11th AIMMS-MOPTA Optimization Modeling Competition

Automated Design of Assortments

1. Problem Description

The goal is to develop a system that can assist a user with creating a variety of "good" assortments of items. The problem data is a collection $\mathcal{I}$ of items $i = 1, \ldots, N$ that have width w_i and height h_i. An **assortment** is a subset $\mathcal{S} \in \mathcal{I}$. An assortment $\mathcal{S}$ is **feasible** if the items can be packed in a rectangular container of width W and height H without overlap, that is, each item $s \in \mathcal{S}$ can be assigned a left-bottom corner coordinate (x_s, y_s) such that the rectangles $R_s = [x_s, x_s + w_s) \times [y_s, y_s + h_s)$ satisfy $R_s \subset [0, W] \times [0, H]$ (inclusion in container) and $R_s \cap R_{s'} = \varnothing$ for all distinct $s, s' \in \mathcal{S}$ (no overlap). The items cannot be rotated, thus for example they cannot occupy $[x_s, x_s + h_s) \times [y_s, y_s + w_s)$ instead of R_s.

The **value** $v(\mathcal{S})$ of a feasible assortment $\mathcal{S}$ is the cumulated surface occupied by the items, that is,

$$v(\mathcal{S}) = \textstyle\sum_{s \in \mathcal{S}} h_s w_s.$$

The user is interested in assortments that maximize $v(\mathcal{S})$ over feasible assortments, or achieve near optimality. Let $v^* = \max_{\mathcal{S}}\{v(\mathcal{S})\}$. We say that $\mathcal{S}$ is **good** if $v(\mathcal{S}) \geq (1 - \epsilon)v^*$ for some $\epsilon \geq 0$.

The user wants to be presented with a set of good solutions $\{\mathcal{S}_m\}_{1 \leq m \leq M}$ such that the **diversity** among the alternative solutions is high. The precise definition of the notion of diversity is left to your team. Diversity can measured along several dimensions, possibly including, but not limited to, (i) the set of items in an assortment, (ii) the distribution of shapes of items in an assortment. However, two solutions with the same items arranged differently are not diverse.

For instance, for shapes, one can assign to each item i a category c_i based on the value of the ratio h_i/w_i. Given K categories, one can assign to an assortment $\mathcal{S}$ a vector $\chi(\mathcal{S}) \in \mathbb{R}^K$ with elements $\chi_k(\mathcal{S}) = |\{j \in \mathcal{S} : c_j = k\}|$. Given a distance measure d between χ and χ' (to be determined), the diversity among solutions could be measured using a function (to be determined) based on the pairwise distances $d(\chi(\mathcal{S}_m), \chi(\mathcal{S}_n))$ for $m, n \in \{1, \ldots, N\}$. This is an example; many other better approaches should exist.

We clarify that the value of an assortment $\mathcal{S}_m$ is based on $v(\mathcal{S}_m)$ only: diversity is only used to characterize the collection of solutions presented to the user. You can assume that M is fixed in advance.

2. Deliverables

The application in mind for the system is to offer the user with alternatives to test in a field experiment. For instance, the user is a marketer who wants to test a variety of assortments for their potential of leading to a sale. Therefore, it is important for the user to be able to interact with the system: visualizing solutions, tuning the near-optimality parameter ϵ, tuning the diversity measures, etc.

Your team has to deliver a complete solution to the problem described above. More specifically, we expect the submission of the following deliverables:

- An implementation of the model in AIMMS;
- A user interface with graphical and textual output;
- A solution of the model for the given test data sets;
- A report of maximum 15 pages, that describes the mathematical background of the model, the solution techniques used, the results obtained and your team's final recommendations.

You are allowed to use topical literature selected by your team. Please cite all used information sources properly, and distinguish your ideas from ideas found in the literature carefully. The **deadline for submission** is Sunday May 19, 2019, 23:59 Pacific Time.

3. Case Data

The case data are available from competition webpage. See `mopta2019_cases.csv` and the data files containing the tuples (i, h_i, w_i): `mopta2019_pieces_1.csv` and `mopta2019_pieces_2.csv`.

4. Software

The academic license for the AIMMS software should be requested from `https://aimms.com/english/developers/licensing/free-licenses/aimmsacademiclicense/`.

5. Questions

Questions about the problem or the competition in general should be directed to Prof. Boris Defourny at `defourny@lehigh.edu`. The subject line of the email should start with "MOPTA Competition 2019". Questions related to the AIMMS software should be directed to `support@aimms.com`.