.34 | 1.15 | 4.16 | 3.62 |
| 2 | 2 | 2 | 4.11 | 0.82 | 0.48 | 0.20 | 0.12 | 0.59 | 0.71 | 0.57 | 0.70 | 0.80 | 0.99 | 1.23 |
| 2 | 2 | 3 | 4.77 | 2.37 | 1.91 | 0.50 | 0.40 | 0.80 | 0.38 | 0.24 | 0.06 | 0.62 | 0.15 | 0.24 |
| 2 | 3 | 1 | 5.30 | 0.18 | 0.44 | 0.03 | 0.08 | 2.49 | 0.39 | 0.16 | 0.13 | 0.40 | 0.33 | 0.83 |
| 2 | 3 | 2 | 3.59 | 1.77 | 0.41 | 0.49 | 0.12 | 0.23 | 0.09 | 0.04 | 0.05 | 0.49 | 0.54 | 1.10 |
| 2 | 3 | 3 | 0.26 | 0.16 | 0.32 | 0.64 | 1.24 | 1.93 | 0.55 | 0.05 | 0.59 | 0.10 | 1.08 | 1.34 |
| 3 | 1 | 1 | 1.23 | 0.32 | 0.11 | 0.26 | 0.09 | 0.33 | 0.67 | 0.82 | 0.93 | 1.23 | 1.39 | 1.13 |
| 3 | 1 | 2 | 1.61 | 2.52 | 1.32 | 1.56 | 0.82 | 0.52 | 1.98 | 0.36 | 0.60 | 0.18 | 0.30 | 1.69 |
| 3 | 1 | 3 | 0.93 | 0.44 | 1.16 | 0.48 | 1.25 | 2.61 | 5.14 | 0.44 | 0.81 | 0.09 | 0.16 | 1.82 |
| 3 | 2 | 1 | 7.82 | 1.69 | 1.67 | 0.22 | 0.21 | 0.99 | 6.01 | 0.39 | 0.95 | 0.07 | 0.16 | 2.41 |
| 3 | 2 | 2 | 4.39 | 0.54 | 0.51 | 0.12 | 0.12 | 0.96 | 1.71 | 1.43 | 0.30 | 0.84 | 0.18 | 0.21 |
| 3 | 2 | 3 | 3.65 | 1.21 | 0.97 | 0.05 | 0.04 | 0.80 | 0.52 | 0.13 | 0.76 | 0.25 | 1.46 | 5.77 |
| 3 | 3 | 1 | 0.12 | 0.34 | 0.25 | 2.92 | 2.15 | 0.74 | 1.83 | 0.95 | 0.24 | 0.52 | 0.13 | 0.25 |
| 3 | 3 | 2 | 0.44 | 0.76 | 0.48 | 1.74 | 1.09 | 0.63 | 1.24 | 0.61 | 0.93 | 0.49 | 0.75 | 1.53 |
| 3 | 3 | 3 | 2.62 | 0.17 | 0.21 | 0.07 | 0.08 | 1.21 | 0.26 | 0.21 | 0.37 | 0.81 | 1.39 | 1.71 |
| **Average** | | | **2.52** | **0.58** | **0.66** | **0.49** | **0.47** | **1.61** | **2.32** | **0.60** | **0.90** | **0.53** | **0.65** | **1.76** |

**Table 7** Three-way ANOVA with respect to metric

|  |  |  |  |
| --- | --- | --- | --- |
| Three-way ANOVA: D1R versus *B*, *S*, and *M* | | | |
| **Source** | **F** | **Sig. (p)** | **Partial eta squared** |
| *B* | 3.851 | 0.025\* | 0.087 |
| *S* | 3.186 | 0.047\* | 0.073 |
| *M* | 5.004 | 0.009\* | 0.110 |
| *B\*S* | 1.248 | 0.297 | 0.058 |
| *B\*M* | 2.501 | 0.049\* | 0.110 |
| *S\*M* | 0.815 | 0.519 | 0.039 |
| *B\*S\*M* | 1.630 | 0.129 | 0.139 |

Sig. (p) < 0.05 indicates a statistically significant difference