A Solution of the Asymmetric TSP with Time Windows

Travelling Salesman Problem (TSP) is a problem of finding a minimum travelling-cost route of *n* cities (Fig.1). Asymmetric TSP (ATSP) is a variant of TSP, where the travelling cost from city *i* to *j* is different from the one from *j* to *i*. TSP with time window (TSP-TW) is another variant of TSP in which a travelling time between two cities and a staying time for visiting each city are additionally defined and an allowed time-window for visiting each city is given as a constraint. These are combinatorial optimization problems, which are considered impossible to find optimal solutions in polynomial time.

This study deals with asymmetric TSP with time window (ATSP-TW). The formulation of ATSP-TW is shown in Fig. 2. An example of ATSP-TW is a slab sequencing problem in steel manufacturing. When rolling out a lot of slabs with various thicknesses and widths is conducted, the difference in thicknesses and widths of neighboring slabs causes the deterioration of product quality, which is reflected as the increase of production cost. Generally this cost is proportional to the differences of thicknesses or widths, but it is asymmetric; for example, the cost when rolling a wide slab after a narrow one is smaller than the cost in reverse order. Slab sequencing problem is a problem to determine the rolling order with minimal cost in consideration of the processing time and deadline of each slab.

Here, we aim to obtain a sub-optimal solution at the reasonable calculation time within five minutes for a large-scale ATSP-TW with up to approximately 300 cities. We are trying a method that relaxes the problem by adding the time-window constraint to the evaluation function and applies simulated annealing (SA), a kind of metaheuristics, for solving the problem.

Keywords : Time Window, Asymmetric TSP, Metaheurisitics.

Reference

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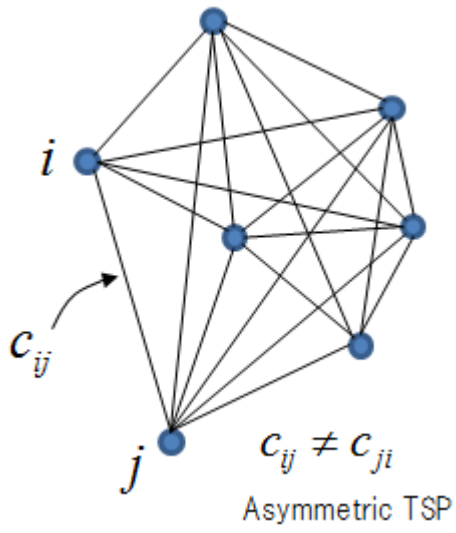

Fig.1 Graph expression of the TSP

Formulation

$$\min \sum_{i=1}^{n-1} c_{\rho(i)\rho(i+1)}$$

Subject to

$$V = \{1,2,...,n\}$$

$$\rho : V \to V$$

$$r_{\rho(i)} \le t_{\rho(i)} \le d_{\rho(i)} (i = 1,...,n)$$

Fig.2 Formulation of the ATSP-TW