Numerical Experiments for

"A Global Archive Sub-Population Genetic Algorithm with Adaptive Strategy in Multi-Objective Parallel-Machine Scheduling Problem"

1. Experiment design for parameters settings in SPGA

There are several parameters that may influence the performance of the algorithm. For example, the larger population size may find better solution quality but cost larger computational expense. When the number of sub-populations is larger, it may have better diversity. However, it may also be a trade-off that to reduce the number of generations. Moreover, the secondary crossover and mutation operator are also considered because it may provide better solution quality. The crossover rate and mutation rate are set to 0.9 and 0.1 respectively. The factors and treatments of these factors are as shown in Table 1.

Table 1. The default parameter setting and the treatments of different factors.

Factor	Treatment
Number of job (A)	35/10, 50/15, 65/18 (jobs/ machines)
Number of sub-population (B)	10, 20, 30, 40
Population Size (C)	100, 155, 210
Secondary Crossover Operator (D)	Apply multiple crossover (1), not using it (0)
Secondary Mutation Operator (E)	Apply multiple mutation (1), not using it (0)

Table 2 shows that the p-value of A, B, C, A*B and A*C are less than 0.05. In other words, these factors can cause significant difference. After considering the interaction effects and the main effect of each factor which causes significant difference.

Table 2. The ANOVA result of the parameter settings

Source	DF	Seq SS	Adj SS	Adj MS	F	P
A	2	33998.13	26195.41	13097.7	1659.63	0.000*
B	3	1414.87	1434.27	478.09	60.58	0.000*
C	2	165.1	142.07	71.04	9	0.000*
D	1	0.36	0.01	0.01	0	0.975
A*B	6	700.04	699.53	116.59	14.77	0.000*
A*C	4	82.39	78.17	19.54	2.48	0.043*
A*D	2	43.06	36.86	18.43	2.34	0.098
B*C	6	28.94	28.97	4.83	0.61	0.721
B*D	3	27.03	26.75	8.92	1.13	0.336
C*D	2	17.46	15.63	7.81	0.99	0.372
A*B*C	12	58.56	58.04	4.84	0.61	0.832
A*B*D	6	34.03	33.66	5.61	0.71	0.641
A*C*D	4	96.6	70.02	17.51	2.22	0.066
B*C*D	6	26.58	27.11	4.52	0.57	0.752
A*B*C*D	12	104.83	105.72	8.81	1.12	0.344
E	1	29.73	29.73	29.73	3.77	0.053
Error	537	4237.98	4237.98	7.89		
Total	609	41065.68				

2. Comparisons for Adaptive Strategies

The experiment compares the SPGA doesn't use any adaptive strategy, the method of Srinivas and Patnaik (1994), and the adaptive strategy of Zhu and Liu (2004). They are coded as 0, 1, and 2 in the experiment. The following ANOVA table represents the interaction between the instance and method which causes significant difference. Therefore, the interaction plot of the two factors is depicted in Fig 2. It shows that the adaptive strategies do not perform better in small size instances, while they outperform in large size instances. Duncan grouping method is applied to distinguish the group for the adaptive strategies. The grouping result is shown in figure 2. It shows that the modified SPGA with the adaptive strategies are better than the modified SPGA without adaptation. Since the time-complexity of Zhu and Liu (2004) is higher than Srinivas and Patnaik (1994), the study suggests using the later one when researchers would like to apply the adaptive strategy.

Table 3. The ANOVA result of the adaptive experiment

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Instance	2	4252.07	4252.07	2126.03	1516.89	0
Method	2	5.34	5.34	2.67	1.91	0.151
Instance*Method	4	15.81	15.81	3.95	2.82	0.026
Error	261	365.81	365.81	1.4		
Total	269	4639.03				

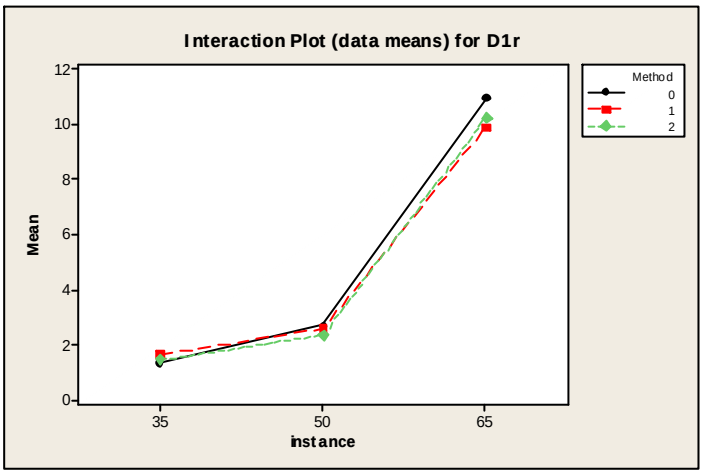

Fig. 1. The interaction plot between the instance and methods

Duncan Grouping	Mean	N	Method
A	6.8502	60	0
B	6.3144	60	2
B	6.2674	60	1

Fig. 2. The Duncan grouping method

3. Numerical results

After the study obtains the result of adaptive strategy for SPGA, the section compares the result with Modified SPGA, NSGA II and SPEA II, by three testing instances. Table 4 shows the statistics result of instance 35 jobs and 10 machines, 50 jobs and 15 machines, and 65 jobs and 18 machines. Furthermore, the experiment result of the original SPGA is demonstrated at table 5.

From the three instances, the modified SPGA is superior to the SPGA, NSGA II, and SPEA II in minimum, average, and maximum value. There is only one exception that the maximum value of modified SPGA is not better than SPGA and SPEA II in the instance of 65 jobs and 18. Then, the adaptive SPGA is better than the Modified SPGA 5.07% through the three instances.

Table 4. The min, average, and max value of different algorithms of the three instances

Instance	Algorithm	Min	Avg.	Max
35/10	Adaptive SPGA	0.494	1.667	3.391
	Modified SPGA’	0.56	1.4722	2.5147
	NSGA II	5.16	11.82	22.22
	SPEA II	4.8	10.39	22.48
50/15	Adaptive SPGA	1.418	2.609	3.554
	Modified SPGA’	1.72	2.876	3.901
	NSGA II	9.68	11.74	13.79
	SPEA II	7.65	10.27	12.89
65/18	Adaptive SPGA	5.092	9.925	13.192
	Modified SPGA’	7.537	10.611	13.941
	NSGA II	20.97	23.08	25.43
	SPEA II	7.7	10.3	12.9

Table 5. The min, average, and max value of different algorithms of the three instances

Instance	SPGA		
	Min	Avg	Max
35／10	3.6	5.8	9.3
50／15	8.6	9.7	10.8
65／18	17.9	19.0	20.1