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Research article

Integrated inventory routing and surgical delay for blood products: A bi-objective trade-off approach

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Appendix A. Parameter tuning

The parameter tuning of NSGA-II adopted in this paper is performed using the Taguchi method [21], which relies on two key tools: orthogonal arrays (OA) and the signal-to-noise (S/N) ratio. The OA is a numerical matrix composed of experimental schemes based on different parameter levels, whereas the S/N ratio serves as a measure of variation that guarantees the robustness of such experimental designs. This experiment was conducted on instance '3T5N', and the procedure mainly consists of the following steps.

Step 1: Determine the control factors and levels, as shown in Table 6. These factors correspond to the parameters of NSGA-II that need to be tuned.

Table 6. Control factors and levels.

Factor	Level 1	Level 2	Level 3
Population size	75	100	125
Crossover probability	0.5	0.7	0.9
Mutation probability	0.1	0.3	0.5
Number of generations	10	20	30

Step 2: Select an orthogonal array, which consists of nine ($L_9\left(3^4\right)$) experimental runs from the standard orthogonal array table, each with a distinct combination of the three parameter levels (see Table 7).

Table 7. Orthogonal array and results.

Experiment number	Population size	Crossover probability	Mutation probability	Number of generations	IGD
1	75	0.5	0.1	10	91327.54
2	75	0.7	0.3	20	53973.59
3	75	0.9	0.5	30	51920.43
4	100	0.5	0.3	30	53173.99
5	100	0.7	0.5	10	60966.63
6	100	0.9	0.1	20	58062.97
7	125	0.5	0.5	20	56828.45
8	125	0.7	0.1	10	91124.33
9	125	0.9	0.3	30	62893.07

Step 3: The nine experimental runs in Table 7 are executed using NSGA-II to obtain the corresponding Inverted Generational Distance (IGD) values, which are given by the following formula:

$$IGD = \frac{1}{\left|F^*\right|}\sum_{i\in F^*}\min_{j\in F} a_{ij} \tag{42}$$

where F^* and F denote the exact Pareto front and the approximate Pareto front computed by NSGA-II, respectively, and a_{ij} represents the Euclidean distance between points *i* and *j*. Smaller IGD values indicate better solution convergence and diversity.

Step 4: For each level of each parameter, the signal-to-noise (S/N) ratio is calculated according to Eq. (43):

$$\left(S/N \text{ ratio}\right)_{ij} = -10\log_{10}\left(\frac{\sum IGD_{ij}^2}{n}\right) \tag{43}$$

where IGD_{ij} denotes the IGD value of parameter *i* at level *j*, and *n* is the number of repetitions of this level in all experimental runs. A larger S/N ratio indicates that this level is more robust.

Step 5: Determine the optimal parameter combination by selecting the level with the maximum S/N ratio for each parameter according to the S/N ratio plot shown in Figure 5.

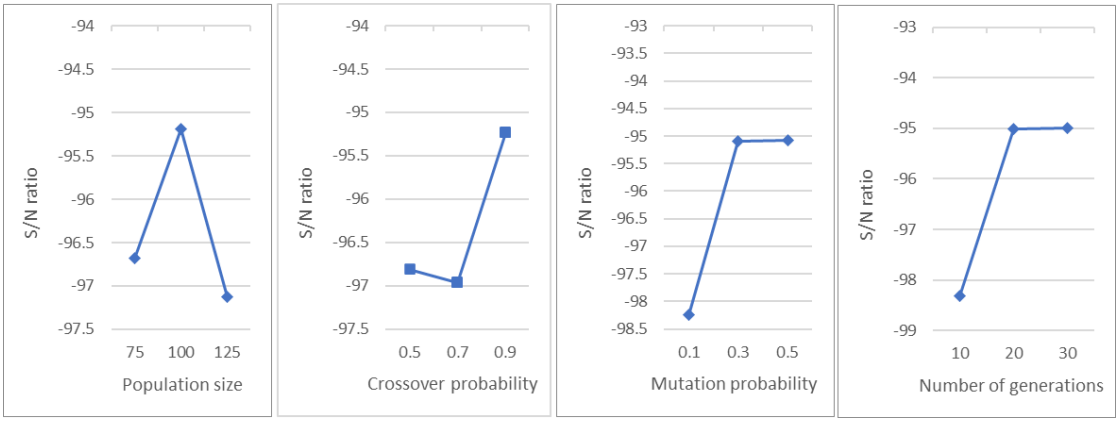


Figure 5. S/N ratio of parameters of NSGA-II.

As shown in Figure 5, the optimal parameter combination obtained by the Taguchi design is: 100 (population size), 0.9 (crossover probability), 0.5 (mutation probability), and 30 (number of generations).

Using the same approach, we tuned the four levels of the parameter 'number of grid points' for the AUGMECON2, namely 1000, 2000, 3000, and 4000. Its S/N ratio plot is shown in Figure 6.

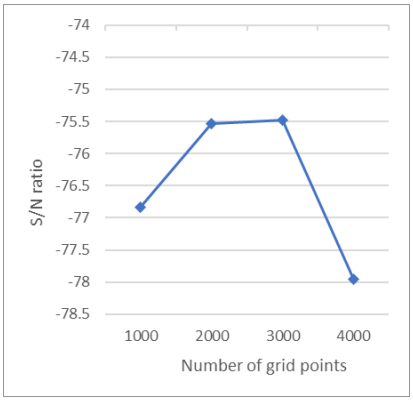


Figure 6. S/N ratio of parameters of AUGMECON2.

It can be seen from Figure 6 that the optimal value of the number of grid points is 3000.

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