

Statistical Test for Designing Tournament Selection in Genetic Programming

Thi Huong Chu^a, Quang Uy Nguyen^{a,*}, Michael O'Neill^b

^a*Faculty of IT, Le Quy Don Technical University, Hanoi, Vietnam*

^b*NCRA Group, University College Dublin, Dublin, Ireland*

Supplement 1. The mean of best fitness, median of test error and average of solutions with tour size=3, 5 and 7 on both of noisy data and noiseless data

Table 1: List of table results in supplement 1

No	Content	Table
1	The mean of best fitness on training original data with tour size=3 and tour size=7	Table 2
2	The mean of best fitness on training noise data with tour size=3 and tour size=7	Table 3
3	The average of solutions size on training noise data with tour size=3 and tour size=7	Table 4
4	The mean of best fitness in the comparison of Statistics Tournament Selection methods with tour size=5	Table 5
5	The median of testing error in the comparison of Statistics Tournament Selection methods tour size=5	Table 6

*Quang Uy Nguyen; Mobile: 84-968490399

Email addresses: huongkts@gmail.com (Thi Huong Chu), quanguyhn@gmail.com (Quang Uy Nguyen), m.oneill@ucd.ie (Michael O'Neill)

6	The average of solution's size in the comparison of Statistics Tournament Selection methods with tour size=5	Table 7
7	The mean of best fitness of TS-RDO and four other techniques with tour size=5	Table 8
8	The median of fittest of TS-RDO and four other techniques with tour size=5	Table 9
9	The average of solutions size of TS-RDO and four other techniques with tour size=5	Table 10

Table 2: The mean best fitness on training original data. The left is with tour size=3 and the right is with tour size=7. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it significantly smaller than GP and marked - if it is significantly greater than GP.

Pro	GP	TS-R	TS-S	TS-P	GP	TS-R	TS-S	TS-P
F1	2.01	2.74	2.98	2.70	1.46	2.29 ⁻	3.13 ⁻	2.29 ⁻
F2	0.24	0.39 ⁻	0.56 ⁻	0.31 ⁻	0.23	0.35 ⁻	0.55 ⁻	0.26
F3	5.19	6.62 ⁻	6.36 ⁻	6.15 ⁻	4.62	5.66 ⁻	6.29 ⁻	4.93 ⁻
F4	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03 ⁺
F5	0.13	0.13	0.13	0.13	0.12	0.13	0.13	0.12
F6	0.44	0.76 ⁻	0.99 ⁻	0.59 ⁻	0.33	0.62 ⁻	1.09 ⁻	0.48 ⁻
F7	0.43	0.47 ⁻	0.51 ⁻	0.44	0.42	0.44	0.52 ⁻	0.40
F8	4.37	4.43	4.72	4.12	5.22	4.51	5.71 ⁻	4.76
F9	1.48	1.98	1.96	1.32	1.62	1.42 ⁺	2.30 ⁻	1.66
F10	7.93	7.94	6.39	8.78	7.72	6.65	5.38 ⁺	8.51
F11	0.10	0.11	0.07	0.09	0.10	0.11 ⁻	0.07	0.10
F12	7.04	7.15 ⁻	7.11 ⁻	7.14 ⁻	6.96	7.14 ⁻	7.11 ⁻	7.06 ⁻
F13	0.87	0.89 ⁻	0.88 ⁻	0.88 ⁻	0.88	0.89 ⁻	0.89 ⁻	0.88 ⁺
F14	76.1	80.5	76.7	79.6	75.8	76.2	74.1	76.1
F15	2.55	2.64	2.45	2.61	2.17	2.23	2.29	2.37
F16	9.74	10.19	9.83	10.39	8.04	8.77	8.40	8.65
F17	3.69	4.05 ⁻	4.11 ⁻	3.97 ⁻	3.39	3.89 ⁻	4.11 ⁻	3.82 ⁻
F18	10.6	11.6	11.4	12.0	9.72	11.0	9.41	10.0
F19	26.4	29.4 ⁻	31.6 ⁻	28.5 ⁻	25.2	29.9 ⁻	31.8 ⁻	27.9 ⁻
F20	10.5	10.8	10.7	10.6	9.35	9.87 ⁻	9.85 ⁻	9.70
F21	4.35	4.47 ⁻	4.41 ⁻	4.44 ⁻	4.23	4.33 ⁻	4.35 ⁻	4.28
F22	1.10	1.33 ⁻	1.29 ⁻	1.24 ⁻	0.84	1.02 ⁻	1.22 ⁻	0.93
F23	4.24	5.35 ⁻	4.66	5.01 ⁻	3.47	4.58 ⁻	7.22 ⁻	4.18 ⁻
F24	8.99	10.7 ⁻	10.9 ⁻	10.3 ⁻	8.08	10.2 ⁻	12.1 ⁻	9.47 ⁻
F25	4.98	6.18 ⁻	6.69 ⁻	5.86 ⁻	4.47	5.79 ⁻	7.18 ⁻	5.40 ⁻

Table 3: The mean best fitness on training noise data. The left is with tour size=3 and the right is with tour size=7. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it significantly smaller than GP and marked - if it is significantly greater than GP.

Pro	GP	neatGP	TS-S	RDO	TS-RDO	GP	neatGP	TS-S	RDO	TS-RDO
F1	2.06	4.78 ⁻	3.41 ⁻	0.15 ⁺	2.43	1.69	4.78 ⁻	3.55 ⁻	0.19 ⁺	3.38 ⁻
F2	0.22	0.41 ⁻	0.57 ⁻	0.05 ⁺	0.21	0.22	0.41 ⁻	0.58 ⁻	0.06 ⁺	0.39 ⁻
F3	5.39	13.11 ⁻	6.63	0.17 ⁺	0.91 ⁺	4.75	13.11 ⁻	6.33	0.21 ⁺	1.52 ⁺
F4	0.10	0.17 ⁻	0.11 ⁻	0.08 ⁺	0.09 ⁺	0.10	0.17 ⁻	0.12 ⁻	0.08 ⁺	0.10
F5	0.14	0.16 ⁻	0.14	0.13	0.15 ⁻	0.14	0.16 ⁻	0.14	0.14	0.15 ⁻
F6	0.76	1.00 ⁻	1.23 ⁻	0.28 ⁺	0.53 ⁺	0.62	1.00 ⁻	1.26 ⁻	0.27 ⁺	0.61
F7	0.48	0.54 ⁻	0.56 ⁻	0.26 ⁺	0.45	0.45	0.54 ⁻	0.57 ⁻	0.27 ⁺	0.46
F8	66.8	69.2 ⁻	67.2 ⁻	65.9	67.3 ⁻	66.5	69.2 ⁻	67.3 ⁻	66.0	67.4 ⁻
F9	3.99	5.64 ⁻	4.61 ⁻	2.95 ⁺	3.22	5.40	5.64 ⁻	6.74 ⁻	2.96 ⁺	3.34
F10	9.93	10.9	6.82	2.72 ⁺	2.85 ⁺	7.96	10.9 ⁻	6.98	3.58 ⁺	2.71 ⁺
F11	0.21	0.30 ⁻	0.21	0.18 ⁺	0.19 ⁺	0.22	0.30 ⁻	0.21 ⁺	0.18	0.19 ⁺
F12	7.15	7.52 ⁻	7.17 ⁻	6.76 ⁺	6.98	7.03	7.52 ⁻	7.17 ⁻	6.81 ⁺	7.06 ⁻
F13	0.88	0.93 ⁻	0.89 ⁻	0.87	0.89 ⁻	0.89	0.93 ⁻	0.89 ⁻	0.87	0.89 ⁺
F14	102.6	109.4 ⁻	104.5 ⁻	94.9 ⁺	102.4	103.1	109.4 ⁻	102.7 ⁺	96.2 ⁺	103.6 ⁻
F15	3.04	3.95 ⁻	3.02	1.86 ⁺	2.01 ⁺	2.52	3.95 ⁻	2.65 ⁻	1.86 ⁺	2.02
F16	19.3	23.82 ⁻	20.0	9.49 ⁺	9.72 ⁺	18.6	23.8 ⁻	19.6	9.37 ⁺	9.78 ⁺
F17	3.97	4.31 ⁻	4.36 ⁻	2.82 ⁺	3.69	3.62	4.31 ⁻	4.37 ⁻	2.57 ⁺	3.78
F18	45.8	56.6 ⁻	45.8	34.6 ⁺	35.6 ⁺	45.4	56.6 ⁻	45.7	33.9 ⁺	35.7 ⁺
F19	26.0	28.50 ⁻	31.5 ⁻	22.1 ⁺	28.3 ⁻	24.3	28.5 ⁻	31.7 ⁻	22.2	28.6 ⁻
F20	16.6	16.9 ⁻	16.7 ⁻	15.0 ⁺	15.6 ⁺	16.3	16.9 ⁻	16.7 ⁻	14.8 ⁺	15.7 ⁺
F21	4.49	4.68 ⁻	4.54	4.05 ⁺	4.18 ⁺	4.41	4.68 ⁻	4.51	4.00 ⁺	4.19 ⁺
F22	3.44	4.22 ⁻	3.75 ⁻	2.78 ⁺	3.45	3.19	4.22 ⁻	3.85 ⁻	2.80 ⁺	3.57 ⁻
F23	5.07	7.14 ⁻	5.07	1.59 ⁺	3.03 ⁺	4.09	7.14 ⁻	8.81 ⁻	1.36 ⁺	3.68
F24	11.6	13.6 ⁻	14.3 ⁻	5.50 ⁺	11.0	10.1	13.6 ⁻	15.6 ⁻	4.57 ⁺	11.8 ⁻
F25	5.46	6.79 ⁻	7.04 ⁻	2.33 ⁺	4.77	4.81	6.79 ⁻	7.48 ⁻	2.07 ⁺	5.49 ⁻

Table 4: The average of solutions size on training noise data. The best (lowest) value is printed bold. The left is with tour size=3 and the right is with tour size=7. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it significantly smaller than GP and marked – if it is significantly greater than GP.

Pro	GP	neatGP	TS-S	RDO	TS-RDO	GP	neatGP	TS-S	RDO	TS-RDO
F1	273	123 ⁺	120 ⁺	248	92⁺	295	123 ⁺	100 ⁺	231	48⁺
F2	184	65 ⁺	35⁺	174	97 ⁺	168	65 ⁺	38⁺	165	49 ⁺
F3	260	103 ⁺	128 ⁺	190 ⁺	98⁺	260	103 ⁺	104 ⁺	183 ⁺	84⁺
F4	250	54⁺	69 ⁺	312 ⁻	174	205	54⁺	78 ⁺	312 ⁻	132 ⁺
F5	85	10⁺	52	50 ⁺	16 ⁺	87	10⁺	35 ⁺	45 ⁺	12 ⁺
F6	178	48 ⁺	45⁺	240 ⁻	104 ⁺	174	48⁺	51 ⁺	231	73 ⁺
F7	145	47 ⁺	46⁺	226 ⁻	77 ⁺	142	47 ⁺	44⁺	208 ⁻	69 ⁺
F8	235	135 ⁺	92 ⁺	153 ⁺	25⁺	366	135 ⁺	70 ⁺	142 ⁺	18⁺
F9	165	68 ⁺	67⁺	171	78 ⁺	220	68 ⁺	60⁺	191	69 ⁺
F10	172	66⁺	110 ⁺	173	98 ⁺	192	66⁺	93 ⁺	185	101 ⁺
F11	149	52 ⁺	69 ⁺	141 ⁺	22⁺	159	52 ⁺	57 ⁺	115 ⁺	16⁺
F12	244	64⁺	100 ⁺	179	75 ⁺	297	64 ⁺	84 ⁺	158 ⁺	46⁺
F13	178	54 ⁺	38 ⁺	160	25⁺	161	54 ⁺	26 ⁺	142	19⁺
F14	323	72 ⁺	209 ⁺	156 ⁺	33⁺	361	72 ⁺	170 ⁺	139 ⁺	31⁺
F15	166	64 ⁺	98 ⁺	135	18⁺	191	64 ⁺	72 ⁺	132 ⁺	18⁺
F16	186	109⁺	124 ⁺	296 ⁻	174	284	109⁺	117 ⁺	349 ⁻	149 ⁺
F17	194	70 ⁺	45⁺	198	84 ⁺	232	70 ⁺	33⁺	243	70 ⁺
F18	168	74⁺	97 ⁺	340 ⁻	204	220	74⁺	86 ⁺	407 ⁻	171 ⁺
F19	213	87 ⁺	13 ⁺	86 ⁺	10⁺	317	87 ⁺	8 ⁺	100 ⁺	8⁺
F20	240	92 ⁺	91⁺	397 ⁻	212	331	92 ⁺	86⁺	462 ⁻	171 ⁺
F21	183	66⁺	88 ⁺	200	110 ⁺	237	66 ⁺	58⁺	242	101 ⁺
F22	194	82 ⁺	84 ⁺	190	52⁺	211	82 ⁺	61 ⁺	188	39⁺
F23	168	52⁺	53 ⁺	233 ⁻	108 ⁺	212	52 ⁺	20⁺	284 ⁻	73 ⁺
F24	169	61 ⁺	35⁺	228 ⁻	54 ⁺	214	61 ⁺	16⁺	275 ⁻	35 ⁺
F25	174	70 ⁺	34⁺	220	72 ⁺	217	70 ⁺	21⁺	260	39 ⁺

Table 5: The mean of best fitness with tour size=5. The left is original data and the right is noise data. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it significantly smaller than GP and marked - if it is significantly greater than GP.

Pro	GP	TS-R	TS-S	TS-P	GP	TS-R	TS-S	TS-P
F1	1.59	2.50 ⁻	2.94 ⁻	2.46 ⁻	1.83	2.56 ⁻	3.33 ⁻	2.50 ⁻
F2	0.23	0.35 ⁻	0.58 ⁻	0.28 ⁻	0.21	0.37 ⁻	0.59 ⁻	0.29 ⁻
F3	4.56	6.20 ⁻	6.57 ⁻	5.08	5.08	5.74 ⁻	6.70 ⁻	4.90
F4	0.05	0.04	0.05	0.04 ⁺	0.10	0.11 ⁻	0.12 ⁻	0.10 ⁻
F5	0.12	0.13	0.13	0.13	0.14	0.14 ⁻	0.14	0.14
F6	0.35	0.58 ⁻	1.01 ⁻	0.56	0.61	1.02 ⁻	1.21 ⁻	0.81 ⁻
F7	0.42	0.45	0.52 ⁻	0.41	0.46	0.49 ⁻	0.56 ⁻	0.47
F8	5.44	4.98	5.48 ⁻	5.01	66.5	67.1 ⁻	67.2 ⁻	66.9 ⁻
F9	2.06	1.73	2.50 ⁻	1.39 ⁺	4.15	4.38	5.56 ⁻	3.96
F10	7.92	7.47	5.58 ⁺	7.39	8.23	8.60	6.89	7.83
F11	0.09	0.09	0.07	0.08	0.21	0.21 ⁺	0.20 ⁺	0.21
F12	6.96	7.13 ⁻	7.07 ⁻	7.13 ⁻	7.02	7.16 ⁻	7.13 ⁻	7.14 ⁻
F13	0.88	0.88 ⁻	0.88 ⁻	0.88 ⁻	0.88	0.89 ⁻	0.90 ⁻	0.89 ⁻
F14	72.8	74.3	78.5	77.6	103.6	103.6 ⁻	102.5 ⁺	102.7 ⁺
F15	2.30	2.50	2.11	2.56	2.51	2.87 ⁻	2.62 ⁻	2.91 ⁻
F16	8.08	8.78	9.22	8.69	18.3	20.1 ⁻	19.6	18.8
F17	3.47	4.00 ⁻	4.07 ⁻	3.80 ⁻	3.68	4.27 ⁻	4.35 ⁻	4.07 ⁻
F18	10.2	11.8	10.4	8.9 ⁺	45.3	46.4	44.9	45.9
F19	25.7	29.8 ⁻	31.8 ⁻	28.3 ⁻	25.4	29.7 ⁻	31.6 ⁻	28.0 ⁻
F20	9.36	9.84 ⁻	9.77	9.58	16.4	16.7 ⁻	16.7 ⁻	16.6 ⁻
F21	4.26	4.38 ⁻	4.36 ⁻	4.30	4.40	4.50 ⁻	4.46	4.48 ⁻
F22	0.84	1.14 ⁻	1.10 ⁻	1.00 ⁻	3.25	3.69 ⁻	3.78 ⁻	3.59 ⁻
F23	3.56	4.83 ⁻	6.04 ⁻	4.23	4.18	5.51 ⁻	7.95 ⁻	5.18 ⁻
F24	8.39	10.5 ⁻	11.7 ⁻	9.74 ⁻	10.4	13.2 ⁻	15.2 ⁻	12.3 ⁻
F25	4.57	5.69 ⁻	6.97 ⁻	5.42 ⁻	5.00	6.29 ⁻	7.26 ⁻	5.94 ⁻

Table 6: The median of testing error with tour size=5. The left is original data and the right is noise data. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it significantly smaller than GP and marked - if it is significantly greater than GP.

Pro	GP	TS-R	TS-S	TS-P	GP	TS-R	TS-S	TS-P
F1	8.86	6.07 ⁺	4.08⁺	6.12 ⁺	10.9	6.10 ⁺	5.17⁺	7.90 ⁺
F2	0.96	0.88 ⁺	0.87⁺	0.96	0.94	0.83 ⁺	0.80⁺	0.92
F3	31.1	15.3 ⁺	14.1⁺	17.4 ⁺	32.4	16.1⁺	16.2 ⁺	19.3 ⁺
F4	0.051	0.048	0.050	0.042⁺	0.147	0.143	0.143	0.141
F5	0.135	0.135	0.129	0.134	0.140	0.14	0.139	0.140
F6	1.36	1.71	1.91	1.92	2.08	2.23	2.06	2.23
F7	1.67	1.77	1.59⁺	1.61	1.77	1.83	1.69	1.81
F8	7.37	7.26	7.39	6.78	67.1	66.9 ⁺	66.8⁺	67.0
F9	1.69	1.59⁺	1.62 ⁺	1.64	5.16	5.49	5.21	5.28
F10	59.7	48.9	25.4⁺	39.7	61.9	61.6	57.1	56.2
F11	0.07	0.08	0.06	0.08	0.199	0.199	0.198⁺	0.201
F12	7.44	7.33 ⁺	7.33⁺	7.37 ⁺	7.39	7.33	7.30⁺	7.36
F13	0.887	0.874	0.871⁺	0.88	0.90	0.90	0.90⁺	0.90
F14	126.8	127.9	124.6	126.7	122.7	122.6	122.5⁺	122.7
F15	4.59	4.99	3.58	5.03	4.36	5.00	4.13	5.03 ⁻
F16	21.3	22.1	25.3	23.3	37.3	36.6	36.0	34.5
F17	5.12	4.90	4.71⁺	5.03	5.65	5.59 ⁺	5.28⁺	5.52 ⁺
F18	9.77	10.78	9.63	6.78⁺	47.6	47.4	44.8	47.0
F19	40.7	38.6 ⁺	36.8⁺	39.9	43.1	40.3 ⁺	37.7⁺	42.2
F20	9.59	9.83	9.46	9.69	9.32	9.13⁺	9.14 ⁺	9.18 ⁺
F21	4.33	4.36 ⁻	4.34	4.31	4.51	4.56	4.48	4.57
F22	1.90	2.14 ⁻	1.82	1.66	5.95	5.90	5.86	5.81
F23	6.84	7.54	8.04	6.53	7.38	7.48	8.48 ⁻	8.69
F24	19.1	16.4 ⁺	12.8⁺	16.5	24.1	19.5 ⁺	16.8⁺	22.7
F25	9.01	8.51	8.33 ⁺	8.12	9.45	8.73	8.31⁺	8.82

Table 7: The average of solution's size with tour size=5. The left is original data and the right is noise data. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it significantly smaller than GP and marked - if it is significantly greater than GP.

Pro	GP	TS-R	TS-S	TS-P	GP	TS-R	TS-S	TS-P
F1	302	258 ⁺	113⁺	250 ⁺	292	245 ⁺	106⁺	253 ⁺
F2	169	140 ⁺	33⁺	164	174	148 ⁺	29⁺	159
F3	277	281	99⁺	270	273	274	104⁺	293
F4	171	205	70⁺	184	270	219	67⁺	228
F5	93	92	44⁺	110	84	89	39⁺	116 ⁻
F6	164	146 ⁺	56⁺	149	182	139 ⁺	52⁺	163
F7	149	150	43⁺	137	138	137 ⁺	58⁺	153
F8	241	199 ⁺	93⁺	201 ⁺	298	189 ⁺	74⁺	187 ⁺
F9	209	141 ⁺	70⁺	140 ⁺	206	126 ⁺	60⁺	139 ⁺
F10	180	168	102⁺	168	198	178 ⁺	91⁺	167 ⁺
F11	157	145	74⁺	149	156	144	61⁺	157
F12	281	209 ⁺	90⁺	229 ⁺	292	212 ⁺	86⁺	248 ⁺
F13	157	109 ⁺	34⁺	148	172	141	34⁺	147 ⁺
F14	312	275	171⁺	292	338	319	156⁺	343
F15	158	147	92⁺	159	191	165	79⁺	186
F16	227	226	180⁺	215	250	234	110⁺	219
F17	231	172 ⁺	41⁺	186 ⁺	217	168 ⁺	32⁺	178 ⁺
F18	198	198	127⁺	182	195	175	87⁺	183
F19	257	100 ⁺	11⁺	171 ⁺	284	94 ⁺	11⁺	150 ⁺
F20	240	244	152⁺	233	301	190 ⁺	91⁺	215 ⁺
F21	226	197	89⁺	197	207	177 ⁺	81⁺	188
F22	207	189	87⁺	201	209	176 ⁺	72⁺	177
F23	186	146 ⁺	33⁺	160	187	131 ⁺	24⁺	147 ⁺
F24	186	134 ⁺	26⁺	156 ⁺	201	121 ⁺	20⁺	141 ⁺
F25	206	143 ⁺	26⁺	159 ⁺	202	139 ⁺	24⁺	158 ⁺

Table 8: The mean of best fitness with tour size=5. The left is original data and the right is noise data. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it is significantly smaller than GP and marked - if it is significantly greater than GP..

Pro	GP	neatGP	TS-S	RDO	TS-RDO	GP	neatGP	TS-S	RDO	TS-RDO
F1	1.59	4.64 ⁻	2.94 ⁻	0.16 ⁺	2.29 ⁻	1.83	4.78 ⁻	3.33 ⁻	0.14 ⁺	3.02 ⁻
F2	0.23	0.40 ⁻	0.58 ⁻	0.06 ⁺	0.31	0.21	0.41 ⁻	0.59 ⁻	0.06 ⁺	0.31
F3	4.56	12.63 ⁻	6.57	0.16 ⁺	1.06 ⁺	5.08	13.11 ⁻	6.70	0.16 ⁺	1.38 ⁺
F4	0.05	0.11 ⁻	0.05	0.01 ⁺	0.01 ⁺	0.10	0.17 ⁻	0.12 ⁻	0.08 ⁺	0.10
F5	0.12	0.15 ⁻	0.13	0.13	0.15 ⁻	0.14	0.16 ⁻	0.14	0.14 ⁻	0.15 ⁻
F6	0.35	0.77 ⁻	1.01 ⁻	0.01 ⁺	0.01 ⁺	0.61	1.00 ⁻	1.21 ⁻	0.28 ⁺	0.58
F7	0.421	0.50 ⁻	0.52 ⁻	0.19 ⁺	0.40	0.46	0.54 ⁻	0.56 ⁻	0.25 ⁺	0.48
F8	5.44	16.61 ⁻	5.48	0.39 ⁺	0.37 ⁺	66.5	69.2 ⁻	67.2 ⁻	65.8	67.4 ⁻
F9	2.06	3.58 ⁻	2.50 ⁻	0.20 ⁺	0.20 ⁺	4.15	5.64 ⁻	5.56 ⁻	2.94 ⁺	3.30
F10	7.92	11.50	5.58	0.95 ⁺	0.32 ⁺	8.23	10.9 ⁻	6.89	3.14 ⁺	2.86 ⁺
F11	0.09	0.29 ⁻	0.07	0.03 ⁺	0.06	0.21	0.30 ⁻	0.20	0.18 ⁺	0.19 ⁺
F12	6.96	7.44 ⁻	7.07 ⁻	6.74 ⁺	7.04 ⁻	7.02	7.52 ⁻	7.13 ⁻	6.74 ⁺	7.03 ⁻
F13	0.88	0.92 ⁻	0.88 ⁻	0.86	0.87 ⁺	0.88	0.93 ⁻	0.90 ⁻	0.87	0.89 ⁻
F14	72.8	83.8 ⁻	78.5	53.8 ⁺	65.9 ⁺	103.6	109.4 ⁻	102.5 ⁺	96.1 ⁺	103.1
F15	2.30	3.53 ⁻	2.11	1.10 ⁺	1.11 ⁺	2.51	3.95 ⁻	2.62 ⁻	1.87 ⁺	2.02
F16	8.08	16.73 ⁻	9.22	2.01 ⁺	2.18 ⁺	18.3	23.8 ⁻	19.6	9.3 ⁺	9.74 ⁺
F17	3.47	4.18 ⁻	4.07 ⁻	2.41 ⁺	3.31	3.68	4.31 ⁻	4.35 ⁻	2.64 ⁺	3.71
F18	10.2	26.4 ⁻	10.4	3.13 ⁺	3.29 ⁺	45.3	56.6 ⁻	44.9	34.1 ⁺	35.7 ⁺
F19	25.7	28.9 ⁻	31.8 ⁻	23.2 ⁺	27.9 ⁻	25.4	28.5 ⁻	31.6 ⁻	22.0 ⁺	28.5 ⁻
F20	9.36	13.5 ⁻	9.77	6.72 ⁺	7.65 ⁺	16.4	16.9 ⁻	16.7 ⁻	14.9 ⁺	15.7 ⁺
F21	4.26	4.59 ⁻	4.36	3.89 ⁺	4.05 ⁺	4.40	4.68 ⁻	4.46	4.01 ⁺	4.17 ⁺
F22	0.84	2.37 ⁻	1.10 ⁻	0.55 ⁺	0.71	3.25	4.22 ⁻	3.78 ⁻	2.75 ⁺	3.53 ⁻
F23	3.56	6.23 ⁻	6.04 ⁻	0.88 ⁺	2.31 ⁺	4.18	7.14 ⁻	7.95 ⁻	1.38 ⁺	3.30
F24	8.39	11.02 ⁻	11.7 ⁻	3.53 ⁺	9.38 ⁻	10.4	13.6 ⁻	15.2 ⁻	4.87 ⁺	11.4 ⁻
F25	4.57	6.43 ⁻	6.97 ⁻	2.07 ⁺	4.62	5.00	6.79 ⁻	7.26 ⁻	2.09 ⁺	5.29

Table 9: The median of fittest with tour size=5. The left is original data and the right is noise data. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it is significantly smaller than GP and marked - if it is significantly greater than GP..

Pro	GP	neatGP	TS-S	RDO	TS-RDO	GP	neatGP	TS-S	RDO	TS-RDO
F1	8.86	12.59 ⁻	4.08⁺	8.23	4.16 ⁺	10.9	13.1	5.17⁺	10.2	6.63 ⁺
F2	0.96	0.84⁺	0.87 ⁺	1.15 ⁻	1.00	0.94	0.84 ⁺	0.80⁺	1.23 ⁻	1.00
F3	31.1	32.2	14.1 ⁺	4.92 ⁺	1.85⁺	32.4	32.2	16.1 ⁺	7.15 ⁺	6.31⁺
F4	0.05	0.12 ⁻	0.05	0.02⁺	0.02 ⁺	0.15	0.19 ⁻	0.14	0.14	0.14⁺
F5	0.135	0.135	0.129⁺	0.138	0.138	0.140	0.140	0.139	0.141	0.141 ⁻
F6	1.36	1.74	1.91	0.00 ⁺	0.00⁺	2.08	2.19	2.06	3.07	1.25⁺
F7	1.667	1.61	1.59	1.22 ⁺	1.19⁺	1.77	1.73	1.69	1.61	1.62
F8	7.37	7.41	7.39	0.00⁺	0.00⁺	67.1	66.9	66.8 ⁺	68.5	66.7⁺
F9	1.69	2.41	1.62	0.20⁺	0.23 ⁺	5.16	5.68	5.21	5.02 ⁺	4.95⁺
F10	59.7	41.0	25.4	0.00 ⁺	0.00⁺	61.9	56.4	57.1	50.9 ⁺	46.7⁺
F11	0.07	0.30 ⁻	0.06	0.00⁺	0.08	0.20	0.32 ⁻	0.20 ⁺	0.20	0.20⁺
F12	7.44	7.34 ⁺	7.33 ⁺	7.49	7.29⁺	7.39	7.41	7.30⁺	7.53 ⁻	7.31 ⁺
F13	0.877	0.874	0.871 ⁺	0.874	0.870⁺	0.898	0.898	0.896	0.901	0.896
F14	126.8	131.3 ⁻	124.6	124.1	122.6⁺	122.7	128.8 ⁻	122.5	122.7	122.6
F15	4.59	5.92 ⁻	3.58	3.24⁺	3.24⁺	4.36	6.21 ⁻	4.13	4.14 ⁺	4.12⁺
F16	21.3	33.7 ⁻	25.3	6.86 ⁺	5.86⁺	37.3	36.3	36.0	12.5 ⁺	11.5⁺
F17	5.12	4.95	4.71⁺	5.66 ⁻	4.88 ⁺	5.65	5.45	5.28⁺	6.56 ⁻	5.36 ⁺
F18	9.77	28.4 ⁻	9.63	3.60 ⁺	3.58⁺	47.6	52.9 ⁻	44.8	38.6 ⁺	36.7⁺
F19	40.7	38.3 ⁺	36.8 ⁺	37.4 ⁺	32.2⁺	43.1	40.2 ⁺	37.7 ⁺	39.3 ⁺	35.6⁺
F20	9.59	9.18	9.46	11.7 ⁻	11.5 ⁻	9.32	8.72⁺	9.14	11.5 ⁻	10.4 ⁻
F21	4.33	4.52 ⁻	4.34	4.23 ⁺	4.18⁺	4.51	4.67 ⁻	4.48	4.41	4.34⁺
F22	1.90	3.29 ⁻	1.82	1.14⁺	1.18 ⁺	5.95	6.19 ⁻	5.86	6.02	5.52⁺
F23	6.84	8.44 ⁻	8.04	6.42	4.38⁺	7.38	9.15 ⁻	8.48	10.17 ⁻	5.95
F24	19.1	17.7	12.8⁺	25.2	14.1 ⁺	24.1	19.1 ⁺	16.8 ⁺	27.6	16.0⁺
F25	9.01	8.89	8.33	15.25 ⁻	7.77⁺	9.45	9.42	8.31 ⁺	12.15 ⁻	7.50⁺

Table 10: The average of solutions size of TS-RDO and four other techniques with tour size=5. The left is original data and the right is noise data. Bold indicates the best (lowest) value. The result of Statistical Test Tournament Selection is marked + if it is significantly smaller than GP and marked - if it is significantly greater than GP..

Pro	GP	neatGP	TS-S	RDO	TS-RDO	GP	neatGP	TS-S	RDO	TS-RDO
F1	302	124 ⁺	113 ⁺	227 ⁺	62⁺	292	123 ⁺	106 ⁺	242	64⁺
F2	169	60 ⁺	33⁺	163	62 ⁺	174	65 ⁺	29⁺	166	67 ⁺
F3	277	112 ⁺	99 ⁺	161 ⁺	48⁺	273	103 ⁺	104 ⁺	190 ⁺	83⁺
F4	171	60⁺	70 ⁺	336 ⁻	178	270	54⁺	67 ⁺	336 ⁻	143
F5	93	12⁺	44 ⁺	43 ⁺	15 ⁺	84	10⁺	39 ⁺	37 ⁺	14 ⁺
F6	164	45 ⁺	56 ⁺	36 ⁺	18⁺	182	48⁺	52 ⁺	234 ⁻	79 ⁺
F7	149	50 ⁺	43⁺	207 ⁻	70 ⁺	138	47⁺	58 ⁺	224 ⁻	67 ⁺
F8	241	118 ⁺	93 ⁺	13 ⁺	10⁺	298	135 ⁺	74 ⁺	168 ⁺	21⁺
F9	209	62 ⁺	70 ⁺	69 ⁺	35⁺	206	68 ⁺	60⁺	190	72 ⁺
F10	180	60 ⁺	102 ⁺	96 ⁺	50⁺	198	66⁺	91 ⁺	181	101 ⁺
F11	157	44 ⁺	74 ⁺	34 ⁺	15⁺	156	52 ⁺	61 ⁺	145 ⁺	21⁺
F12	281	67 ⁺	90 ⁺	179 ⁺	41⁺	292	64 ⁺	86 ⁺	188 ⁺	57⁺
F13	157	49 ⁺	34 ⁺	127 ⁺	22⁺	172	54 ⁺	34 ⁺	146	24⁺
F14	312	66 ⁺	171 ⁺	164 ⁺	60⁺	338	72 ⁺	156 ⁺	154 ⁺	36⁺
F15	158	58 ⁺	92 ⁺	51 ⁺	31⁺	191	64 ⁺	79 ⁺	138 ⁺	15⁺
F16	227	103⁺	180 ⁺	321 ⁻	172 ⁺	250	109⁺	110 ⁺	339 ⁻	161 ⁺
F17	231	62 ⁺	41⁺	232	97 ⁺	217	70 ⁺	32⁺	219	78 ⁺
F18	198	71⁺	127 ⁺	362 ⁻	188	195	74⁺	87 ⁺	392 ⁻	172
F19	257	79 ⁺	11 ⁺	85 ⁺	8⁺	284	87 ⁺	11 ⁺	96 ⁺	9⁺
F20	240	87⁺	152 ⁺	374 ⁻	222	301	92 ⁺	91⁺	447 ⁻	190 ⁺
F21	226	63⁺	89 ⁺	228	110 ⁺	207	66⁺	81 ⁺	229	110 ⁺
F22	207	83 ⁺	87 ⁺	129 ⁺	53⁺	209	82 ⁺	72 ⁺	194	46⁺
F23	186	55 ⁺	33⁺	272 ⁻	92 ⁺	187	52 ⁺	24⁺	259 ⁻	95 ⁺
F24	186	68 ⁺	26⁺	265 ⁻	59 ⁺	201	61 ⁺	20⁺	260	41 ⁺
F25	206	63 ⁺	26⁺	257	77 ⁺	202	70 ⁺	24⁺	248	46 ⁺