

Université Libre de Bruxelles

Faculty of Applied Science IRIDIA

INFO-H-421: Heuristic Optimization

Implementation exercise 1: IIA for PFSP with WT Objective

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Abstract

This work presents an implementation as well as a statistical study of iterative improvement algorithms for the permutation flow-shop scheduling problem (PFSP) with weighted tardiness objective.

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| | 2.1 Average percentage deviation from the best known solutions | 4 |
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1 Iterative Improvement

- 1.1 Average percentage deviation from the best known solutions
- 1.2 Average computation time

- 2 Variable Neighborhood Search
- 2.1 Average percentage deviation from the best known solutions
- 2.2 Average computation time

3 Student t-test and Wilcoxon test

4 Running time optimizations

5 Use cases

5.1 Regular usage

```
stdin prompt
# java -jar dist/scc.jar
stdin pipe
# cat test/in/1 | java -jar dist/scc.jar

5.2 Tests
make them
# cd test && make
```

lli test/out/gcd

run them

- # lli test/out/lcm
- # lli test/out/fibonnaci
- # lli test/out/impl
- # lli test/out/binarysearch
- # lli test/out/signed
- # lli test/out/multiply
- # lli test/out/divide
- # lli test/out/literals
- # lli test/out/iotest

A Average computation time and Standard Deviation

Table 1: std dev and running time for 100x20 instances

| alg | std dev | avg time |
|--------|----------|---------------------|
| IIRBE | 12.8909 | 38897 ms |
| IIRBI | 10.7560 | 84735 ms |
| IIRBT | 143.5449 | 526 ms |
| IIRFE | 3.5779 | 206754 ms |
| IIRFI | 1.4422 | 227619 ms |
| IIRFT | 140.0989 | 720 ms |
| IISBE | 10.5009 | 29129 ms |
| IISBI | 5.6719 | 56915 ms |
| IISBT | 41.6100 | $407 \mathrm{\ ms}$ |
| IISFE | 5.1229 | 66387 ms |
| IISFI | 1.8223 | 146201 ms |
| IISFT | 38.3003 | 495 ms |
| VRFTEI | 4.1919 | 65035 ms |
| VRFTIE | 4.6870 | 104372 ms |
| VSFTEI | 6.9544 | 31686 ms |
| VSFTIE | 4.1647 | 45708 ms |

Table 2: std dev and running time for 100x20 instances (sorted by dev)

| alg | std dev | avg time |
|--------|----------|-------------------|
| IIRFI | 1.4422 | 227619 ms |
| IISFI | 1.8223 | 146201 ms |
| IIRFE | 3.5779 | 206754 ms |
| VSFTIE | 4.1647 | 45708 ms |
| VRFTEI | 4.1919 | 65035 ms |
| VRFTIE | 4.6870 | 104372 ms |
| IISFE | 5.1229 | 66387 ms |
| IISBI | 5.6719 | 56915 ms |
| VSFTEI | 6.9544 | 31686 ms |
| IISBE | 10.5009 | 29129 ms |
| IIRBI | 10.7560 | 84735 ms |
| IIRBE | 12.8909 | 38897 ms |
| IISFT | 38.3003 | 495 ms |
| IISBT | 41.6100 | 407 ms |
| IIRFT | 140.0989 | 720 ms |
| IIRBT | 143.5449 | $526~\mathrm{ms}$ |

Table 3: std dev and running time for 100x20 instances (sorted by time)

| alg | std dev | avg time |
|--------|----------|------------|
| IISBT | 41.6100 | 407 ms |
| IISFT | 38.3003 | 495 ms |
| IIRBT | 143.5449 | 526 ms |
| IIRFT | 140.0989 | 720 ms |
| IISBE | 10.5009 | 29129 ms |
| VSFTEI | 6.9544 | 31686 ms |
| IIRBE | 12.8909 | 38897 ms |
| VSFTIE | 4.1647 | 45708 ms |
| IISBI | 5.6719 | 56915 ms |
| VRFTEI | 4.1919 | 65035 ms |
| IISFE | 5.1229 | 66387 ms |
| IIRBI | 10.7560 | 84735 ms |
| VRFTIE | 4.6870 | 104372 ms |
| IISFI | 1.8223 | 146201 ms |
| IIRFE | 3.5779 | 206754 ms |
| IIRFI | 1.4422 | 227619 ms |

Table 4: std dev and running time for 50x20 instances

| alg | std dev | avg time |
|--------|-----------|----------------------|
| IIRBE | 59.2969 | 3024 ms |
| IIRBI | 49.3596 | 6007 ms |
| IIRBT | 1033.8080 | 46 ms |
| IIRFE | 25.7903 | 10132 ms |
| IIRFI | 15.2501 | 12937 ms |
| IIRFT | 990.2279 | $67 \mathrm{ms}$ |
| IISBE | 50.8140 | 1395 ms |
| IISBI | 24.7393 | 3099 ms |
| IISBT | 144.9350 | $46 \mathrm{\ ms}$ |
| IISFE | 33.9047 | $2587 \mathrm{\ ms}$ |
| IISFI | 17.8570 | 6242 ms |
| IISFT | 141.1087 | 63 ms |
| VRFTEI | 20.9437 | 3807 ms |
| VRFTIE | 20.2999 | 5241 ms |
| VSFTEI | 22.7949 | 1738 ms |
| VSFTIE | 22.1499 | 2089 ms |

Table 5: std dev and running time for 50x20 instances (sorted by dev)

| alg | std dev | avg time |
|--------|---------|----------|
| IIRFI | 15.2501 | 12937 ms |
| IISFI | 17.8570 | 6242 ms |
| VRFTIE | 20.2999 | 5241 ms |
| VRFTEI | 20.9437 | 3807 ms |
| VSFTIE | 22.1499 | 2089 ms |

| VSFTEI | 22.7949 | 1738 ms |
|--------|-----------|--------------------|
| IISBI | 24.7393 | 3099 ms |
| IIRFE | 25.7903 | 10132 ms |
| IISFE | 33.9047 | 2587 ms |
| IIRBI | 49.3596 | 6007 ms |
| IISBE | 50.8140 | 1395 ms |
| IIRBE | 59.2969 | $3024~\mathrm{ms}$ |
| IISFT | 141.1087 | 63 ms |
| IISBT | 144.9350 | $46 \mathrm{\ ms}$ |
| IIRFT | 990.2279 | $67 \mathrm{\ ms}$ |
| IIRBT | 1033.8080 | $46 \mathrm{\ ms}$ |

Table 6: std dev and running time for 50x20 instances (sorted by time)

| alg | std dev | avg time |
|--------|-----------|----------------------|
| IISBT | 144.9350 | 46 ms |
| IIRBT | 1033.8080 | $46 \mathrm{\ ms}$ |
| IISFT | 141.1087 | 63 ms |
| IIRFT | 990.2279 | $67 \mathrm{\ ms}$ |
| IISBE | 50.8140 | 1395 ms |
| VSFTEI | 22.7949 | 1738 ms |
| VSFTIE | 22.1499 | 2089 ms |
| IISFE | 33.9047 | 2587 ms |
| IIRBE | 59.2969 | 3024 ms |
| IISBI | 24.7393 | 3099 ms |
| VRFTEI | 20.9437 | 3807 ms |
| VRFTIE | 20.2999 | 5241 ms |
| IIRBI | 49.3596 | $6007 \mathrm{\ ms}$ |
| IISFI | 17.8570 | 6242 ms |
| IIRFE | 25.7903 | 10132 ms |
| IIRFI | 15.2501 | 12937 ms |

Table 7: std dev and running time for 60x20 instances

| alg | std dev | avg time |
|-------|----------|----------------------|
| IIRBE | 28.6631 | $5670 \mathrm{\ ms}$ |
| IIRBI | 17.3015 | 12453 ms |
| IIRBT | 346.7143 | 89 ms |
| IIRFE | 11.7075 | 21836 ms |
| IIRFI | 5.6391 | 26875 ms |
| IIRFT | 337.2030 | 134 ms |
| IISBE | 26.1016 | 3215 ms |
| IISBI | 11.0622 | 6949 ms |
| IISBT | 87.5727 | $103 \mathrm{\ ms}$ |
| IISFE | 18.7445 | 6925 ms |
| IISFI | 7.4053 | 15870 ms |

| IISFT | 86.9753 | 96 ms |
|--------|---------|-----------|
| VRFTEI | 8.2510 | 9027 ms |
| VRFTIE | 9.4924 | 12230 ms |
| VSFTEI | 11.0565 | 5102 ms |
| VSFTIE | 11.4802 | 4950 ms |

Table 8: std dev and running time for 60x20 instances (sorted by dev)

| alg | std dev | avg time |
|--------|----------|----------------------|
| IIRFI | 5.6391 | 26875 ms |
| IISFI | 7.4053 | 15870 ms |
| VRFTEI | 8.2510 | 9027 ms |
| VRFTIE | 9.4924 | 12230 ms |
| VSFTEI | 11.0565 | $5102 \mathrm{\ ms}$ |
| IISBI | 11.0622 | 6949 ms |
| VSFTIE | 11.4802 | 4950 ms |
| IIRFE | 11.7075 | 21836 ms |
| IIRBI | 17.3015 | 12453 ms |
| IISFE | 18.7445 | 6925 ms |
| IISBE | 26.1016 | 3215 ms |
| IIRBE | 28.6631 | 5670 ms |
| IISFT | 86.9753 | 96 ms |
| IISBT | 87.5727 | $103 \mathrm{\ ms}$ |
| IIRFT | 337.2030 | 134 ms |
| IIRBT | 346.7143 | 89 ms |

Table 9: std dev and running time for 60x20 instances (sorted by time)

| alg | std dev | avg time |
|--------|----------|----------------------|
| IIRBT | 346.7143 | 89 ms |
| IISFT | 86.9753 | 96 ms |
| IISBT | 87.5727 | $103 \mathrm{\ ms}$ |
| IIRFT | 337.2030 | 134 ms |
| IISBE | 26.1016 | 3215 ms |
| VSFTIE | 11.4802 | 4950 ms |
| VSFTEI | 11.0565 | 5102 ms |
| IIRBE | 28.6631 | $5670 \mathrm{\ ms}$ |
| IISFE | 18.7445 | 6925 ms |
| IISBI | 11.0622 | 6949 ms |
| VRFTEI | 8.2510 | 9027 ms |
| VRFTIE | 9.4924 | 12230 ms |
| IIRBI | 17.3015 | 12453 ms |
| IISFI | 7.4053 | 15870 ms |
| IIRFE | 11.7075 | 21836 ms |
| IIRFI | 5.6391 | 26875 ms |

Table 10: std dev and running time for 70x20 instances

| alg | std dev | avg time |
|--------|----------|-----------------------|
| IIRBE | 22.7553 | 10629 ms |
| IIRBI | 18.4159 | 22954 ms |
| IIRBT | 282.1761 | 140 ms |
| IIRFE | 11.5822 | 41312 ms |
| IIRFI | 3.2664 | 56675 ms |
| IIRFT | 276.0339 | 211 ms |
| IISBE | 23.8240 | $6561 \mathrm{\ ms}$ |
| IISBI | 12.5178 | 12583 ms |
| IISBT | 79.7734 | $169 \mathrm{\ ms}$ |
| IISFE | 13.6888 | $15677 \mathrm{\ ms}$ |
| IISFI | 4.9066 | 33175 ms |
| IISFT | 72.7923 | 199 ms |
| VRFTEI | 12.2226 | 15231 ms |
| VRFTIE | 7.7359 | 23723 ms |
| VSFTEI | 13.0754 | 8724 ms |
| VSFTIE | 7.9641 | 11209 ms |

Table 11: std dev and running time for 70x20 instances (sorted by dev)

| alm | std dev | arım tima |
|--------|----------|----------------------|
| alg | sta dev | avg time |
| IIRFI | 3.2664 | 56675 ms |
| IISFI | 4.9066 | 33175 ms |
| VRFTIE | 7.7359 | 23723 ms |
| VSFTIE | 7.9641 | 11209 ms |
| IIRFE | 11.5822 | 41312 ms |
| VRFTEI | 12.2226 | 15231 ms |
| IISBI | 12.5178 | 12583 ms |
| VSFTEI | 13.0754 | 8724 ms |
| IISFE | 13.6888 | 15677 ms |
| IIRBI | 18.4159 | 22954 ms |
| IIRBE | 22.7553 | 10629 ms |
| IISBE | 23.8240 | $6561 \mathrm{\ ms}$ |
| IISFT | 72.7923 | $199 \mathrm{\ ms}$ |
| IISBT | 79.7734 | $169 \mathrm{\ ms}$ |
| IIRFT | 276.0339 | 211 ms |
| IIRBT | 282.1761 | $140 \mathrm{\ ms}$ |

Table 12: std dev and running time for 70x20 instances (sorted by time)

| alg | std dev | avg time |
|-------|----------|---------------------|
| IIRBT | 282.1761 | $140 \mathrm{\ ms}$ |
| IISBT | 79.7734 | $169 \mathrm{\ ms}$ |
| IISFT | 72.7923 | $199 \mathrm{\ ms}$ |
| IIRFT | 276.0339 | 211 ms |

| IISBE | 23.8240 | $6561 \mathrm{\ ms}$ |
|--------|---------|-----------------------|
| VSFTEI | 13.0754 | 8724 ms |
| IIRBE | 22.7553 | 10629 ms |
| VSFTIE | 7.9641 | 11209 ms |
| IISBI | 12.5178 | $12583 \mathrm{\ ms}$ |
| VRFTEI | 12.2226 | $15231 \mathrm{\ ms}$ |
| IISFE | 13.6888 | $15677 \mathrm{\ ms}$ |
| IIRBI | 18.4159 | 22954 ms |
| VRFTIE | 7.7359 | 23723 ms |
| IISFI | 4.9066 | 33175 ms |
| IIRFE | 11.5822 | 41312 ms |
| IIRFI | 3.2664 | 56675 ms |

Table 13: std dev and running time for 80x20 instances

| alg | std dev | avg time |
|--------|----------|---------------------|
| IIRBE | 22.7754 | 15895 ms |
| IIRBI | 14.9170 | 36674 ms |
| IIRBT | 201.0257 | 246 ms |
| IIRFE | 8.2952 | $70783~\mathrm{ms}$ |
| IIRFI | 3.8864 | 95764 ms |
| IIRFT | 195.8405 | 344 ms |
| IISBE | 19.6925 | 10478 ms |
| IISBI | 11.0241 | 22032 ms |
| IISBT | 58.9942 | 239 ms |
| IISFE | 11.0078 | 26698 ms |
| IISFI | 4.3316 | 59391 ms |
| IISFT | 56.9208 | $257 \mathrm{\ ms}$ |
| VRFTEI | 7.4860 | 27598 ms |
| VRFTIE | 9.4001 | 38650 ms |
| VSFTEI | 7.5906 | 15367 ms |
| VSFTIE | 6.6299 | $19624~\mathrm{ms}$ |

Table 14: std dev and running time for 80x20 instances (sorted by dev)

| alg | std dev | avg time |
|--------|---------|-----------|
| IIRFI | 3.8864 | 95764 ms |
| IISFI | 4.3316 | 59391 ms |
| VSFTIE | 6.6299 | 19624 ms |
| VRFTEI | 7.4860 | 27598 ms |
| VSFTEI | 7.5906 | 15367 ms |
| IIRFE | 8.2952 | 70783 ms |
| VRFTIE | 9.4001 | 38650 ms |
| IISFE | 11.0078 | 26698 ms |
| IISBI | 11.0241 | 22032 ms |
| IIRBI | 14.9170 | 36674 ms |

| IISBE | 19.6925 | 10478 ms |
|-------|----------|-----------|
| IIRBE | 22.7754 | 15895 ms |
| IISFT | 56.9208 | 257 ms |
| IISBT | 58.9942 | 239 ms |
| IIRFT | 195.8405 | 344 ms |
| IIRBT | 201.0257 | 246 ms |

Table 15: std dev and running time for 80x20 instances (sorted by time)

| alg | std dev | avg time |
|--------|----------|---------------------|
| IISBT | 58.9942 | 239 ms |
| IIRBT | 201.0257 | $246 \mathrm{\ ms}$ |
| IISFT | 56.9208 | $257 \mathrm{\ ms}$ |
| IIRFT | 195.8405 | 344 ms |
| IISBE | 19.6925 | 10478 ms |
| VSFTEI | 7.5906 | 15367 ms |
| IIRBE | 22.7754 | 15895 ms |
| VSFTIE | 6.6299 | 19624 ms |
| IISBI | 11.0241 | 22032 ms |
| IISFE | 11.0078 | 26698 ms |
| VRFTEI | 7.4860 | 27598 ms |
| IIRBI | 14.9170 | 36674 ms |
| VRFTIE | 9.4001 | 38650 ms |
| IISFI | 4.3316 | 59391 ms |
| IIRFE | 8.2952 | 70783 ms |
| IIRFI | 3.8864 | 95764 ms |

Table 16: std dev and running time for 90x20 instances

| alg | std dev | avg time |
|--------|----------|-----------------------|
| IIRBE | 15.2368 | 26077 ms |
| IIRBI | 12.4893 | 57794 ms |
| IIRBT | 160.2339 | 382 ms |
| IIRFE | 5.2240 | 124030 ms |
| IIRFI | 2.5965 | 148202 ms |
| IIRFT | 152.3347 | 547 ms |
| IISBE | 14.5337 | 16752 ms |
| IISBI | 8.6073 | 35823 ms |
| IISBT | 55.3209 | 369 ms |
| IISFE | 8.2186 | 40071 ms |
| IISFI | 2.4010 | 96740 ms |
| IISFT | 49.4902 | 384 ms |
| VRFTEI | 5.7313 | 45848 ms |
| VRFTIE | 5.7316 | $66100 \mathrm{\ ms}$ |
| VSFTEI | 8.2814 | 22000 ms |
| VSFTIE | 3.7770 | 31559 ms |

Table 17: std dev and running time for 90x20 instances (sorted by dev)

| alg | std dev | avg time |
|--------|----------|---------------------|
| IISFI | 2.4010 | 96740 ms |
| IIRFI | 2.5965 | 148202 ms |
| VSFTIE | 3.7770 | 31559 ms |
| IIRFE | 5.2240 | 124030 ms |
| VRFTEI | 5.7313 | 45848 ms |
| VRFTIE | 5.7316 | 66100 ms |
| IISFE | 8.2186 | 40071 ms |
| VSFTEI | 8.2814 | 22000 ms |
| IISBI | 8.6073 | 35823 ms |
| IIRBI | 12.4893 | 57794 ms |
| IISBE | 14.5337 | 16752 ms |
| IIRBE | 15.2368 | 26077 ms |
| IISFT | 49.4902 | 384 ms |
| IISBT | 55.3209 | 369 ms |
| IIRFT | 152.3347 | $547 \mathrm{\ ms}$ |
| IIRBT | 160.2339 | 382 ms |

Table 18: std dev and running time for 90x20 instances (sorted by time)

| alg | $\operatorname{std} \operatorname{dev}$ | avg time |
|--------|---|------------|
| IISBT | 55.3209 | 369 ms |
| IIRBT | 160.2339 | 382 ms |
| IISFT | 49.4902 | 384 ms |
| IIRFT | 152.3347 | 547 ms |
| IISBE | 14.5337 | 16752 ms |
| VSFTEI | 8.2814 | 22000 ms |
| IIRBE | 15.2368 | 26077 ms |
| VSFTIE | 3.7770 | 31559 ms |
| IISBI | 8.6073 | 35823 ms |
| IISFE | 8.2186 | 40071 ms |
| VRFTEI | 5.7313 | 45848 ms |
| IIRBI | 12.4893 | 57794 ms |
| VRFTIE | 5.7316 | 66100 ms |
| IISFI | 2.4010 | 96740 ms |
| IIRFE | 5.2240 | 124030 ms |
| IIRFI | 2.5965 | 148202 ms |

B Statistical Tests

Table 19: Student t-test and Wilcoxon test results for 100x20 instances

| IISFT VRFTEI VRFTIE VSFTEI VSFTIE | 7.768e-05 7.835e-03 | 1.953e-03 1.953e-03 1.953e-03 9.766e-03 | 2.147e-07 1.780e-04 4.460e-04 8.312e-04 | 1.953e-U3 1.953e-U3 1.953e-U3 1.953e-U3 | 1.311e-07 1.231e-08 9.520e-09 6.346e-09 | 3 1.953e-03 1.953e-03 1.953e-03 1.953e-03 1.953e-03 | 1 1.574e-08 4.630e-01 2.435e-01 1.293e-02 5.366e-01 | 2 1.953e-03 5.566e-01 4.922e-01 1.367e-02 9.219e-01 | 1 1.091e-09 1.489e-03 5.792e-03 6.210e-04 7.741e-03 | 1 1.953e-03 5.859e-03 9.766e-03 1.953e-03 2.734e-02 | 9 6.886e-08 8.686e-09 6.998e-09 4.501e-09 6.820e-09 | 3 1.953e-03 1.953e-03 1.953e-03 1.953e-03 1.953e-03 | 6 2.172e-08 2.624e-04 8.200e-04 9.324e-03 9.774e-05 | 3 1.953e-03 1.953e-03 1.953e-03 1.367e-02 1.953e-03 | 3 2.898e-08 2.596e-01 4.658e-01 3.171e-01 2.172e-01 | 3 1.953e-03 1.934e-01 5.566e-01 2.754e-01 2.324e-01 | 9 2.215e-02 1.379e-09 4.131e-09 4.390e-09 2.526e-09 | 3 6.445e-02 1.953e-03 1.953e-03 1.953e-03 1.953e-03 | 2.364e-08 3.108e-01 6.394e-01 | 3 1.953e-03 4.316e-01 6.953e-01 2.754e-01 6.250e-01 | 2.928e-09 1.704e-02 1.274e-02 2.193e-03 7.659e-03 | 1.953e-03 1.367e-02 2.734e-02 1.953e-03 1.367e-02 | 6.471e-09 1.884e-08 8.078e-08 1.155e-08 | 1.953e-03 1.953e-03 1.953e-03 1.953e-03 | 5.878e-01 4.054e-02 9.657e-01 | 7.695e-01 3.711e-02 1.000e+00 | 9 5619-03 5 3179-01 | _ |
|---|---------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|-------------------------------|---|---|---|---|---|-------------------------------|-------------------------------|-----------------------|---|
| IISFI | | | | | | 1.953e-03 | 1.352e-01 | 398e-02 | 3 7.081e-01 | 3 4.316e-01 | 9 7.942e-09 | 3 1.953e-03 | 14 4.712e-06 | 1.953e-03 |)1 5.068e-03 | 11 9.766e-03 | 08 1.288e-09 | 1.953e-03 | 5.068e-03 | 9.766e-03 | | | | | | | | |
| IISFE | _ | \rightarrow | | _ | | 1.953e-03 | 1.150e-01 | 1.602e-01 | 2.484e-03 | 9.766e-03 | 8.389e-09 | 1.953e-03 | 3.344e-04 | 1.953e-03 | 7.040e-01 | 5.566e-01 | 1.260e-08 | 1.953e-03 | | | | | | | | | | |
| IISBT | | _ | | _ | 1.684e-07 | 1.953e-03 | 3.521e-09 | 1.953e-03 | 2.875e-10 | 1.953e-03 | 1.025e-07 | 1.953e-03 | 8.072e-09 | 1.953e-03 | 7.508e-09 | 1.953e-03 | | | | | | | | | | | | |
| IISBI | 5.812e-04 | 1.953e-03 | 6.414e-03 | 5.859e-U3 | 1.268e-08 | 1.953e-03 | 4.458e-02 | 6.445e-02 | 2.513e-03 | 3.906e-03 | 8.383e-09 | 1.953e-03 | 2.246e-03 | 5.859e-03 | | | | | | | | | | | | | | |
| IISBE | 2.685e-02 | 2.734e-02 | 8.318e-01 | 8.45/e-UI | 9.167e-09 | 1.953e-03 | 5.077e-05 | 1.953e-03 | 1.089e-06 | 1.953e-03 | 5.665e-09 | 1.953e-03 | | | | | | | | | | | | | | | | |
| IIRFT | 1.016e-08 | 1.953e-03 | 8.856e-09 | 1.953e-U3 | 3.669e-02 | 4.883e-02 | 4.719e-09 | 1.953e-03 | 4.160e-09 | 1.953e-03 | | | | | | | | | | | | | | | | | | |
| IIRFI | 9.121e-07 | 1.953e-03 | 3.503e-05 | 1.953e-U3 | 6.484e-09 | 1.953e-03 | 2.089e-03 | 5.859e-03 | | | | | | | | | | | | | | | | | | | | |
| IIRFE | 7.299e-06 | 1.953e-03 | 4.187e-04 | 1.953e-U3 | 6.716e-09 | 1.953e-03 | | | | | | | | | | | | | | | | | | | | | | |
| IIRBT | | \dashv | | 1.953e-U3 | | | | | | | | | | | | | | | | | | | | | | | | |
| IIRBI | | 3.750e-01 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | IIRBE | | IIRBI | | TOOL | IILDI | 11011 | IIKFE | TOOL | IILLI | Hadii | IIIVE I | 1011 | HSBE | TGSII | HSBI | FEG | IISBI | 11011 | HOFE | 10011 | IISFI | HOLL | IISFI | 1000 | VRFTEI | 17.007.1 | ֡ |

Table 21: Student t-test and Wilcoxon test results for 50x20 instances

| TEI VSFTIE | e-03 5.760e-04 | + | | e-03 1.750e-03 | e-03 1.953e-03 | e-01 2.367e-01 | e-01 3.223e-01 | e-01 1.458e-02 | e-02 3.711e-02 | e-03 2.007e-03 | e-03 1.953e-03 | e-02 4.025e-03 | e-02 3.906e-03 | e-01 7.035e-01 | e-01 8.457e-01 | e-05 3.188e-05 | e-03 1.953e-03 | e-02 2.921e-02 | e-02 1.953e-02 | e-01 2.274e-01 | e-01 3.750e-01 | e-04 8.267e-05 | e-03 1.953e-03 | e-01 7.479e-01 | e-01 9.219e-01 | e-01 7.111e-01 | e-01 1.000e+00 | |
|-----------------|-------------------------------|---------------|-----------|---------------------|---------------------|-----------------------|-----------------------|---------------------|---------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------|-----------------|----------------|------------------|--|
| VRFTIE VSFTEI | 8.102e-04 5.302e-03 | + | | 1.851e-03 1.931e-03 | 1.953e-03 1.953e-03 | 3e-01 6.928e-01 |)e-01 6.250e-01 | le-01 3.396e-01 | te-01 6.445e-02 | 5e-03 2.231e-03 | 1.953e-03 1.953e-03 | te-04 2.784e-02 | 1.953e-03 4.883e-02 | te-01 8.571e-01 |)e-01 9.219e-01 | 3.938e-05 5.510e-05 | 1.953e-03 1.953e-03 | 3.735e-02 6.278e-02 | 1.953e-02 6.445e-02 | 3e-01 5.752e-01 |)e-01 3.223e-01 | 1.760e-04 2.172e-04 | 1.953e-03 1.953e-03 | le-01 8.144e-01 | 7e-01 9.219e-01 | 7.571e-01 | 6.953e-01 | |
| VRFTEI VRI | | + | | 1.786e-03 1.851 | 1.953e-03 1.955 | 1.625e-01 2.223e-01 | 3.223e-01 3.750e-01 | 9.588e-02 2.941e-01 | 1.602e-01 2.324e-01 | 2.040e-03 2.115e-03 | 1.953e-03 1.953 | 5.566e-04 2.414e-04 | 1.953e-03 1.953 | 5.017e-01 3.954e-01 | 7.695e-01 6.250e-01 | 2.123e-05 3.938 | 1.953e-03 1.953 | 3.635e-02 3.735 | 6.445e-02 1.953 | 3.966e-01 5.673e-01 | 3.223e-01 6.250e-01 | 9.295e-05 1.760 | 953e-03 1.955 | 8.011e-01 | 8.457e-01 | | | |
| IISFT VI | 4.383e-04 1.153e-03 3.938e-04 | 3 891e-04 9 0 | | 2.590e-03 1.7 | 1.953e-03 1.9 | $7.125e-05 \mid 1.6$ | 1.953e-03 3.2 | 4.462e-05 9.5 | 1.953e-03 1.6 | 3.046e-03 2.0 | 1.953e-03 1.9 | 6.605e-04 5.5 | $1.953e-03 \mid 1.9$ | 1.324e-04 5.0 | 1.953e-03 7.6 | 7.044e-01 2.1 | 6.953e-01 1.9 | 3.996e-04 3.6 | 1.953e-03 6.4 | $1.062e-04 \mid 3.9$ | $1.953e-03 \mid 3.2$ | 9.5 | 1.9 | | | | | |
| IISFI | | | 5.859e-03 | 1.726e-03 | 1.953e-03 | 3.453e-02 | 2.734e-02 | 3.827e-01 | 2.754e-01 | 1.973e-03 | 1.953e-03 | 4.349e-04 | 1.953e-03 | 2.058e-01 | 1.934e-01 | 3.371e-05 | 1.953e-03 | ⊢ | 1.953e-02 | | | | | | | | | |
| IISFE | 1 2.273e-02 | | | 3 2.028e-03 | 3 1.953e-03 | 5 1.346e-01 | 3 4.883e-02 | 5 4.674e-03 | 3 1.367e-02 | 3 2.338e-03 | 3 1.953e-03 | 4 6.041e-02 | 3 8.398e-02 | 5 2.372e-01 | 3 2.754e-01 | 1.039e-04 | 1.953e-03 | | | | | | | | | | | |
| IISBT | 1.136e-04 | - | | 13 3.078e-03 | 1.953e-03 | 1.939e-05 | 1 1.953e-03 | 1.658e-05 | 1.953e-03 | 3 3.614e-03 | 1.953e-03 | 1.524e-04 | 1.953e-03 | 4.882e-05 | 1.953e-03 | | | | | | | | | | | | | |
| IISBI | 01 9.331e-03 | | | 03 1.773e-03 | 03 1.953e-03 | 3 8.242e-01 | 3 8.457e-01 | 04 1.055e-01 | 03 6.445e-02 | 3 2.026e-03 | 03 1.953e-03 | 7.956e-06 | 1.953e-03 | | | | | | | | | | | | | | | |
| IISBE | 03 4.176e-01 | | | 02 2.102e-03 | 03 1.953e-03 | .03 1.195e-03 | 03 3.906e-03 | .03 3.689e-04 | .03 1.953e-03 | 2.414e-03 | 1.953e-03 | | | | | | | | | | | | | | | | | |
| IIRFT | -04 2.422e-03 | | | -03 1.246e-02 | -03 1.953e-03 | -04 2.002e-03 | -03 1.953e-03 | 1.887e-03 | 1.953e-03 | | | | | | | | | | | | | | | | | | | |
| E IIRFI | e-03 2.888e-04 | ٦ ٥ | , – | e-03 1.649e-03 | e-03 1.953e-03 | 2.851e-04 | 1.953e-03 | | | | | | | | | | | | | | | | | | | | | |
| IIRBT IIRFE | 2.105e-03 1.050e-03 | | | 1.746e-03 | 1.953e-03 | | | | | | | | | | | | | | | | | | | | | | | |
| IIRBI IIR | 4.237e-01 2.10 | | 1.95 | | | | | | | | | | | | | | | | | | | | | | | | | |
| II | IIRBE 4. | T | IIRBI | 5 5 | IIKBI | 33311 | IILE | TEET | III | FEGUL | III | 0.0011 | HSBE | 11001 | IISBI | ECOI | IISBI | 11011 | HSFE | 11011 | HSFI | HUDII | LISET | 1000 | V RF LEI | VEFTE | V DF LIE | |

Table 23: Student t-test and Wilcoxon test results for 60x20 instances

| | IIRBI | IIRBT | IIRFE | IIRFI | IIRFT | IISBE | IISBI | IISBT | IISFE | IISFI | IISFT | VRFTEI | VRFTEI VRFTIE VSFTEI | | VSFTIE |
|-----------|-----------|-----------|-----------|-----------|------------------------------|-----------|-----------|-----------|-----------|-----------|-----------------------------------|-------------|--------------------------|-----------|-----------|
| IIBBE | 1.088e-02 | 1.531e-05 | 1 | 1.762e-04 | | | | | 4.248e-03 | | 8.691e-05 | | 9.319e-04 | - | 6.926e-04 |
| TIMBE | 9.766e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 6.250e-01 | 1.953e-03 | 1.953e-03 | 5.859e-03 | | 1.953e-03 1.953e-03 1.953e-03 | 1.953e-03 | 5.859e-03 | 3.906e-03 | 1.953e-03 |
| 119911 | | 1.702e-05 | _ | 1.193e-03 | | _ | | 7.531e-06 | 5.632e-01 | 4.096e-03 | | 2.290e-03 | 8.653e-03 | 8.239e-02 | 1.858e-02 |
| III | | 1.953e-03 | 6.445e-02 | 1.953e-03 | 1.953e-03 | 1.953e-02 | 8.398e-02 | 1.953e-03 | 9.219e-01 | 5.859e-03 | 1.953e-03 | 1.953e-03 | 9.766e-03 | 6.445e-02 | 4.883e-02 |
| Haari | | | 1.818e-05 | 1.514e-05 | .514e-05 2.360e-01 2.146e-05 | 2.146e-05 | 1.628e-05 | 1.372e-04 | 1.445e-05 | | 1.341e-05 1.823e-04 1.540e-05 | | 1.544e-05 | 1.764e-05 | 1.483e-05 |
| IIPDI | _ | | 1.953e-03 | 1.953e-03 | 3.223e-01 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 11000 | | | | 1.866e-03 | 1.105e-05 | 9.102e-05 | 7.374e-01 | 2.813e-06 | 4.483e-02 | 5.706e-02 | 1.190e-05 | 6.177e-02 | 3.345e-01 | - | 9.351e-01 |
| IILLE | _ | | | 3.906e-03 | 1.953e-03 | 1.953e-03 | 4.922e-01 | 1.953e-03 | 1.055e-01 | 4.883e-02 | 1.953e-03 | 6.445e-02 | 2.754e-01 | _ | 7.695e-01 |
| TEET | | | | | 9.408e-06 | 3.031e-07 | 1.928e-02 | 2.350e-06 | 1.192e-03 | 2.318e-01 | 1.029e-05 | 1.060e-01 | 2.052e-02 | 2.385e-02 | 2.151e-02 |
| TILLE | | | | | 1.953e-03 | 1.953e-03 | 1.953e-02 | 1.953e-03 | 1.953e-03 | 3.750e-01 | 1.953e-03 | 1.055e-01 | 2.734e-02 | 1.953e-02 | 9.766e-03 |
| TEET | | | | | | 1.328e-05 | 1.024e-05 | 8.720e-05 | 8.501e-06 | 8.282e-06 | 1.188e-04 | 9.320e-06 | 9.510e-06 | 1.079e-05 | 9.128e-06 |
| TIPE I | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 11000 | | | | | | | 1.239e-04 | 3.067e-05 | 3.208e-02 | 2.052e-06 | 1.306e-04 6.884e-06 | | 1.021e-06 | 1.437e-05 | 5.026e-04 |
| IISDE | | | | | | | 1.953e-03 | 1.953e-03 | 6.445e-02 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| IGDI | | | | | | | | 3.926e-06 | 2.432e-02 | 2.464e-02 | 1.628e-05 | 2.502e-01 | 4.903e-01 | 9.978e-01 | 8.890e-01 |
| IISBI | _ | | | | | | | 1.953e-03 | 9.766e-03 | 6.445e-02 | 6.445e-02 1.953e-03 1.934e-01 | | 4.316e-01 | 8.457e-01 | 6.953e-01 |
| TGDI | | | | | | | | | 1.604e-05 | 3.031e-06 | 8.624e-01 | 1.266e-06 | 4.423e-06 | 3.843e-06 | 5.824e-06 |
| Tagir | | | | | | | | | 1.953e-03 | 1.953e-03 | 6.953e-01 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 11011 | | | | | | | | | | 2.584e-04 | 8.005e-05 | 2.694e - 03 | 6.378e-03 | 6.310e-02 | 5.017e-03 |
| LISEE | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 9.766e-03 | 4.883e-02 | 5.859e-03 |
| 110011 | | | | | | | | | | | 1.589e-05 | 6.365e-01 | 1.852e-01 | 1.504e-01 | 4.614e-02 |
| IISFI | _ | | | | | | | | | | 1.953e-03 | 6.953e-01 | 1.934e-01 | 1.602e-01 | 4.883e-02 |
| HESTI | | | | | | | | | | | | 7.053e-06 | 2.286e-05 | 1.598e-05 | 3.296e-05 |
| LISET | _ | | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 1000 | | | | | | | | | | | | | 5.764e-01 | 2.669e-01 | 1.248e-01 |
| VEFIEL | _ | | | | | | | | | | | | 5.566e-01 | 2.754e-01 | 1.602e-01 |
| WETTE | | | | | | | | | | | | | | 4.790e-01 | 4.337e-01 |
| A ICE TIE | | | | | | | | | | | | | | 3.223e-01 | 7.695e-01 |
| Webmer | | | | | | | | | | | | | | | 9.075e-01 |
| V OF LEL | _ | | | | | | | | | | | | | | 1.000e+00 |

Table 25: Student t-test and Wilcoxon test results for 70x20 instances

| | IRBI | IIRBT | IIRFE | IIRFI | IIRFT | IISBE | IISBI | IISBT | IISFE | IISFI | IISFT | VRFTEI | VRFTIE VSFTEI | | VSFTIE |
|----------|-----------|-----------|-----------|-----------|--------------------|-----------|-----------|-----------|-----------|-------------|---------------------|-----------|-----------------|-----------|-----------|
| | 4.802e-02 | 1.162e-06 | 2.569e-04 | 1.826e-06 | 1.234e-06 | 6.053e-01 | 2.531e-03 | 3.828e-07 | 4.157e-03 | 4.726e-05 | 1.669e-06 | 9.504e-04 | 2.198e-05 | 4.465e-03 | 2.234e-05 |
| IRBE 1.3 | 1.367e-02 | 1.953e-03 | 3.906e-03 | 1.953e-03 | 1.953e-03 | 4.922e-01 | 9.766e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 5.859e-03 | 1.953e-03 |
| Iddi | | 9.731e-07 | 4.090e-03 | 1.976e-05 | 1.069e-06 | 9.915e-02 | 4.887e-02 | 3.671e-07 | 3.688e-02 | 1.774e-04 | 1.842e-06 | 1.412e-02 | 2.819e-04 | 1.727e-02 | 1.841e-04 |
| IRDI | | 1.953e-03 | 1.367e-02 | 1.953e-03 | 1.953e-03 | 1.602e-01 | 6.445e-02 | 1.953e-03 | 2.734e-02 | 1.953e-03 | 1.953e-03 2.734e-02 | 2.734e-02 | 1.953e-03 | 2.734e-02 | 1.953e-03 |
| E | | | 6.002e-07 | 4.380e-07 | 3.957e-02 | 1.093e-06 | 4.323e-07 | 7.573e-06 | 6.870e-07 | 5.121e-07 | 4.412e-06 | 5.514e-07 | 5.577e-07 | 6.608e-07 | 5.694e-07 |
| IIRBI | | | 1.953e-03 | 1.953e-03 | 6.445e-02 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 2221 | | | | 3.350e-06 | .350e-06 6.597e-07 | 1.990e-04 | 5.459e-01 | 1.616e-08 | 2.052e-01 | 2.225e-03 | 9.732e-08 | 6.513e-01 | 1.639e-02 | 4.280e-01 | 2.224e-03 |
| ILLE | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 6.250e-01 | 1.953e-03 | 2.754e-01 | 1.953e-03 | 1.953e-03 | 8.457e-01 | 1.953e-02 | 6.250e-01 | 1.953e-03 |
| TEET | | | | | 4.652e-07 | 1.008e-06 | 1.366e-04 | 1.072e-08 | 5.150e-06 | 2.959e-01 | 5.354e-08 | 1.025e-05 | 1.904e-04 | 5.106e-04 | 4.183e-04 |
| ILLI | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 3.750e-01 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| T10 011 | | | | | | 1.161e-06 | 4.645e-07 | 8.887e-06 | 7.294e-07 | 5.449e-07 | 5.280e-06 | 5.804e-07 | 5.856e-07 | 7.100e-07 | 6.172e-07 |
| TPF I | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 1001 | | | | | | | 2.730e-03 | 1.613e-07 | 9.739e-04 | 2.425e-05 | 1.127e-06 | 2.153e-04 | 1.016e-05 | 4.487e-03 | 1.397e-05 |
| TODE | | | | | | | 9.766e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 9.766e-03 | 1.953e-03 |
| 10011 | | | | | | | | 9.832e-09 | 6.036e-01 | 2.375e-03 | 4.699e-08 | 8.837e-01 | 4.317e-02 | 7.857e-01 | 3.997e-02 |
| Iggi | | | | | | | | 1.953e-03 | 6.250e-01 | 5.859e - 03 | 1.953e-03 | 7.695e-01 | 4.883e-02 | 9.219e-01 | 6.445e-02 |
| TGDI | | | | | | | | | 7.166e-08 | 1.429e-08 | 1.540e-02 | 4.389e-08 | 3.659e-08 | 1.388e-08 | 3.203e-08 |
| 1351 | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-02 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 71077 | | | | | | | | | | 2.626e-04 | 7.709e-07 | 1.302e-01 | 5.140e-05 | 7.157e-01 | 8.351e-04 |
| 1316 | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.602e-01 | 1.953e-03 | 4.316e-01 | 1.953e-03 |
| 1001 | | | | | | | | | | | 1.051e-07 | 2.180e-03 | 1.627e-01 | 4.541e-04 | 5.706e-02 |
| IISFI | | | | | | | | | | | 1.953e-03 | 3.906e-03 | 3.223e-01 | 1.953e-03 | 2.734e-02 |
| H431 | | | | | | | | | | | | 4.563e-07 | 2.649e-07 | 2.582e-07 | 2.153e-07 |
| 1135.1 | | | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 170071 | | | | | | | | | | | | | 3.083e-04 | 6.186e-01 | 3.844e-03 |
| nr i Ei | | | | | | | | | | | | | 1.953e-03 | 8.457e-01 | 3.906e-03 |
| VETTE | | | | | | | | | | | | | | 2.467e-02 | 8.377e-01 |
| 111. | | | | | | | | | | | | | | 5.859e-03 | 9.219e-01 |
| 1.00.001 | | | | | | | | | | | | | | | 2.173e-02 |
| SFIEL | | | | | | | | | | | | | | | 9.766e-03 |

Table 27: Student t-test and Wilcoxon test results for 80x20 instances

| | IIRBI | IIRBT | IIRFE | IIRFI | IIRFT | IISBE | IISBI | IISBT | IISFE | IISFI | IISFT | VRFTEI | VRFTEI VRFTIE VSFTEI | VSFTEI | VSFTIE |
|--------|-----------|-----------|-----------|-------------|----------------------|-----------|---|-----------|---------------------|-----------|---|-----------|--------------------------|-----------|-----------|
| TIDDE | 1.023e-03 | 5.018e-07 | 4.254e-05 | 1.666e - 05 | 3.326e-07 | 2.318e-01 | 2.611e-04 | 1.621e-06 | 3.470e-04 | 2.035e-06 | 2.324e-06 | 2.979e-05 | 1.277e-04 | 1.631e-05 | 1.863e-05 |
| TIMBE | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | .953e-03 1.953e-03 | 3.750e-01 | 3.906e-03 | 1.953e-03 | 1.953e-03 1.953e-03 | 1.953e-03 | 1.953e-03 1.953e-03 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 110011 | | 3.666e-07 | 2.487e-03 | 1.303e-05 | 2.546e-07 | 6.311e-02 | 2.445e-02 | 1.644e-06 | 1.355e-02 | 5.893e-06 | 2.503e-06 | 3.741e-04 | 1.143e-02 | 6.523e-04 | 1.610e-04 |
| III | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 4.883e-02 | 2.734e-02 | 1.953e-03 | 5.859e-03 | 1.953e-03 | 1.953e-03 1.953e-03 | 1.953e-03 | 1.953e-02 | 3.906e-03 | 1.953e-03 |
| Haaii | | | 3.341e-07 | 3.220e-07 | 3.368e-02 | 4.591e-07 | 3.220e-07 3.368e-02 4.591e-07 4.841e-07 | 5.014e-06 | 3.318e-07 | 2.751e-07 | 5.014e-06 3.318e-07 2.751e-07 3.713e-06 3.150e-07 | | 2.157e-07 | 3.408e-07 | 4.089e-07 |
| IIII | | | 1.953e-03 | 1.953e-03 | 3.711e-02 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| TIDEE | | | | 1.696e-03 | 2.404e-07 | 1.292e-04 | 4.879e-02 | 2.527e-07 | 3.822e-02 | 5.247e-04 | 4.154e-07 | 4.448e-01 | 3.823e-01 | 3.807e-01 | 3.044e-01 |
| III | | | | 3.906e-03 | 1.953e-03 | 1.953e-03 | 4.883e-02 | 1.953e-03 | 2.734e-02 | 1.953e-03 | 1.953e-03 1.953e-03 | 3.750e-01 | 3.750e-01 | 4.316e-01 | 3.750e-01 |
| TEET | | | | | 2.289e-07 | 2.427e-05 | 3.928e-04 | 2.361e-07 | 1.850e-05 | 6.612e-01 | 4.006e-07 | 2.020e-02 | 6.699e-03 | 1.274e-02 | 5.711e-02 |
| TILL | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 7.695e-01 | 1.953e-03 | 3.711e-02 | 1.367e-02 | 1.367e-02 | 4.883e-02 |
| TIGIL | | | | | | 3.458e-07 | 3.615e-07 | 3.641e-06 | 2.403e-07 | 1.983e-07 | 2.607e-06 | 2.364e-07 | 1.485e-07 | 2.487e-07 | 2.935e-07 |
| TILL | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 11001 | | | | | | | 3.857e-03 | 1.811e-06 | 2.081e-04 | 1.393e-05 | 1.393e-05 4.590e-06 | 2.874e-05 | 1.319e-03 | 6.896e-05 | 1.348e-04 |
| HSBE | | | | | | | 9.766e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 3.906e-03 | 1.953e-03 | 1.953e-03 |
| TIGDI | | | | | | | | 8.458e-07 | 9.916e-01 | 4.160e-06 | 4.160e-06 1.514e-06 | 3.420e-03 | 4.318e-01 | 2.997e-02 | 1.218e-02 |
| IGGII | | | | | | | | 1.953e-03 | 8.457e-01 | 1.953e-03 | 1.953e-03 1.953e-03 | 5.859e-03 | 3.223e-01 | 4.883e-02 | 1.953e-02 |
| TGDI | | | | | | | | | 6.442e-07 | 1.599e-07 | 2.247e-02 | 3.126e-07 | 1.981e-07 | 3.382e-07 | 8.264e-08 |
| TOSH | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-02 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 11011 | | | | | | | | | | 6.772e-05 | 1.192e-06 | 7.061e-03 | 2.914e-01 | 1.120e-02 | 6.836e-03 |
| TISTE | | | | | | | | | | 1.953e-03 | 1.953e-03 | 5.859e-03 | 8.398e-02 | 9.766e-03 | 1.953e-02 |
| 10011 | | | | | | | | | | | 2.600e-07 | 4.975e-04 | 5.602e-03 | 4.937e-03 | 8.980e-02 |
| IJCII | | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 3.906e-03 | 1.934e-01 |
| HUDII | | | | | | | | | | | | 5.905e-07 | 2.237e-07 | 5.321e-07 | 1.886e-07 |
| T JOIT | | | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 1000 | | | | | | | | | | | | | 2.813e-01 | 9.159e-01 | 5.094e-01 |
| VEFIEL | | | | | | | | | | | | | 4.316e-01 | 1.000e+00 | 5.566e-01 |
| VPETTE | | | | | | | | | | | | | | 2.486e-01 | 1.812e-01 |
| 1 | | | | | | | | | | | | | | 4.922e-01 | 1.934e-01 |
| VSFTEI | | | | | | | | | | | | | | | 5.195e-01 |
| 17.17 | | | | | | | | | | | | | | | 4.922e-01 |

Table 29: Student t-test and Wilcoxon test results for 90x20 instances

| | IIRBI | IIRBT | IIRFE | IIRFI | IIRFT | IISBE | IISBI | IISBT | IISFE | IISFI | IISFT | VRFTEI | VRFTIE | VSFTEI | VSFTIE |
|---|-----------|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|---|-----------|-----------|-----------------------|-----------|-----------|-----------|
| TI CITI | 1.307e-01 | 4.570e-08 | 2.243e-06 | 2.742e-07 | 3.137e-08 | 6.574e-01 | 1.919e-03 | 2.810e-07 | 4.460e-06 | 1.110e-07 | 1.641e-06 | 6.462e-07 | 1.189e-05 | 4.742e-05 | 5.857e-07 |
| IIRBE | 1.602e-01 | 1.602e-01 1.953e-03 | 1.953e-03 | Т | 1.953e-03 | 8.457e-01 | | 1.953e-03 | 1.953e-03 1.953e-03 1.953e-03 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| ITEDI | | 4.421e-08 | 2.679e-04 | 4.974e-04 | 3.081e-08 | 2.059e-01 | 8.023e-02 | 2.127e-07 | 2.533e-02 | 1.945e-04 | 6.627e-07 | 8.784e-04 | 6.640e-04 | 6.566e-02 | 7.527e-04 |
| III | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 2.754e-01 | 4.883e-02 | 1.953e-03 | 3.711e-02 | 1.953e-03 | 1.953e-03 | 1.953e-03 1.953e-03 | 1.953e-03 | 4.883e-02 | 1.953e-03 |
| Footi | | | 3.184e-08 | 3.177e-08 | 2.748e-04 | 3.485e-08 | 5.426e-08 | 1.436e-07 | 4.314e-08 | 1.906e-08 | 3.939e-08 | 2.290e-08 | 2.082e-08 | 4.896e-08 | 3.372e-08 |
| III | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| TIDE | | | | 1.651e-02 | 2.183e-08 | 5.428e-05 | 3.027e-02 | | 2.730e-08 4.424e-03 | 4.007e-03 | 1.845e-07 | 4.366e-01 | 5.193e-01 | 2.463e-02 | 5.856e-02 |
| TILLE | | | | 2.734e-02 | 1.953e-03 | 1.953e-03 | 3.711e-02 | 1.953e-03 | 3.906e-03 | 9.766e-03 | 1.953e-03 | 4.316e-01 | 6.953e-01 | 2.734e-02 | 8.398e-02 |
| ITDEL | | | | | 2.227e-08 | 8.971e-06 | 3.371e-04 | 4.348e-08 | 2.602e-06 | 7.992e-01 | 2.874e-07 | 1.033e-02 | 1.726e-02 | 4.834e-05 | 9.990e-02 |
| TILLET | | | | | 1.953e-03 | 1.953e-03 | 3.906e-03 | 1.953e-03 | 1.953e-03 | 1.000e+00 | 1.953e-03 | 3.711e-02 | 1.953e-02 | 1.953e-03 | 6.445e-02 |
| TOOL | | | | | | 2.435e-08 | 3.908e-08 | 8.587e-08 | 3.051e-08 | 1.266e-08 | 2.142e-08 | 1.562e-08 | 1.322e-08 | 3.324e-08 | 2.280e-08 |
| TIUL | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 1100 | | | | | | | 4.514e-03 | 5.309e-08 | 9.671e-04 | 1.108e-05 | 5.393e-07 | 8.759e-05 | 6.046e-05 | 3.381e-03 | 5.464e-05 |
| HODE | | | | | | | 9.766e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 3.906e-03 | 1.953e-03 | 9.766e-03 | 1.953e-03 |
| TGDI | | | | | | | | 1.195e-07 | 7.905e-01 | 4.065e-04 | 7.558e-07 | 8.741e-02 | 5.297e-02 | 8.348e-01 | 6.182e-03 |
| IGGII | | | | | | | | 1.953e-03 | 5.566e-01 | 3.906e-03 | 1.953e-03 | 1.309e-01 | 6.445e-02 | 5.566e-01 | 9.766e-03 |
| TGDI | | | | | | | | | 1.346e-07 | 1.299e-08 | 1.740e-03 | 2.618e-08 | 1.494e-08 | 9.236e-08 | 3.017e-08 |
| TOSH | | | | | | | | | 1.953e-03 | 1.953e-03 | 3.906e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 7.07.71 | | | | | | | | | | 1.559e-04 | 8.415e-07 | 2.209e-02 | 5.379e-02 | 9.380e-01 | 1.153e-04 |
| 1131 | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-02 | 4.883e-02 | 1.000e+00 | 1.953e-03 |
| 11251 | | | | | | | | | | | 6.427e-08 | 5.193e-04 | 7.566e-04 | 6.247e-04 | 1.053e-01 |
| 13011 | | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 | 8.398e-02 |
| TICEL | | | | | | | | | | | | 1.342e-07 | 8.606e-08 | 8.799e-07 | 2.412e-07 |
| TISLI | | | | | | | | | | | | 1.953e-03 | 1.953e-03 | 1.953e-03 | 1.953e-03 |
| 171111111111111111111111111111111111111 | | | | | | | | | | | | | 9.997e-01 | 5.736e-02 | 4.898e-02 |
| V DF 1 E1 | | | | | | | | | | | | | 8.457e-01 | 3.711e-02 | 6.445e-02 |
| VBETTE | | | | | | | | | | | | | | 1.043e-01 | 9.911e-02 |
| 777 | | | | | | | | | | | | | | 1.055e-01 | 1.309e-01 |
| VCPTPI | | | | | | | | | | | | | | | 4.441e-05 |
| V OF LEL | | | | | | | | | | | | | | | 1.953e-03 |