Optimal Cutting Problem

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The Problem

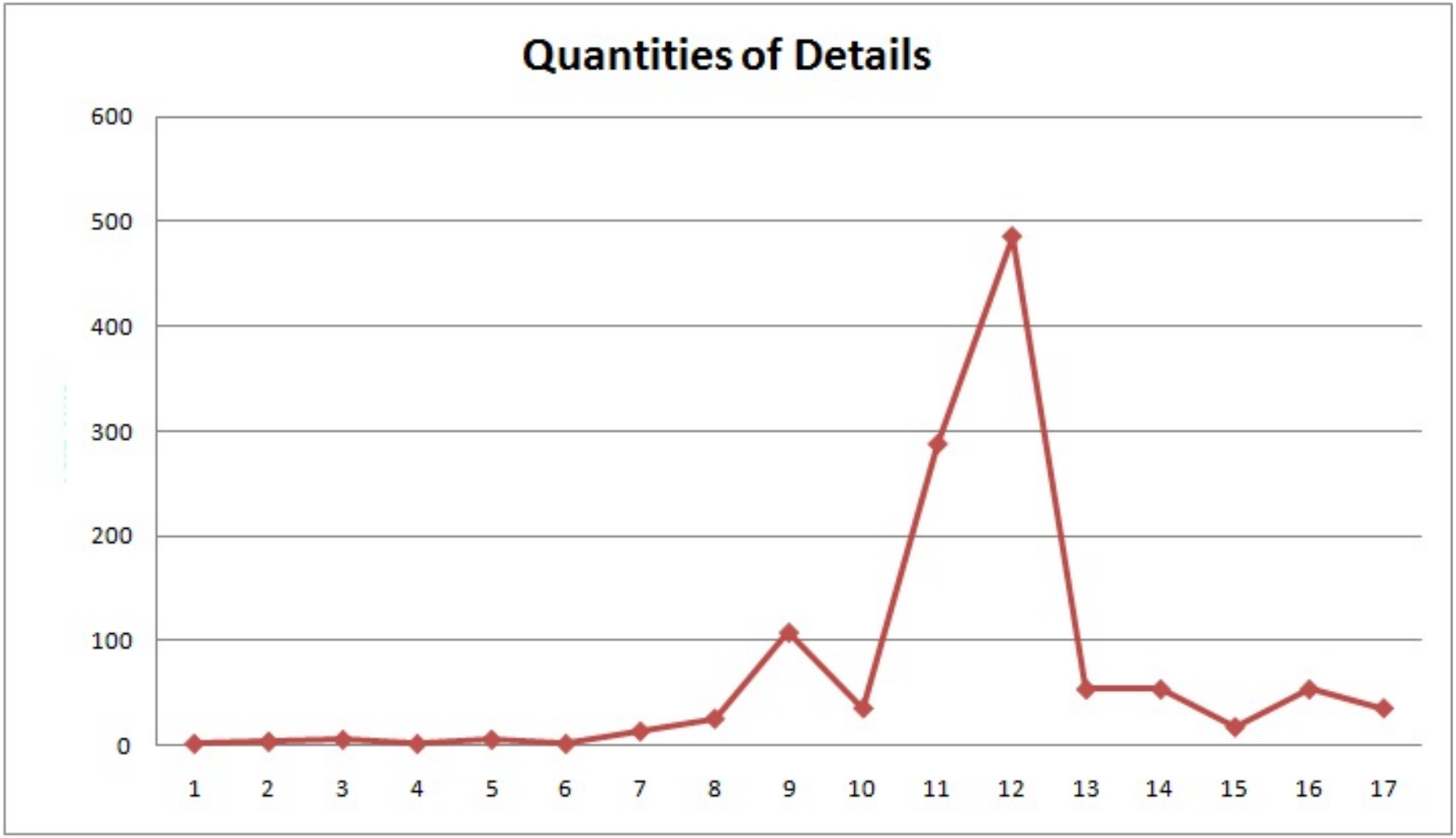
One of the tasks of the Construction office of the company is to create sheets containing a lot of objects describing a building construction.

For this reason it is necessary to arrange all small patterns in the big sheet of the initial material with a minimum wastage.

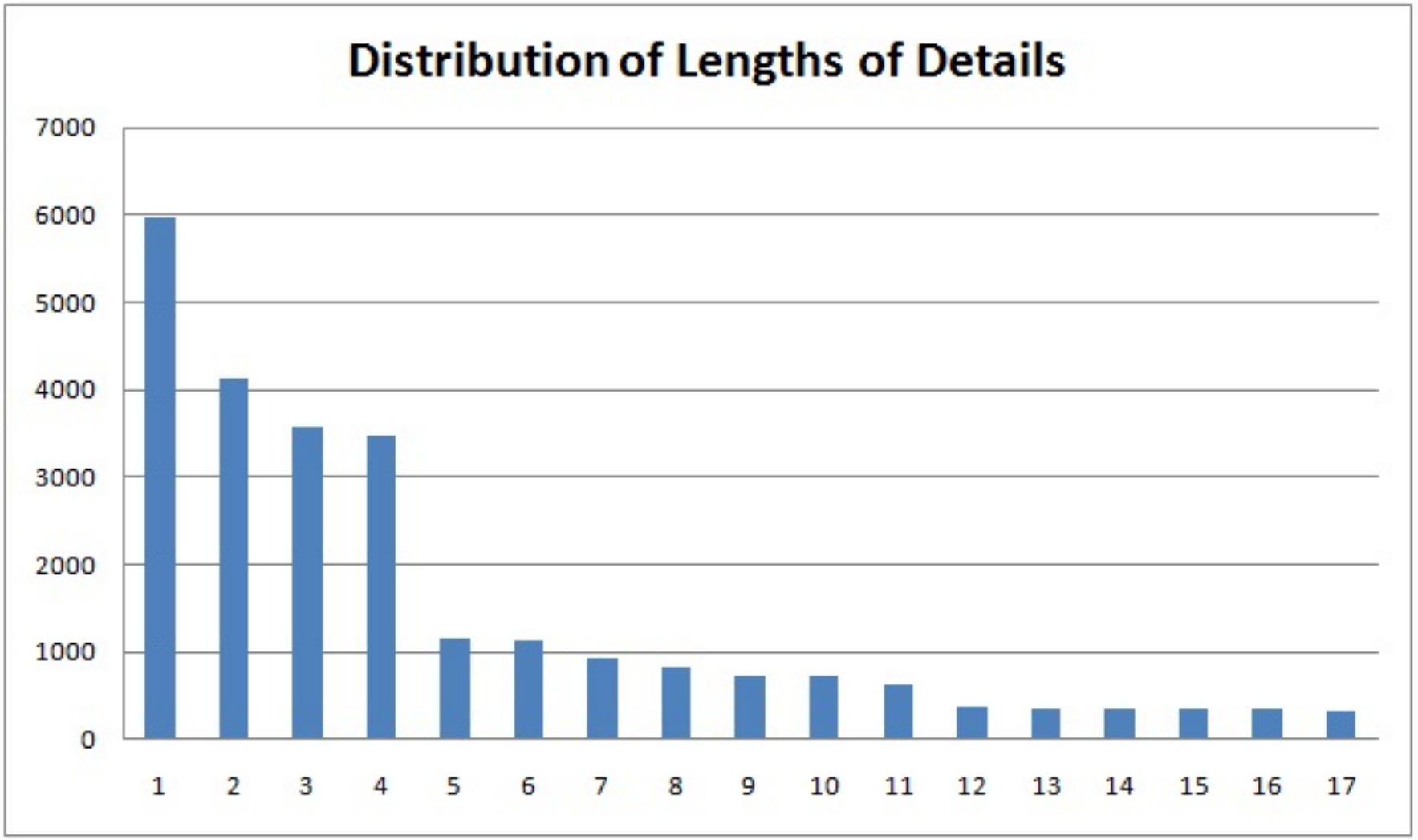
Real Data

Позиция	Сечение	Брой	Дължина [mm]	Тегло		
				Ед. тегло [kg/m]	на елемента [kg]	Общо [kg]
L дограма 9	L 50x4	20	5790	3,0500	17,66	353,19
L дограма 10	L 50x4	2	4912	3,0500	14,98	29,96
планка 20	PLATE 8x80	20	170		0,84	16,70
планка 33	PLATE 8x80	4	105		0,52	2,07
планка 36	PLATE 8x80	24	100		0,49	11,76
планка 47	PLATE 5x70	10	70		0,19	1,89
планка 48	PLATE 5x180	10	70		0,49	4,91
планка 49	PLATE 5x205	3	70		0,56	1,68
планка 50	PLATE 5x205	3	63		0,50	1,51
профил 25	ШГР 100x80x5	19	5950	9,4900	56,47	1072,84
профил 26	SHS 100x4	3	5950	12,0000	71,40	214,20
профил 27	RHS 100x50x5	6	5800	10,9000	63,22	379,32
профил 28	RHS 100x50x5	6	5720	10,9000	62,35	374,09
профил 29	SHS 100x4	3	3020	12,0000	36,25	108,74
профил 30	ШГР 100x80x5	1	1000	9,4900	9,49	9,49
профил 31	SHS 100x4	6	780	12,0000	9,36	56,16
профил 40	EQA 70x7	2	70	7,3800	0,52	1,03
профил 41	EQA 70x7	45	55	7,3800	0,41	18,27
профил 42	SHS 100x4	6	3974	12,0000	47,69	286,13
профил 44	SHS 40x4	24	246	4,4600	1,10	26,33
профил 45	SHS 40x4	60	230	4,4600	1,03	61,56
профил 46	SHS 40x4	36	230	4,4600	1,03	36,94
профил 47	SHS 40x4	18	200	4,4600	0,89	16,06
профил 54	EQA 70x7	2	6995	7,3800	51,62	103,25
профил 55	EQA 70x7	2	6990	7,3800	51,59	103,17
профил 56	EQA 70x7	9	3880	7,3800	28,63	257,71
профил 57	EQA 70x7	2	3880	7,3800	28,63	57,27
профил 58	EQA 70x7	10	3880	7,3800	28,63	286,34
профил 59	EQA 70x7	1	3880	7,3800	28,63	28,63
профил 60	EQA 70x7	11	1875	7,3800	13,84	152,21
профил 61	EQA 70x7	2	1870	7,3800	13,80	27,60
профил 62	EQA 70x7	9	1870	7,3800	13,80	124,21

Real Data


Quantities of Details
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Real Data


Distribution of Lengths of Details
7000
6000
5000
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Task 1: Two Dimensional Cutting Stock Problem

- We have a large piece of paper with dimensions $X = 1000$ mm, $Y = 15000$ mm. On this paper many small rectangles (drawings) with dimensions (a_i, b_i), $i = 1, ..., n$ should be arranged. The goal is to arrange the rectangles in such a way that they fill the entire width of the paper (1000 mm) using minimal length of the sheet.

- The company hasn't had a solution of the task.

Task 2: One Dimensional Cutting Stock Problem

- We have in stock profiles with specific fixed section and constant length L meters. After the design is given, we need to obtain n_j number of pieces with length l_j meters, $j = 1, ..., m$ each. The task is to produce the desired quantities of pieces using minimum number of profiles.

- The company has had a solution of the problem, but the used algorithm is slow and doesn't provide sufficiently good approximate solution.

Our Approach:

- For the 2D cutting stock problem: we have proposed a **genetic algorithm**.
- For the 1D cutting stock problem: we have proposed a simple algorithm based on **initial ordering of the details by length and putting them consecutively on the profile in order to get the best possible fit**.
- For both cases we have chosen criteria for sufficiently good approximate solution.

What We Have Done

Task 1:

- we have created a program, that implements the proposed genetic algorithm;
- we have made many experimental tests with huge amount of data;
- we have reached near optimal solution.

What We Have Done

Task 2:

- first we have applied the suggested simple algorithm which improved significantly the speed of finding a near solution;
- second we have applied the genetic algorithm developed for the 2D case for solving this particular 1D example;
- for the concrete example both approaches provided exact optimal solution;
- we have implemented simple algorithm in JAVA, Lisp and MS Excel.

What We Have Done

Task 2: Re-optimization

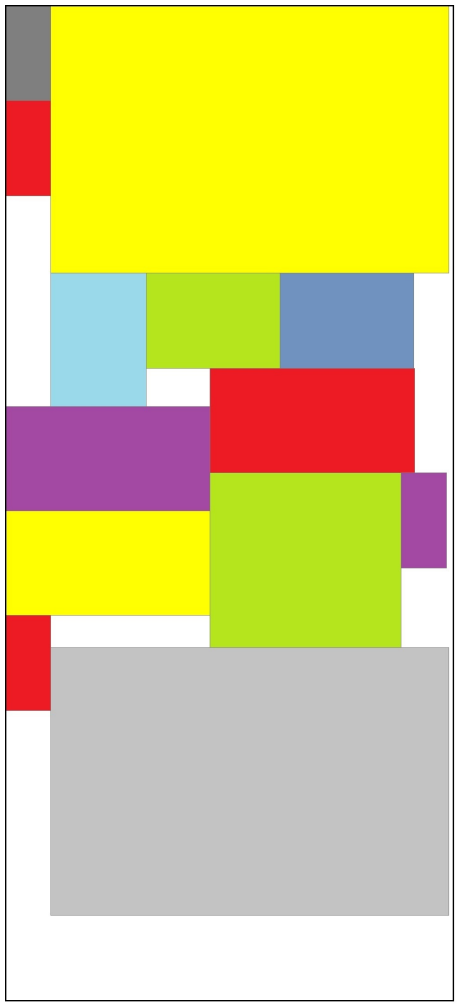
We have re-optimized simple algorithm, which led to further reduction of wastage.
For specific real data after the application of simple algorithm wastage was 2.9%, then after re-optimization wastage decreased to 2%.

The Results

- tests with a real set of data the company gave;
- we have improved the algorithms and have applied them;
- the company STOBET was pleased with the solutions and the results we received.

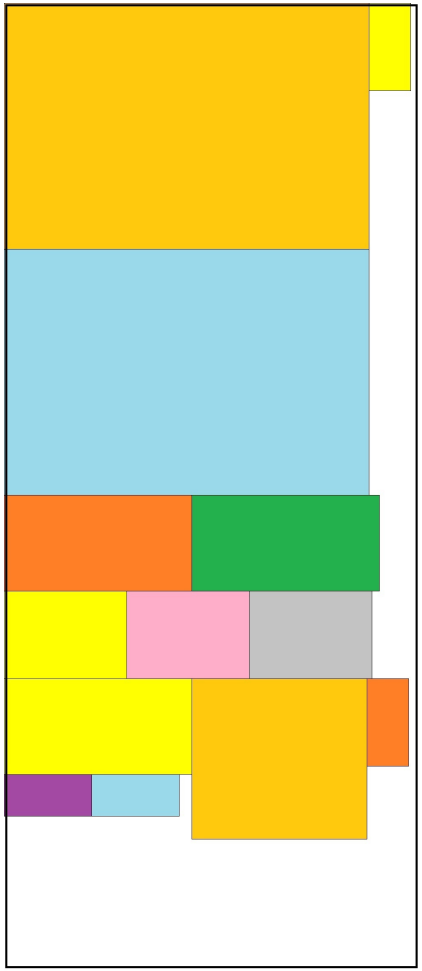
The Results

Graphics for the Solution of a Certain 2D Example



The Results

Graphics for the Solution of a Certain 2D Example



The Results

Graphics for the Solution of a Certain 1D Example

Thank you for your attention!