Set Covering Problem

PIA: Part I

Operations Research, 032
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1 Part I: Formulation and Planning

1.1 Definition

The **Set Covering Problem (SCP)** consists in selecting a subset with minimum cost in a collection of subsets that are part of a universal set of elements. Each subset has certain elements, and the objective is to cover all elements with the minimum number of subsets.

1.2 Objectives

- Minimize the total cost of the subsets selected.
- Include all elements of the universal set.

1.3 Applications

This problem appears in multiple problems of Operations Research, such as:

- Installation's location (hospitals, service stations, etc.).
- Covering of resources.
- Distribution and planning of routes.

1.4 Model classification

- Type: Full Binary Linear Programming.
- Why? Decision variables are binary, the objective function and restrictions are linear.

1.5 Model elements

Parameters:

- m: number of elements.
- n: number of subsets.
- c_j: Cost of selecting subset j.
- a_{ij}: binary matrix that indicates if the subset j has the element i.

Decision variables:

$$x_j = \begin{cases} 1 & \text{if the } j \text{ subset is selected} \\ 0 & \text{it isn't selected} \end{cases}$$

Objective function:

$$\min \sum_{j=1}^{n} c_j x_j$$

Constraints:

$$\sum_{j=1}^{n} a_{ij} x_j \geq 1 \quad \forall i = 1, \ldots, m$$

1.6 Initial Design for Implementation

- Programming language: Python
- Libraries: `PuLP`, `pandas`, `matplotlib`
- Code structure: data input, model definition, solution, and result visualization.

1.7 Project Planning

Week	Activity	Tools
1	Formulation and Planning	Overleaf
2	Codification and Visualization	Python (PuLP)
3	Testing and Optimization	Python (Pandas)
4	Final Results	Python (matplotlib)
5	Presentation	Canva
6	Final report	GitHub, LaTeX

References

[1] Balas, E., & Padberg, M. W. (1972). On the Set-Covering Problem. *Operations Research*, 20(6), 1152–1161. http://dx.doi.org/10.1287/opre.20.6.1152