Computer Science
Operations Research

Simplex Algoritm

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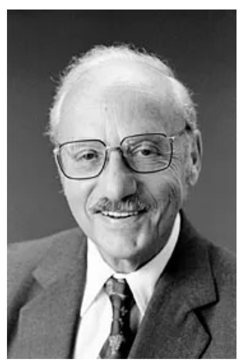
1 The Simplex Algorithm

The simplex algorithm, developed by George Dantzig in 1947, arises from the need to solve linear programming problems.m 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: Test1

The problem inputted by the user is called "Test1"and consists of maximizing the following fuction:

$Z = x1 \cdot 0.500000 + x2 \cdot 3.000000 + x3 \cdot 1.000000 + x4 \cdot 4.000000$

Subject to:

$x1 \cdot 1.000000 + x2 \cdot 1.000000 + x3 \cdot 1.000000 + x4 \cdot 1.000000 \leq 40.000000$

$x1 \cdot 2.000000 + x2 \cdot 1.000000 + x3 \cdot -1.000000 + x4 \cdot -1.000000 \geq 10.000000$

$x1 \cdot 0.000000 + x2 \cdot -1.000000 + x3 \cdot 0.000000 + x4 \cdot 1.000000 \geq 10.000000$

3 Initial Matrix with M cost

The initial simplex table is shown below, where the cost of M is represented in the first row. This cost is added to the objective function to penalize the presence of artificial variables in the basis.

Z	$x1$	$x2$	$x3$	$x4$	$s1$	$e1$	$e2$	$a1$	$a2$	b
0.000	-0.500	-3.000	-1.000	-4.000	0.000	0.000	0.000	0.000 + 1.0M	0.000 + 1.0M	0.000
0.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	40.000
0.000	2.000	1.000	-1.000	-1.000	0.000	-1.000	0.000	1.000	0.000	10.000
0.000	0.000	-1.000	0.000	1.000	0.000	0.000	-1.000	0.000	1.000	10.000

4 Initial Normalized Matrix

Z	$x1$	$x2$	$x3$	$x4$	$s1$	$e1$	$e2$	$a1$	$a2$	b
0.000	-0.500 + -2.0M	-3.000	-1.000 + 1.0M	-4.000	0.000	0.000 + 1.0M	0.000 + 1.0M	0.000	0.000	0.000 + -20.0M
0.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	40.000
0.000	2.000	1.000	-1.000	-1.000	0.000	-1.000	0.000	1.000	0.000	10.000
0.000	0.000	-1.000	0.000	1.000	0.000	0.000	-1.000	0.000	1.000	10.000

5 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.

5.1 Pivot Table

Z	$x1$	$x2$	$x3$	$x4$	$s1$	$e1$	$e2$	$a1$	$a2$	b	Fractions
0.000	0.000	-2.750 + 1.0M	-1.250	-4.250 + -1.0M	0.000	-0.250	0.000 + 1.0M	0.250 + 1.0M	0.000	2.500 + -10.0M	
0.000	0.000	0.500	1.500	1.500	1.000	0.500	0.000	-0.500	0.000	35.000	40.000
0.000	1.000	0.500	-0.500	-0.500	0.000	-0.500	0.000	0.500	0.000	5.000	5.000
0.000	0.000	-1.000	0.000	1.000	0.000	0.000	-1.000	0.000	1.000	10.000	*Invalid*

5.2 Pivot Table

Z	$x1$	$x2$	$x3$	$x4$	$s1$	$e1$	$e2$	$a1$	$a2$	b	Fractions
0.000	0.000	-7.000	-1.250	0.000	0.000	-0.250	-4.250	0.250 + 1.0M	4.250 + 1.0M	45.000	
0.000	0.000	2.000	1.500	0.000	1.000	0.500	1.500	-0.500	-1.500	20.000	23.333
0.000	1.000	0.000	-0.500	0.000	0.000	-0.500	-0.500	0.500	0.500	10.000	*Invalid*
0.000	0.000	-1.000	0.000	1.000	0.000	0.000	-1.000	0.000	1.000	10.000	10.000

5.3 Pivot Table

Z	$x1$	$x2$	$x3$	$x4$	$s1$	$e1$	$e2$	$a1$	$a2$	b	Fractions
0.000	0.000	0.000	4.000	0.000	3.500	1.500	1.000	-1.500 + 1.0M	-1.000 + 1.0M	115.000	
0.000	0.000	1.000	0.750	0.000	0.500	0.250	0.750	-0.250	-0.750	10.000	10.000
0.000	1.000	0.000	-0.500	0.000	0.000	-0.500	-0.500	0.500	0.500	10.000	*Invalid*
0.000	0.000	0.000	0.750	1.000	0.500	0.250	-0.250	-0.250	0.250	20.000	*Invalid*

6 Unique Solution

6.1 Explanation

In this case, the problem has a single optimal solution that satisfies the established constraints.

6.2 Solution table

Z	$x1$	$x2$	$x3$	$x4$	$s1$	$e1$	$e2$	$a1$	$a2$	b
0.000	0.000	0.000	4.000	0.000	3.500	1.500	1.000	-1.500 + 1.0M	-1.000 + 1.0M	115.000
0.000	0.000	1.000	0.750	0.000	0.500	0.250	0.750	-0.250	-0.750	10.000
0.000	1.000	0.000	-0.500	0.000	0.000	-0.500	-0.500	0.500	0.500	10.000
0.000	0.000	0.000	0.750	1.000	0.500	0.250	-0.250	-0.250	0.250	20.000

6.3 Unique Solution

Solution

$$\begin{bmatrix} x1 = 10.00 \\ x2 = 10.00 \\ x3 = 0.00 \\ x4 = 20.00 \end{bmatrix}$$

6.4 Optimal Solution

The final result of maximizing the given function is 115.000 as a result of setting the variables to the values:

- $x1 = 10.000$
- $x2 = 10.000$
- $x3 = 0.000$
- $x4 = 20.000$
- $s1 = 0.000$
- $e1 = 0.000$
- $e2 = 0.000$
- $a1 = 0.000$
- $a2 = 0.000$