Test Problems for Multiobjective Discrete Optimization Problems

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December 22, 2013

Three classes of test problems are used to generate random instances for multiobjective discrete optimization problems. The test problems are multiobjective knapsack problem, multiobjective assignment problem, and multiobjective integer linear programming problems. The multiobjective knapsack and assignment problems are the test problems from [2]. These test problems are used to compare different algorithms on generating nondominated solutions for MODO problems. The multiobjective integer linear programming problems test problems are from [1]. In [1], different nadir point detarmination algorithms are test on these three classes of test problems

The multiobjective knapsack problem

The multiobjective knapsack problem consists of n objects, r^{th} object in the knapsack has a positive integer weight w_r and p non-negative integer profits v_r where p represents number of objective functions. The knapsack has a positive integer capacity W. Decision variable x_r denotes whether item r is selected for the knapsack or not.

$$\begin{aligned} \max \quad & \sum_{r=1}^{n} v_{jr} x_r \quad j = 1, \ldots, p \\ \text{s.t.} \quad & \sum_{r=1}^{n} w_r x_r \leq W \\ & x_r \in \{0, 1\} \quad r = 1, \ldots, n \end{aligned}$$

The multiobjective knapsack problem instances are generated for $p = 3$, 4 and 5 cases, and v_{jr} and w_r are random integers drawn from the interval $[1, 1000]$ where $j \in \{1, \ldots, p\}$ and $r \in \{1, \ldots, n\}$. The capacity of the knapsack is calculated as $W = \left\lceil \left(\sum_{j=1}^{n} w_j\right) / 2 \right\rceil$. The total number of data files for the multiobjective knapsack problem is 160 where 100 of them for $p = 3$, 40 of them for $p = 4$, and 20 of them for $p = 5$. The data file names are given in the following format, "KP_p-X_n-Y_ins-Z.dat". KP stands for the knapsack problem, X represents the number of objective functions, Y shows the number of objects, and Z is the instance number.

The format of each data data file is:

Number of objective functions (p).

Number of objects (n).

Capacity of the knapsack (W).

Profits of the objects in each objective function, ($v \in \mathbb{Z}^{p\times n}$).

Weights of the objects ($w \in \mathbb{Z}^n$).

The multiobjective assignment problem

The assignment problem aims to obtain optimal assignments between a set of agents $r \in \{1, \ldots, n\}$ and a set of tasks $l \in \{1 \ldots, n\}$ where each assignment has a non-negative cost c_{jrl}. The multiobjective assignment problem is formulated as follows,

$$\begin{aligned}
\min \quad & \sum_{r=1}^{n}\sum_{l=1}^{n} c_{jrl}x_{rl} \quad j = 1, \ldots, p \\
\text{s.t.} \quad & \sum_{l=1}^{n} x_{rl} = 1 \quad r = 1, \ldots, n \\
& \sum_{r=1}^{n} x_{rl} = 1 \quad l = 1, \ldots, n \\
& x_{rl} \in \{0, 1\} \quad r = 1, \ldots, n;\ l = 1, \ldots, n
\end{aligned}$$

Test problem instances for the multiobjective assignment problem are formed in sizes varying from 5 to 50 with increments of 5 and $p = 3$. The objective function coefficients are generated randomly in the interval $[1, 20]$, and all are integers. The total number of data files for the multiobjective assignment problem is 100. The data file names are given in the following format, "AP_p-X_n-Y_ins-Z.dat". AP stands for the assignment problem, X represents the number of objective functions, Y shows the number of tasks, and Z is the instance number.

The format of each data data file is:

Number of objective functions (p).

Number of tasks (n).

Cost of the assignment, ($c \in \mathbb{Z}^{p\times n\times n}$).

The multiobjective integer linear problem

In multiobjective integer linear programming (MOILP) problems, m and n represent the number of constraints and number of variables, respectively, and x is the decision vector of the problem. Given coefficients of the objective functions c_{jl}, the technical coefficients a_{rl}, and right-hand side values b_r where $r \in \{1, \ldots, m\}$, $l \in \{1, \ldots, n\}$, and $j \in \{1, \ldots, p\}$, MOILP problem is defined as follows,

$$\begin{aligned}
\max \quad & \sum_{l=1}^{n} c_{jl}x_l \quad j = 1, \ldots, p \\
\text{s.t.} \quad & \sum_{l=1}^{n} a_{rl}x_l \leq b_r \quad r = 1, \ldots, m \\
& x_l \geq 0 \text{ and integer} \quad l = 1, \ldots, n.
\end{aligned}$$

We consider MOILP problems with $p = 3, 4$ and 5, $m = 5, 10, \ldots, 50$ and $n = 2m$ for each m. The coefficients of the objective functions (c_{jl}) are generated in the ranges $[-100, -1]$ and $[0, 100]$ with probability 0.2 and 0.8, respectively. The technical coefficients (a_{rl}) are generated in the ranges $[-100, -1]$ with probability 0.1, $[1, 100]$ with probability 0.8, and $a_{rl} = 0$ with probability 0.1. Finally, right-hand side value (b_r) of each constraint is also generated randomly in the range of 100 and $\sum_{l=1}^{n} a_{rl}$[1]. The total number of data files for the MOILP is 220 where 100 of them for $p = 3$, 80 of them for $p = 4$, and 40 of them for $p = 5$. The data file names are given in the following format, "ILP_p-U_n-X_m-Y_ins-Z.dat". ILP stands for the integer linear problem, U represents the number of objective functions, X and Y show the number of columns (decision variables) and rows (number of constraints) respectively, and Z is the instance number.

The format of each data data file is:

Number of objective functions (p).

Number of columns (n).

Number of rows (m).

Coefficients of the objective functions, ($c \in \mathbb{Z}^{p\times n}$).

Technical coefficients, ($a \in \mathbb{Z}^{m\times n}$).

Right-hand side values, ($b \in \mathbb{Z}^{m}$).

References

[1] G. Kirlik and S. Sayın. Computing nadir point for multiobjective discrete optimization problems. *Journal of Global Optimization*, 2013. (under review).

[2] G. Kirlik and S. Sayın. A new algorithm for generating all nondominated solutions of multiobjective discrete optimization problems. *European Journal of Operational Research*, 232(3):479 – 488, 2014.

[1] According to random MOILP generation scheme, it is possible for a generated MOILP instance to have an unbounded efficient set. Only one such instance was encountered in the $p = 5$ category. The name of the instance is "ILP_p-5_n-10_m-5_ins-1.dat".