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Time-dependent sustainable vehicle routing problem in city logistics

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Supplementary data:

Detailed data of parameter setting using Taguchi method

Metaheuristics parameters significantly impact final solutions quality. Hence, they should be tuned before solving main numerical instances. In this paper, Taguchi method is used as one of the common methods to adjust the parameters and detailed data used in this method are presented in this section. According to the Taguchi method, an orthogonal array *L27* is used. This means that an instance is solved by each of the metaheuristics for 27 different combinations of parameters values. The solution results for different combinations are presented in Table 1. After each execution and calculating the performance metrics, we normalize each of them. The normalized metrics are presented in Table 2. After normalization, the weighted mean of the normalized metrics is used as the response variable (R) to calculate the signal-to-noise ratio (S/N). The aim of Taguchi method is to find maximum "mean of S/N ratio" and "mean of response variables" (See Table 3 for more details).

Table 1. The orthogonal array L_{27} and results of metrics for NSGA-II and MOFW in the first replication

#	Factors					NSGA-II					MOFW				
	A	B	C	D	E	QM	NPS	DM	SM	MID	QM	NPS	DM	SM	MID
1	1	1	1	1	1	0.511	4	1.029	0.834	0.913	0.705	5	1.375	0.688	1.156
2	1	1	1	1	2	0.492	4	0.999	0.762	0.915	0.73	6	1.365	0.65	1.096
3	1	1	1	1	3	0.396	4	0.922	0.929	0.862	0.698	6	1.354	0.561	0.984
4	1	2	2	2	1	0.625	6	1.431	0.666	0.811	0.981	9	1.503	0.412	0.641
5	1	2	2	2	2	0.681	6	1.195	0.754	0.736	0.897	9	1.507	0.428	0.729
6	1	2	2	2	3	0.674	6	1.265	0.481	0.676	0.936	9	1.529	0.252	0.724
7	1	3	3	3	1	0.572	6	1.281	0.971	0.904	0.733	7	1.399	0.949	1.321
8	1	3	3	3	2	0.702	6	1.261	0.481	0.689	0.814	7	1.434	0.844	1.307
9	1	3	3	3	3	0.762	7	1.5	0.265	0.644	0.842	7	1.459	0.997	1.333
10	2	1	2	3	1	0.664	5	1.267	0.794	0.881	0.765	7	1.451	0.777	1.006
11	2	1	2	3	2	0.554	5	1.314	0.677	0.726	0.819	7	1.463	0.744	1.068
12	2	1	2	3	3	0.621	6	1.279	0.638	0.701	0.805	8	1.496	0.566	0.975
13	2	2	3	1	1	0.548	6	1.138	0.488	0.719	0.756	7	1.467	0.727	1.111
14	2	2	3	1	2	0.621	5	1.258	0.553	0.728	0.774	7	1.436	0.736	1.103
15	2	2	3	1	3	0.689	6	1.329	0.502	0.683	0.832	8	1.447	0.537	1
16	2	3	1	2	1	0.554	5	1.343	0.659	0.673	0.739	6	1.478	0.627	1.152
17	2	3	1	2	2	0.674	6	1.368	0.519	0.772	0.84	7	1.48	0.712	1.063

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18	2	3	1	2	3	0.911	7	1.588	0.352	0.646	0.813	9	1.498	0.558	0.907
19	3	1	3	2	1	0.837	6	1.481	0.407	0.621	0.749	7	1.427	0.519	0.983
20	3	1	3	2	2	0.868	6	1.713	0.268	0.591	0.834	8	1.461	0.522	0.915
21	3	1	3	2	3	0.782	7	1.517	0.295	0.588	0.931	10	1.547	0.445	0.615
22	3	2	1	3	1	0.614	5	1.26	0.85	0.904	0.8	8	1.486	0.727	1.069
23	3	2	1	3	2	0.674	5	1.235	0.576	0.687	0.822	8	1.473	0.657	0.875
24	3	2	1	3	3	0.654	6	1.458	0.663	0.755	0.92	9	1.523	0.447	0.738
25	3	3	2	1	1	0.755	5	1.199	0.503	0.77	0.783	7	1.493	0.636	1.146
26	3	3	2	1	2	0.735	6	1.438	0.442	0.713	0.864	8	1.469	0.557	0.976
27	3	3	2	1	3	0.816	8	1.572	0.406	0.613	0.869	9	1.521	0.306	0.821

Table 2. Normalized metrics and response variable (R) for NSGA-II and MOFW in the first replication

#	Factors					NSGA-II						MOFW					
	A	B	C	D	E	QM	NPS	DM	SM	MID	R	QM	NPS	DM	SM	MID	R
1	1	1	1	1	1	0.223	0	0.136	0.194	0.004	0.112	0.024	0	0.11	0.415	0.247	0.152
2	1	1	1	1	2	0.186	0	0.097	0.297	0	0.109	0.114	0.2	0.056	0.467	0.33	0.23
3	1	1	1	1	3	0	0	0	0.06	0.161	0.055	0	0.2	0	0.585	0.486	0.251
4	1	2	2	2	1	0.445	0.5	0.644	0.432	0.316	0.443	1	0.8	0.772	0.786	0.963	0.898
5	1	2	2	2	2	0.553	0.5	0.346	0.307	0.548	0.479	0.702	0.8	0.794	0.764	0.841	0.778
6	1	2	2	2	3	0.538	0.5	0.433	0.694	0.73	0.595	0.839	0.8	0.907	1	0.847	0.869
7	1	3	3	3	1	0.34	0.5	0.455	0	0.033	0.243	0.123	0.4	0.235	0.065	0.017	0.14
8	1	3	3	3	2	0.594	0.5	0.429	0.694	0.689	0.598	0.41	0.4	0.415	0.206	0.035	0.273
9	1	3	3	3	3	0.71	0.75	0.731	1	0.828	0.794	0.507	0.4	0.546	0	0	0.28
10	2	1	2	3	1	0.519	0.25	0.436	0.25	0.104	0.312	0.239	0.4	0.505	0.296	0.455	0.37
11	2	1	2	3	2	0.307	0.25	0.495	0.416	0.578	0.419	0.429	0.4	0.568	0.34	0.369	0.415
12	2	1	2	3	3	0.436	0.5	0.452	0.471	0.654	0.515	0.377	0.6	0.735	0.579	0.499	0.524
13	2	2	3	1	1	0.295	0.5	0.274	0.684	0.599	0.464	0.204	0.4	0.586	0.363	0.309	0.339
14	2	2	3	1	2	0.437	0.25	0.425	0.591	0.57	0.469	0.269	0.4	0.425	0.35	0.32	0.336
15	2	2	3	1	3	0.568	0.5	0.515	0.664	0.709	0.605	0.474	0.6	0.482	0.619	0.463	0.511
16	2	3	1	2	1	0.306	0.25	0.533	0.441	0.74	0.474	0.146	0.2	0.646	0.497	0.252	0.305
17	2	3	1	2	2	0.54	0.5	0.564	0.64	0.437	0.523	0.501	0.4	0.652	0.382	0.376	0.455
18	2	3	1	2	3	1	0.75	0.842	0.877	0.822	0.873	0.406	0.8	0.745	0.589	0.593	0.59
19	3	1	3	2	1	0.856	0.5	0.707	0.798	0.9	0.788	0.179	0.4	0.379	0.641	0.487	0.393
20	3	1	3	2	2	0.916	0.5	1	0.996	0.989	0.901	0.48	0.6	0.554	0.638	0.582	0.559
21	3	1	3	2	3	0.749	0.75	0.753	0.957	1	0.851	0.822	1	1	0.741	1	0.912
22	3	2	1	3	1	0.423	0.25	0.427	0.171	0.033	0.251	0.362	0.6	0.683	0.364	0.368	0.444
23	3	2	1	3	2	0.54	0.25	0.396	0.559	0.696	0.525	0.437	0.6	0.62	0.457	0.638	0.547
24	3	2	1	3	3	0.5	0.5	0.678	0.437	0.49	0.514	0.783	0.8	0.875	0.738	0.829	0.805
25	3	3	2	1	1	0.696	0.25	0.35	0.663	0.444	0.506	0.299	0.4	0.722	0.486	0.26	0.39
26	3	3	2	1	2	0.658	0.5	0.652	0.749	0.616	0.636	0.584	0.6	0.598	0.591	0.497	0.565
27	3	3	2	1	3	0.815	1	0.821	0.8	0.924	0.871	0.604	0.8	0.864	0.928	0.713	0.747

Table 3. Result of experiments (R1 and R2 are Response variables in the first and second replication, respectively)

#	Factors					NSGA-II				MOFW			
	A	B	C	D	E	R1	R2	S/N	Mean	R1	R2	S/N	Mean
1	1	1	1	1	1	0.112	0.053	-23.37	0.082	0.152	0.172	-15.859	0.162
2	1	1	1	1	2	0.109	0.075	-21.187	0.092	0.23	0.28	-11.988	0.255
3	1	1	1	1	3	0.055	0.024	-30.19	0.039	0.251	0.197	-13.172	0.224
4	1	2	2	2	1	0.443	0.412	-7.399	0.427	0.898	0.795	-1.498	0.846
5	1	2	2	2	2	0.479	0.467	-6.503	0.473	0.778	0.839	-1.869	0.808

6	1	2	2	2	3	0.595	0.623	-4.316	0.609	0.869	0.894	-1.1	0.881
7	1	3	3	3	1	0.243	0.362	-10.896	0.302	0.14	0.243	-15.307	0.192
8	1	3	3	3	2	0.598	0.534	-4.978	0.566	0.273	0.277	-11.217	0.275
9	1	3	3	3	3	0.794	0.734	-2.357	0.764	0.28	0.343	-10.263	0.312
10	2	1	2	3	1	0.312	0.324	-9.959	0.318	0.37	0.425	-8.077	0.398
11	2	1	2	3	2	0.419	0.436	-7.389	0.427	0.415	0.491	-6.972	0.453
12	2	1	2	3	3	0.515	0.4	-6.998	0.457	0.524	0.554	-5.381	0.539
13	2	2	3	1	1	0.464	0.511	-6.27	0.488	0.339	0.446	-8.363	0.393
14	2	2	3	1	2	0.469	0.467	-6.597	0.468	0.336	0.536	-7.898	0.436
15	2	2	3	1	3	0.605	0.51	-5.166	0.558	0.511	0.533	-5.658	0.522
16	2	3	1	2	1	0.474	0.555	-5.853	0.515	0.305	0.4	-9.287	0.353
17	2	3	1	2	2	0.523	0.588	-5.156	0.555	0.455	0.43	-7.091	0.443
18	2	3	1	2	3	0.873	0.84	-1.348	0.857	0.59	0.572	-4.718	0.581
19	3	1	3	2	1	0.788	0.899	-1.537	0.843	0.393	0.494	-7.234	0.443
20	3	1	3	2	2	0.901	0.802	-1.444	0.851	0.559	0.512	-5.45	0.535
21	3	1	3	2	3	0.851	0.965	-0.89	0.908	0.912	0.769	-1.605	0.84
22	3	2	1	3	1	0.251	0.243	-12.143	0.247	0.444	0.543	-6.272	0.493
23	3	2	1	3	2	0.525	0.505	-5.762	0.515	0.547	0.626	-4.697	0.586
24	3	2	1	3	3	0.514	0.5	-5.905	0.507	0.805	0.871	-1.556	0.838
25	3	3	2	1	1	0.506	0.531	-5.706	0.519	0.39	0.475	-7.413	0.432
26	3	3	2	1	2	0.636	0.525	-4.846	0.58	0.565	0.518	-5.357	0.541
27	3	3	2	1	3	0.871	0.828	-1.422	0.85	0.747	0.866	-1.94	0.806