Université Libre de Bruxelles

Faculty of Applied Science

IRIDIA

INFO-H-421 : Heuristic Optimization

Implementation exercise 1 : IIA for PFSP with WT Objective

Authors

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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.

Contents

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
```

run them

```
# lli test/out/gcd
# 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 computation 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 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 computation 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 ms

Table 3: std dev and computation 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 computation 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 ms
IISBE	50.8140	1395 ms
IISBI	24.7393	3099 ms
IISBT	144.9350	46 ms
IISFE	33.9047	2587 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 computation 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 ms
IISFT	141.1087	63 ms
IISBT	144.9350	46 ms
IIRFT	990.2279	67 ms
IIRBT	1033.8080	46 ms

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

alg	**std dev**	**avg time**
IISBT	144.9350	46 ms
IIRBT	1033.8080	46 ms
IISFT	141.1087	63 ms
IIRFT	990.2279	67 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 ms
IISFI	17.8570	6242 ms
IIRFE	25.7903	10132 ms
IIRFI	15.2501	12937 ms

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

alg	**std dev**	**avg time**
IIRBE	28.6631	5670 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 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 computation 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 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 ms
IIRFT	337.2030	134 ms
IIRBT	346.7143	89 ms

Table 9: std dev and computation 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 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 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 computation 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 ms
IISBI	12.5178	12583 ms
IISBT	79.7734	169 ms
IISFE	13.6888	15677 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 computation time for 70x20 instances (sorted by dev)

alg	**std 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 ms
IISFT	72.7923	199 ms
IISBT	79.7734	169 ms
IIRFT	276.0339	211 ms
IIRBT	282.1761	140 ms

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

alg	**std dev**	**avg time**
IIRBT	282.1761	140 ms
IISBT	79.7734	169 ms
IISFT	72.7923	199 ms
IIRFT	276.0339	211 ms
IISBE	23.8240	6561 ms
VSFTEI	13.0754	8724 ms
IIRBE	22.7553	10629 ms
VSFTIE	7.9641	11209 ms
IISBI	12.5178	12583 ms
VRFTEI	12.2226	15231 ms
IISFE	13.6888	15677 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 computation 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 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 ms
VRFTEI	7.4860	27598 ms
VRFTIE	9.4001	38650 ms
VSFTEI	7.5906	15367 ms
VSFTIE	6.6299	19624 ms

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

alg	**std dev**	**avg time**
IISBT	58.9942	239 ms
IIRBT	201.0257	246 ms
IISFT	56.9208	257 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 computation 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 ms
VSFTEI	8.2814	22000 ms
VSFTIE	3.7770	31559 ms

Table 17: std dev and computation 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 ms
IIRBT	160.2339	382 ms

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

alg	**std 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

	IIRBI	IIRBT	IIRFE	IIRFI	IIRFT	IISBE	IISBI	IISBT	IISFE	IISFI	IISFT	VRFTEI	VRFTIE	VSFTEI	VSFTIE
IIRBE	2.710e-01 3.750e-01	1.524e-08 1.953e-03	7.299e-06 1.953e-03	9.121e-07 1.953e-03	1.016e-08 1.953e-03	2.685e-02 2.734e-02	5.812e-04 1.953e-03	1.345e-07 1.953e-03	7.877e-07 1.953e-03	8.000e-06 1.953e-03	1.382e-07 1.953e-03	7.797e-05 1.953e-03	7.768e-05 1.953e-03	7.835e-03 9.766e-03	1.406e-04 1.953e-03
IIRBI		1.245e-08 1.953e-03	4.187e-04 1.953e-03	3.503e-05 1.953e-03	8.856e-09 1.953e-03	8.318e-01 8.457e-01	6.414e-03 5.859e-03	1.243e-08 1.953e-03	4.079e-03 9.766e-03	6.356e-06 1.953e-03	2.147e-07 1.953e-03	1.780e-04 1.953e-03	4.460e-04 1.953e-03	8.312e-04 1.953e-03	2.719e-06 1.953e-03
IIRBT			6.716e-09 1.953e-03	6.484e-09 1.953e-03	3.669e-02 4.883e-02	9.167e-09 1.953e-03	1.268e-08 1.953e-03	1.684e-07 1.953e-03	1.151e-08 1.953e-03	1.177e-08 1.953e-03	1.311e-07 1.953e-03	1.231e-08 1.953e-03	9.520e-09 1.953e-03	6.346e-09 1.953e-03	9.798e-09 1.953e-03
IIRFE				2.089e-03 5.859e-03	4.719e-09 1.953e-03	5.077e-05 1.953e-03	4.458e-02 6.445e-02	3.521e-09 1.953e-03	1.150e-01 1.602e-01	1.352e-01 8.398e-02	1.574e-08 1.953e-03	4.630e-01 5.566e-01	2.435e-01 4.922e-01	1.293e-02 1.367e-02	5.366e-01 9.219e-01
IIRFI					4.160e-09 1.953e-03	1.089e-06 1.953e-03	2.513e-03 3.906e-03	2.875e-10 1.953e-03	2.484e-03 9.766e-03	7.081e-01 4.316e-01	1.091e-09 1.953e-03	1.489e-03 5.859e-03	5.792e-03 9.766e-03	6.210e-04 1.953e-03	7.741e-03 2.734e-02
IIRFT						5.665e-09 1.953e-03	8.383e-09 1.953e-03	1.025e-07 1.953e-03	8.389e-09 1.953e-03	7.942e-09 1.953e-03	6.886e-08 1.953e-03	8.686e-09 1.953e-03	6.998e-09 1.953e-03	4.501e-09 1.953e-03	6.820e-09 1.953e-03
IISBE							2.246e-03 5.859e-03	8.072e-09 1.953e-03	3.344e-04 1.953e-03	4.712e-06 1.953e-03	2.172e-08 1.953e-03	2.624e-04 1.953e-03	8.200e-04 1.953e-03	9.324e-03 1.367e-02	9.774e-05 1.953e-03
IISBI								7.508e-09 1.953e-03	7.040e-01 5.566e-01	5.068e-03 9.766e-03	2.898e-08 1.953e-03	2.596e-01 1.934e-01	4.658e-01 5.566e-01	3.171e-01 2.754e-01	2.172e-01 2.324e-01
IISBT									1.260e-08 1.953e-03	1.288e-09 1.953e-03	2.215e-02 6.445e-02	1.379e-09 1.953e-03	4.131e-09 1.953e-03	4.390e-09 1.953e-03	2.526e-09 1.953e-03
IISFE										5.068e-03 9.766e-03	2.364e-08 1.953e-03	3.108e-01 4.316e-01	6.394e-01 6.953e-01	2.643e-01 2.754e-01	3.856e-01 6.250e-01
IISFI											2.928e-09 1.953e-03	1.704e-02 1.367e-02	1.274e-02 2.734e-02	2.193e-03 1.953e-03	7.659e-03 1.367e-02
IISFT												6.471e-09 1.953e-03	1.884e-08 1.953e-03	8.078e-08 1.953e-03	1.155e-08 1.953e-03
VRFTEI													5.878e-01 7.695e-01	4.054e-02 3.711e-02	9.657e-01 1.000e+00
VRFTIE														9.561e-02 6.445e-02	5.217e-01 4.922e-01
VSFTEI															1.307e-02 2.734e-02

Table 20: Student t-test and Wilcoxon test results for 50x20 instances

	IIRBI	IIRBT	IIRFE	IIRFI	IIRFT	IISBE	IISBI	IISBT	IISFE	IISFI	IISFT	VRFTEI	VRFTIE	VSFTEI	VSFTIE
IIRBE	4.237e-01 3.750e-01	2.105e-03 1.953e-03	1.050e-03 1.953e-03	2.888e-04 1.953e-03	2.422e-03 1.953e-03	4.176e-01 1.934e-01	9.331e-03 9.766e-03	1.136e-04 1.953e-03	2.273e-02 1.953e-02	4.383e-04 1.953e-03	1.153e-03 1.953e-03	3.938e-04 1.953e-03	8.102e-04 1.953e-03	5.302e-03 3.906e-03	5.760e-04 1.953e-03
IIRBI		2.042e-03 1.953e-03	3.310e-02 9.766e-03	9.663e-03 1.953e-03	2.376e-03 1.953e-03	9.005e-01 1.309e-01	6.473e-02 1.953e-02	7.896e-05 1.953e-03	1.473e-01 1.309e-01	2.763e-02 5.859e-03	3.821e-04 1.953e-03	2.944e-02 1.953e-03	2.914e-02 1.953e-03	4.773e-03 1.953e-03	2.370e-02 3.906e-03
IIRBT			1.746e-03 1.953e-03	1.649e-03 1.953e-03	1.246e-02 1.953e-03	2.102e-03 1.953e-03	1.773e-03 1.953e-03	3.078e-03 1.953e-03	2.028e-03 1.953e-03	1.726e-03 1.953e-03	2.590e-03 1.953e-03	1.786e-03 1.953e-03	1.851e-03 1.953e-03	1.931e-03 1.953e-03	1.750e-03 1.953e-03
IIRFE				2.851e-04 1.953e-03	2.002e-03 1.953e-03	1.195e-03 3.906e-03	8.242e-01 8.457e-01	1.939e-05 1.953e-03	1.346e-01 4.883e-02	3.453e-02 2.734e-02	7.125e-05 1.953e-03	1.625e-01 3.223e-01	2.223e-01 3.750e-01	6.928e-01 6.250e-01	2.367e-01 3.223e-01
IIRFI					1.887e-03 1.953e-03	3.689e-04 1.953e-03	1.055e-01 6.445e-02	1.658e-05 1.953e-03	4.674e-03 1.367e-02	3.827e-01 2.754e-01	4.462e-05 1.953e-03	9.588e-02 1.602e-01	2.941e-01 2.324e-01	3.396e-01 6.445e-02	1.458e-02 3.711e-02
IIRFT						2.414e-03 1.953e-03	2.026e-03 1.953e-03	3.614e-03 1.953e-03	2.338e-03 1.953e-03	1.973e-03 1.953e-03	3.046e-03 1.953e-03	2.040e-03 1.953e-03	2.115e-03 1.953e-03	2.231e-03 1.953e-03	2.007e-03 1.953e-03
IISBE							7.956e-06 1.953e-03	1.524e-04 1.953e-03	6.041e-02 8.398e-02	4.349e-04 1.953e-03	6.605e-04 1.953e-03	5.566e-04 1.953e-03	2.414e-04 1.953e-03	2.784e-02 4.883e-02	4.025e-03 3.906e-03
IISBI								4.882e-05 1.953e-03	2.372e-01 2.754e-01	2.058e-01 1.934e-01	1.324e-04 1.953e-03	5.017e-01 7.695e-01	3.954e-01 6.250e-01	8.571e-01 9.219e-01	7.035e-01 8.457e-01
IISBT									1.039e-04 1.953e-03	3.371e-05 1.953e-03	7.044e-01 6.953e-01	2.123e-05 1.953e-03	3.938e-05 1.953e-03	5.510e-05 1.953e-03	3.188e-05 1.953e-03
IISFE										7.951e-03 1.953e-02	3.996e-04 1.953e-03	3.635e-02 6.445e-02	3.735e-02 1.953e-02	6.278e-02 6.445e-02	2.921e-02 1.953e-02
IISFI											1.062e-04 1.953e-03	3.966e-01 3.223e-01	5.673e-01 6.250e-01	5.752e-01 3.223e-01	2.274e-01 3.750e-01
IISFT												9.295e-05 1.953e-03	1.760e-04 1.953e-03	2.172e-04 1.953e-03	8.267e-05 1.953e-03
VRFTEI													8.011e-01 8.457e-01	8.144e-01 9.219e-01	7.479e-01 9.219e-01
VRFTIE														7.571e-01 6.953e-01	7.111e-01 1.000e+00
VSFTEI															9.212e-01 6.250e-01

Table 21: Student t-test and Wilcoxon test results for 60x20 instances

	IIRBI	IIRBT	IIRFE	IIRFI	IIRFT	IISBE	IISBI	IISBT	IISFE	IISFI	IISFT	VRFTEI	VRFTIE	VSFTEI	VSFTIE
IIRBE	1.088e-02 9.766e-03	1.531e-05 1.953e-03	7.785e-04 1.953e-03	1.762e-04 1.953e-03	8.857e-06 1.953e-03	5.297e-01 6.250e-01	6.365e-04 1.953e-03	1.351e-05 1.953e-03	4.248e-03 5.859e-03	8.829e-05 1.953e-03	8.691e-05 1.953e-03	1.454e-04 1.953e-03	9.319e-04 5.859e-03	2.005e-03 3.906e-03	6.926e-04 1.953e-03
IIRBI		1.702e-05 1.953e-03	6.335e-02 6.445e-02	1.193e-03 1.953e-03	9.910e-06 1.953e-03	7.851e-03 1.953e-02	1.163e-01 8.398e-02	7.531e-06 1.953e-03	5.632e-01 9.219e-01	4.096e-03 5.859e-03	5.040e-05 1.953e-03	2.290e-03 1.953e-03	8.653e-03 9.766e-03	8.239e-02 6.445e-02	1.858e-02 4.883e-02
IIRBT			1.818e-05 1.953e-03	1.514e-05 1.953e-03	2.360e-01 3.223e-01	2.146e-05 1.953e-03	1.628e-05 1.953e-03	1.372e-04 1.953e-03	1.445e-05 1.953e-03	1.341e-05 1.953e-03	1.823e-04 1.953e-03	1.540e-05 1.953e-03	1.544e-05 1.953e-03	1.764e-05 1.953e-03	1.483e-05 1.953e-03
IIRFE				1.866e-03 3.906e-03	1.105e-05 1.953e-03	9.102e-05 1.953e-03	7.374e-01 4.922e-01	2.813e-06 1.953e-03	4.483e-02 1.055e-01	5.706e-02 4.883e-02	1.190e-05 1.953e-03	6.177e-02 6.445e-02	3.345e-01 2.754e-01	6.772e-01 5.566e-01	9.351e-01 7.695e-01
IIRFI					9.408e-06 1.953e-03	3.031e-07 1.953e-03	1.928e-02 1.953e-02	2.350e-06 1.953e-03	1.192e-03 1.953e-03	2.318e-01 3.750e-01	1.029e-05 1.953e-03	1.060e-01 1.055e-01	2.052e-02 2.734e-02	2.385e-02 1.953e-02	2.151e-02 9.766e-03
IIRFT						1.328e-05 1.953e-03	1.024e-05 1.953e-03	8.720e-05 1.953e-03	8.501e-06 1.953e-03	8.282e-06 1.953e-03	1.188e-04 1.953e-03	9.320e-06 1.953e-03	9.510e-06 1.953e-03	1.079e-05 1.953e-03	9.128e-06 1.953e-03
IISBE							1.239e-04 1.953e-03	3.067e-05 1.953e-03	3.208e-02 6.445e-02	2.052e-06 1.953e-03	1.306e-04 1.953e-03	6.884e-06 1.953e-03	1.021e-06 1.953e-03	1.437e-05 1.953e-03	5.026e-04 1.953e-03
IISBI								3.926e-06 1.953e-03	2.432e-02 9.766e-03	2.464e-02 6.445e-02	1.628e-05 1.953e-03	2.502e-01 1.934e-01	4.903e-01 4.316e-01	9.978e-01 8.457e-01	8.890e-01 6.953e-01
IISBT									1.604e-05 1.953e-03	3.031e-06 1.953e-03	8.624e-01 6.953e-01	1.266e-06 1.953e-03	4.423e-06 1.953e-03	3.843e-06 1.953e-03	5.824e-06 1.953e-03
IISFE										2.584e-04 1.953e-03	8.005e-05 1.953e-03	2.694e-03 1.953e-03	6.378e-03 9.766e-03	6.310e-02 4.883e-02	5.017e-03 5.859e-03
IISFI											1.589e-05 1.953e-03	6.365e-01 6.953e-01	1.852e-01 1.934e-01	1.504e-01 1.602e-01	4.614e-02 4.883e-02
IISFT												7.053e-06 1.953e-03	2.286e-05 1.953e-03	1.598e-05 1.953e-03	3.296e-05 1.953e-03
VRFTEI													5.764e-01 5.566e-01	2.669e-01 2.754e-01	1.248e-01 1.602e-01
VRFTIE														4.790e-01 3.223e-01	4.337e-01 7.695e-01
VSFTEI															9.075e-01 1.000e+00

Table 22: Student t-test and Wilcoxon test results for 70x20 instances

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

Table 23: Student t-test and Wilcoxon test results for 80x20 instances

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

Table 24: 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
IIRBE	1.307e-01 1.602e-01	4.570e-08 1.953e-03	2.243e-06 1.953e-03	2.742e-07 1.953e-03	3.137e-08 1.953e-03	6.574e-01 8.457e-01	1.919e-03 1.953e-03	2.810e-07 1.953e-03	4.460e-06 1.953e-03	1.110e-07 1.953e-03	1.641e-06 1.953e-03	6.462e-07 1.953e-03	1.189e-05 1.953e-03	4.742e-05 1.953e-03	5.857e-07 1.953e-03
IIRBI		4.421e-08 1.953e-03	2.679e-04 1.953e-03	4.974e-04 1.953e-03	3.081e-08 1.953e-03	2.059e-01 2.754e-01	8.023e-02 4.883e-02	2.127e-07 1.953e-03	2.533e-02 3.711e-02	1.945e-04 1.953e-03	6.627e-07 1.953e-03	8.784e-04 1.953e-03	6.640e-04 1.953e-03	6.566e-02 4.883e-02	7.527e-04 1.953e-03
IIRBT			3.184e-08 1.953e-03	3.177e-08 1.953e-03	2.748e-04 1.953e-03	3.485e-08 1.953e-03	5.426e-08 1.953e-03	1.436e-07 1.953e-03	4.314e-08 1.953e-03	1.906e-08 1.953e-03	3.939e-08 1.953e-03	2.290e-08 1.953e-03	2.082e-08 1.953e-03	4.896e-08 1.953e-03	3.372e-08 1.953e-03
IIRFE				1.651e-02 2.734e-02	2.183e-08 1.953e-03	5.428e-05 1.953e-03	3.027e-02 3.711e-02	2.730e-08 1.953e-03	4.424e-03 3.906e-03	4.007e-03 9.766e-03	1.845e-07 1.953e-03	4.366e-01 4.316e-01	5.193e-01 6.953e-01	2.463e-02 2.734e-02	5.856e-02 8.398e-02
IIRFI					2.227e-08 1.953e-03	8.971e-06 1.953e-03	3.371e-04 3.906e-03	4.348e-08 1.953e-03	2.602e-06 1.953e-03	7.992e-01 1.000e+00	2.874e-07 1.953e-03	1.033e-02 3.711e-02	1.726e-02 1.953e-02	4.834e-05 1.953e-03	9.990e-02 6.445e-02
IIRFT						2.435e-08 1.953e-03	3.908e-08 1.953e-03	8.587e-08 1.953e-03	3.051e-08 1.953e-03	1.266e-08 1.953e-03	2.142e-08 1.953e-03	1.562e-08 1.953e-03	1.322e-08 1.953e-03	3.324e-08 1.953e-03	2.280e-08 1.953e-03
IISBE							4.514e-03 9.766e-03	5.309e-08 1.953e-03	9.671e-04 1.953e-03	1.108e-05 1.953e-03	5.393e-07 1.953e-03	8.759e-05 3.906e-03	6.046e-05 1.953e-03	3.381e-03 9.766e-03	5.464e-05 1.953e-03
IISBI								1.195e-07 1.953e-03	7.905e-01 5.566e-01	4.065e-04 3.906e-03	7.558e-07 1.953e-03	8.741e-02 1.309e-01	5.297e-02 6.445e-02	8.348e-01 5.566e-01	6.182e-03 9.766e-03
IISBT									1.346e-07 1.953e-03	1.299e-08 1.953e-03	1.740e-03 3.906e-03	2.618e-08 1.953e-03	1.494e-08 1.953e-03	9.236e-08 1.953e-03	3.017e-08 1.953e-03
IISFE										1.559e-04 1.953e-03	8.415e-07 1.953e-03	2.209e-02 1.953e-02	5.379e-02 4.883e-02	9.380e-01 1.000e+00	1.153e-04 1.953e-03
IISFI											6.427e-08 1.953e-03	5.193e-04 1.953e-03	7.566e-04 1.953e-03	6.247e-04 1.953e-03	1.053e-01 8.398e-02
IISFT												1.342e-07 1.953e-03	8.606e-08 1.953e-03	8.799e-07 1.953e-03	2.412e-07 1.953e-03
VRFTEI													9.997e-01 8.457e-01	5.736e-02 3.711e-02	4.898e-02 6.445e-02
VRFTIE														1.043e-01 1.055e-01	9.911e-02 1.309e-01
VSFTEI															4.441e-05 1.953e-03