Group Project - Description

Given a set $N = \{1, \ldots, n\}$ of items that each has an associated profit p_i and weight w_i. Moreover, there is an associated joint profit p_{ij} for $i \neq j$. You are also given $M = \{1, \ldots, m\}$ knapsacks, each with a capacity constraint C_k for $k = 1, \ldots, m$. The goal is to choose from N and place chosen items into one of the M knapsacks such that the overall profit of the objects is maximized, while minimizing the total weight of items, and maximizing the value of the least profitable knapsack[1]. Each object can be allocated to only one knapsack, and the total weight of items in a knapsack cannot exceed its capacity. The three objective functions are (with some abuse of notation):

$$maximize f_1(S) = \sum_{k \in M} \sum_{i \in S} p_i + \sum_{k \in M} \sum_{i,j,j \neq i} p_{ij} \quad (1)$$

$$minimize f_2(S) = \sum_{k \in M} \sum_{i \in S} w_i \quad (2)$$

$$maximize f_3(S) = \min_{k \in M} \left\{ \sum_{i \in S} p_i + \sum_{i,j,i \neq j} p_{ij} \right\} \quad (3)$$

where $S \in \{0, \ldots, m\}^n$ is the set of selected items in each knapsack, and we say $i \in S$ to imply iterating only the items in S chosen from N.

The goal of the project is to devise the best nature-inspired algorithm you can for solving the above multi-objective quadratic multi-knapsack problem. You can use any nature-inspired methods as the basis of your framework, and can include local searching, matheuristics, etc., but computation time will be a factor in grading, not only the quality of analyses and approach. You must perform proper statistical analyses (including to quantify the Pareto front), create plots/etc, and give clear descriptions/mathematics of your methods and justification for every design choice/algorithm. You will use ALL the data sets found here https://cedric.cnam.fr/~soutif/QKP/QKP.html in your analysis with the modification that the number of knapsacks $M \in 3, 5, 10$ and for each problem instance the capacity of each knapsack is set to 80% of the sum of all item weights divided by the number of knapsacks.

What to submit?

- Using the given Latex template, a maximum 15 page technical report with references as appropriate. The language and presentation style should be as in published articles, except you do not have to provide an in-depth literature review (but can get bonus points if you do provide a GOOD one).
- Your source code. The code must be well-documented with instructions for how to use it. NO HARD CODING of problem parameters - a user should be able to execute the code with ZERO editing on any problem instance and algorithm parameter settings.
- If done correctly, and well, bonus points for performing landscape analyses/empirical hardness/etc are also possible. Please discuss with Prof. Ventresca beforehand!
- Another option for bonus points could be to allow for negative p_{ij} and to design a good set of problem instances.

[1] It may be helpful to think of the value of the items as a stock price, the weight as a risk, the knapsacks as portfolios.