



Computer Science
Operations Research

Simplex Algorithm

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1 The Simplex Algorithm

The simplex algorithm, developed by George Dantzig in 1947, arises from the need to solve linear programming problems. This problem was fundamentally proposed by Kantorovich and Koopman, who developed the optimal location problem and the problem of resources. The Simplex method optimizes an objective function subject to linear constraints, using an iterative process to improve the value of the objective function until the optimal solution is reached. Its ability to solve complex problems and its use in various applications make it an essential tool in the optimization of resources and strategic decisions in industry, economics, and operations research.

Given the time of its development, it was essentially thought to be solved by hand; however, now there are digital tools that allow the process to be automated.

1.1 George Dantzig

The American mathematician was born in 1914 and died in 2005. In addition to being the creator of the Simplex algorithm, he was head of the Scientific Computing of Operations Research (SCOOP), where he promoted linear programming for strategic purposes during World War II.



2 Problem: P8

The problem inputted by the user is called “P8” and consists of maximizing the following function:

$$Z = x_1 \cdot 36.000000 + x_2 \cdot 30.000000 + x_3 \cdot -3.000000 + x_4 \cdot -4.000000$$

Subject to:

$$x_1 \cdot 1.000000 + x_2 \cdot 1.000000 + x_3 \cdot -1.000000 + x_4 \cdot 0.000000 \leq 5.000000$$

$$x_1 \cdot 6.000000 + x_2 \cdot 5.000000 + x_3 \cdot 0.000000 + x_4 \cdot -1.000000 \leq 10.000000$$

3 Initial Matrix with M cost

The initial simplex table is shown below.

Z	x_1	x_2	x_3	x_4	S_1	S_2	b
1.000	-36.000	-30.000	3.000	4.000	0.000	0.000	0.000
0.000	1.000	1.000	-1.000	0.000	1.000	0.000	5.000
0.000	6.000	5.000	0.000	-1.000	0.000	1.000	10.000

4 Intermediate Matrixes

The intermediate tables are shown below. A column is added to show the fractions of each row. The selected column to enter the basis is colored in pink while the pivot and selected fraction value are colored in a darker shade of pink.

4.1 Pivot Table

Z	x_1	x_2	x_3	x_4	S_1	S_2	b	Fractions
1.000	0.000	-0.000	3.000	-2.000	0.000	6.000	60.000	
0.000	0.000	0.167	-1.000	0.167	1.000	-0.167	3.333	5.000
0.000	1.000	0.833	0.000	-0.167	0.000	0.167	1.667	1.667

4.2 Pivot Table

Z	x_1	x_2	x_3	x_4	S_1	S_2	b	Fractions
1.000	0.000	2.000	-9.000	0.000	12.000	4.000	100.000	
0.000	0.000	1.000	-6.000	1.000	6.000	-1.000	20.000	20.000
0.000	1.000	1.000	-1.000	0.000	1.000	0.000	5.000	Invalid

5 Result Analysis

5.1 Unbounded problems

Sometimes the simplex algorithm may be faced with an unbounded problem, as a result of poor constraint management at the time of modeling. In the simplex table this is represented by a column full of negatives.

In this case it is found in the column 3 where there are no valid fractions:

Z	x_1	x_2	x_3	x_4	S_1	S_2	b	Fractions
1.000	0.000	2.000	-9.000	0.000	12.000	4.000	100.000	
0.000	0.000	1.000	-6.000	1.000	6.000	-1.000	20.000	Invalid
0.000	1.000	1.000	-1.000	0.000	1.000	0.000	5.000	Invalid