DECISION MODELS
FINAL PROJECT

Packing Santa's Sleigh

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Summary

- **The Problem**
- The Dataset
- The Methodological Approach
- The Results

Given a list of presents, pack them in Santa's sleigh in the most compact way and in the best order possible. The sleigh is 1000 x 1000 with infinite vertical extent. Presents come in random sizes and are represented by their extent in the X, Y and Z dimensions.

Strategic Balance Sheet

What Must Be Done

1) Low ID packages must be positioned at the sleigh's top;
2) High ID packages must be positioned at the sleigh's bottom.

Evaluation

- The compactness of the packing (max height of the sleigh)
- The ordering of the presents (Low ID at the top, High ID at the bottom).

The evaluation metric **M** is given by

$$M = 2 max_i(z_i) + \sigma(\Gamma)$$

Where

Zi = z−coordinate of the ith present

+

$$\sigma(\Gamma) = \sum_{i=1}^{Np} |i - \Gamma_i|$$

Γ = order the presents appear

Summary

Let's analyze the data source in detail

The dataset is publicly available on the Kaggle online platform.

A visual representation

Codice_final_project_2019.R × | presents ×

Filter

	PresentId	Dimension1	Dimension2	Dimension3
1	1	2	5	3
2	2	243	207	73
3	3	236	78	160
4	4	10	8	3
5	5	9	9	10
6	6	170	120	171
7	7	218	116	91
8	8	142	206	222
9	9	37	8	28
10	10	3	2	7
11	11	42	41	22
12	12	11	42	31
13	13	28	20	83
14	14	29	13	76
15	15	98	200	96

Showing 1 to 15 of 1,000,000 entries

Some technical stuff

Format: CSV
Instances: 1 Million
Dimensions: 4

- ID – Type: Integer;
- Dimension 1 – Type: Integer;
- Dimension 2 – Type: Integer;
- Dimension 3 – Type: Integer

There are no NA values
Gifts' dimensions for each axis go from 2 to 250
Presents' distribution doesn't depend on the ID

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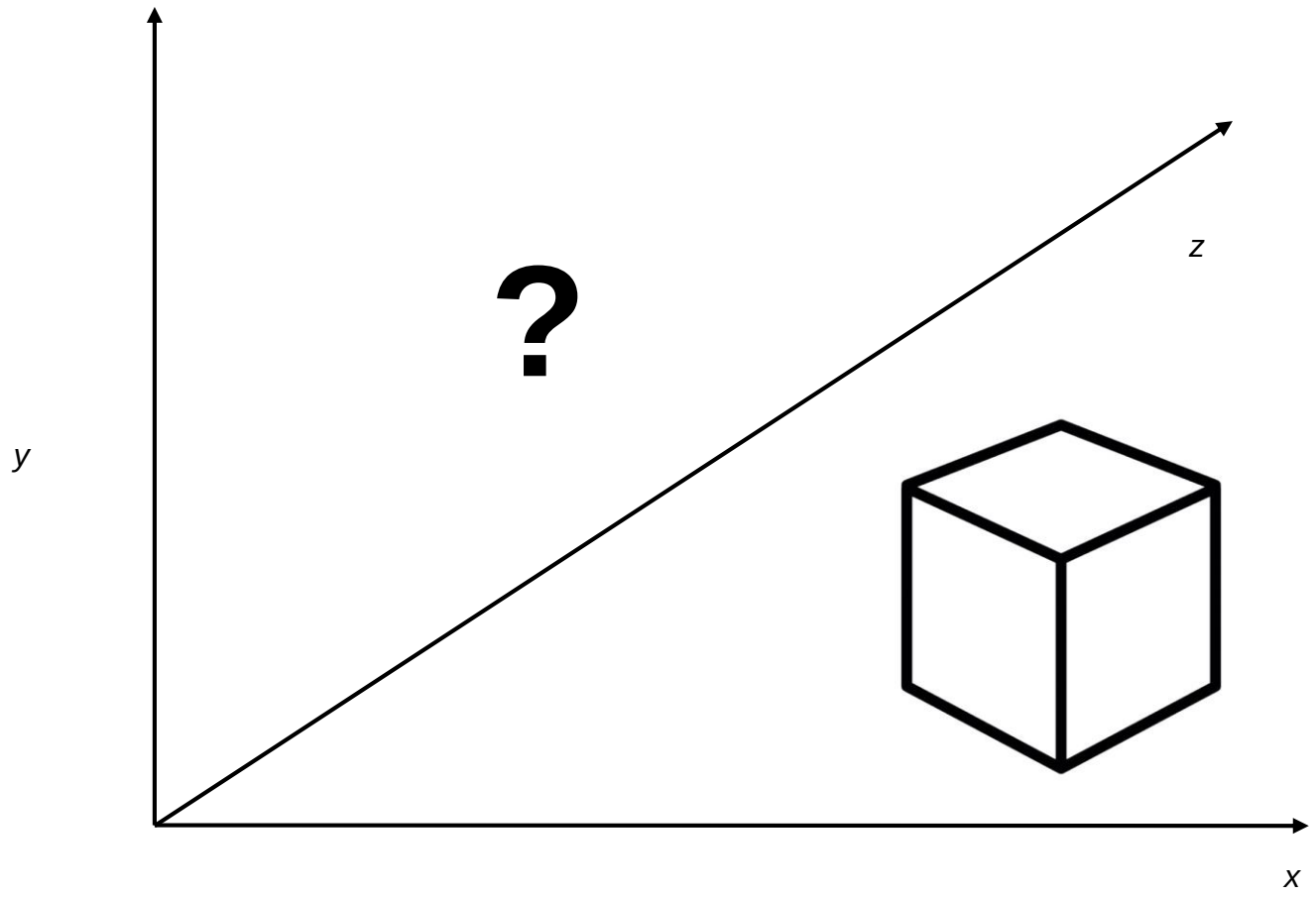
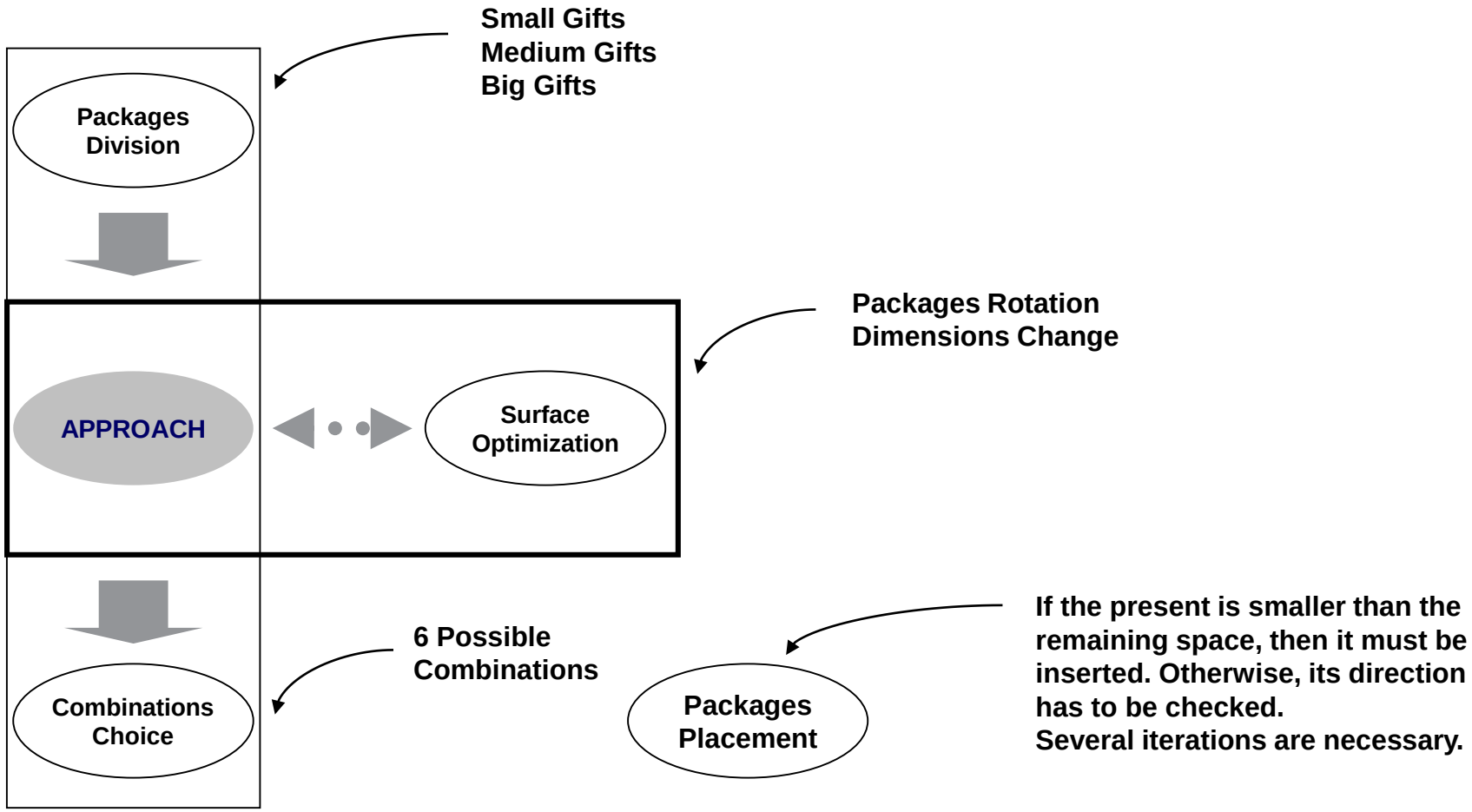
How can the gifts be rotated?



How can the gifts be located on the sleigh?

Let's look at all the steps that the methodological approach is made of. Absence of gravity is a key factor that must be remembered and taken into account

Different Steps



A graphical representation of how the packages placement is done – STEP 1

If the gifts are smaller than the remaining area, they must be inserted. Otherwise, their direction has to be checked.

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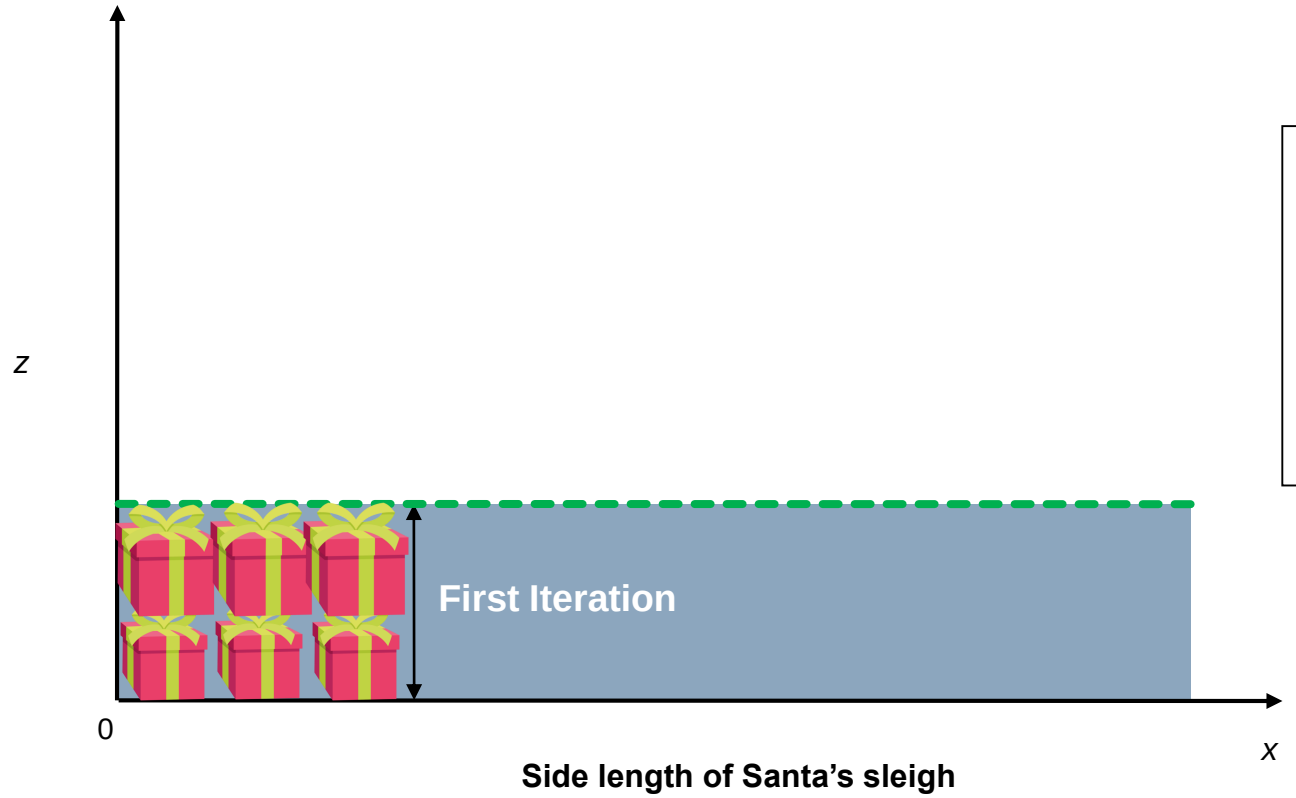
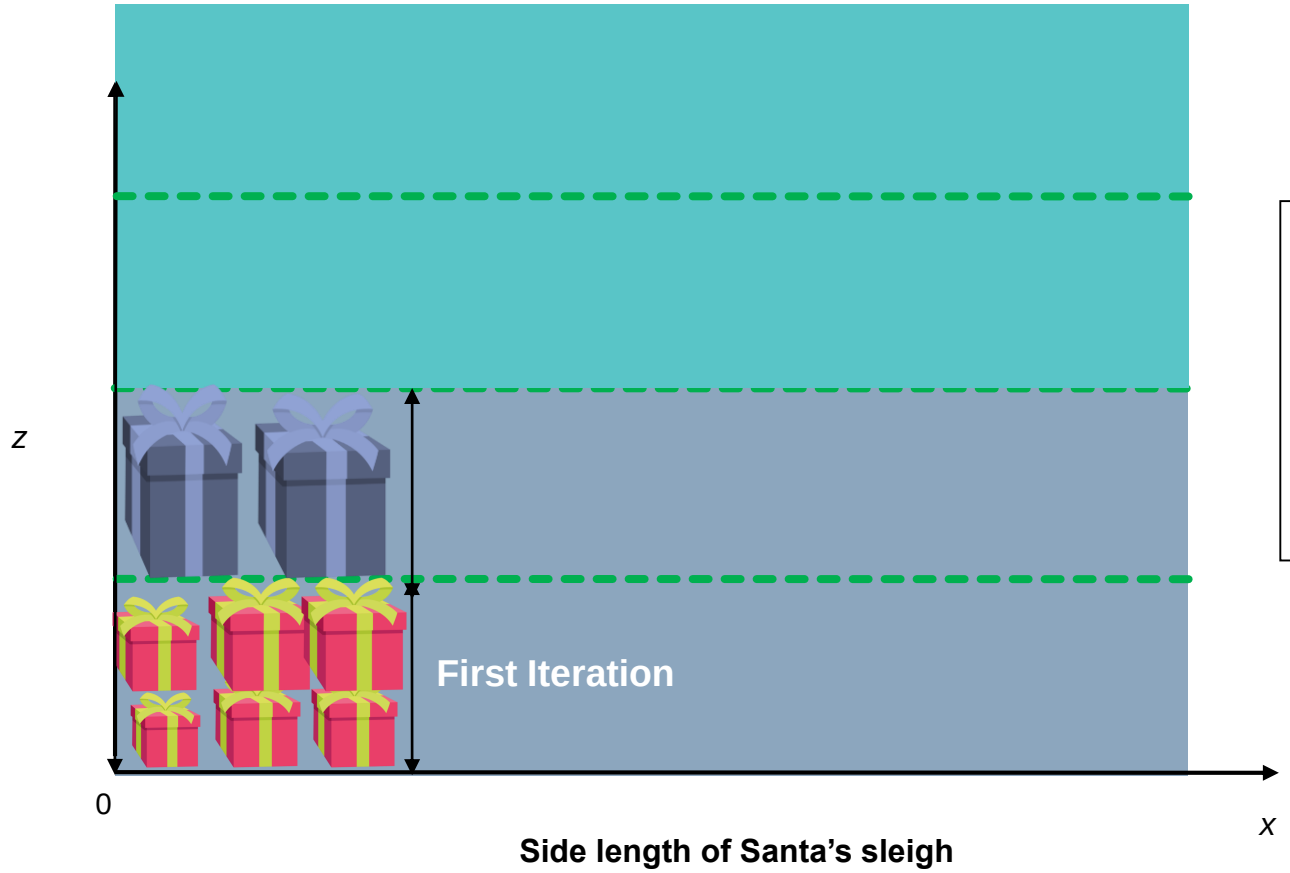
A graphical representation of how the packages placement is done – STEP 2



Each new iteration's starting point is the maximum height reached by the presents of the layer below

A graphical representation of how the packages placement is done – STEP 3



Each new iteration's starting point is the maximum height reached by the presents of the layer below

Second Iteration

Let's give a look at the Combinations choices.

COMBINATION A	X-Y-Z	HEIGHT 1
COMBINATION B	X-Z-Y	HEIGHT 2
COMBINATION C	Y-X-Z	HEIGHT 3
COMBINATION D	Y-Z-X	HEIGHT 4
COMBINATION E	Z-X-Y	HEIGHT 5
COMBINATION F	Z-Y-X	HEIGHT 6

First metric: Height

Every existing combination was tested and the best one was finally chosen

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Which final conclusions and observations can be derived?

- **Project Final Scores – Maximum Height Reached**
  - X-Y-Z → 1056105
  - X-Z-Y → 1236146
  - Z-X-Y → 1525841
  - Z-Y-X → 1442467
  - Y-Z-X → 1196627
  - Y-X-Z → 1050789

  - These results were scored using groups of **6000 presents**.

Position	1	2	3	4	5	6	…
Pres. Id	2	6	8	145	96	266	…

Which final conclusions and observations can be derived?

Final Height Value Reached: 1375598

This final result was obtained analyzing samples of only **500 gifts**, instead.

This score represented indeed a medium value for both the metrics used to solve the problem.

Code Execution Time

Processing time → **about 30 minutes** with:

- ID of the packs
- Maximum height reached
- Vectorial data structures

Processing time → **16 hours** with:

- Matrix data structure