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Improved Weighted Sum Multi Objective Programming

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ABSTRACT

Optimizing the combined objective function is the most common approach of Multi Objective Programming (MOP). The scalaization of objective functions have been recommended for combining the objective functions of various dimensions. The Weighted Sum Multi Objective Programming (WSMOP) has also been used for obtaining desirable solution. Several WSMOP methods are used for solving multi objective problems. Few weaknesses have noticed in WSMOP methods. An improved method of WSMOP is proposed in the present study for obtaining desirable solution of multi objective programming problems.

Keywords: *Multi Objective Programming, Normalization, Weighted Sum Multi Objective Programming.*

I. INTRODUCTION

Multi Objective Programming is commonly used to achieve multiple objectives simultaneously. The optimization of combined objective function is the most preferred method of solving MOP problems. The method has been successfully applied for resources use planning in agriculture [1], [2]. Several variants of the formulation of combined objective functions have been proposed [3], [4] for obtaining desirable solution. The basic characteristics of various methods of MOP have been described in the study [5]. These MOP techniques may not necessarily be providing preferred solutions for all the problems. The weighted sum method [6] of MOP has been found efficient in generating the desirable solutions. Few drawbacks in weighted sum method has been observed [7]. The present study proposed an improve weighted sum method of multi objective programming.

II. EXISTING WEIGHTED SUM MULTI OBJECTIVE PROGRAMMING METHOD

The existing WSMOP method is described below:

$$Max. Z = \sum_{i=1}^{m} wiZi - \sum_{j=m+1}^{n} wjZj$$

Subject to;

AX ≥ / ≤/ = b

X ≥ 0

where Z is combined objective function, Zi is ith objective function to be maximized, Zj is jth objective function to be minimized, w_i & w_j are the weights assigned to ith and jth objective function and $\sum_{i=1}^{m} w_i = 1$, A is the coefficient associated to decision variable X and b is the constraint vector.

III. IMPROVED WEIGHTED SUM MULTI OBJECTIVE PROGRAMMING METHOD

The existing WSMOP model can be revised as described below:

$$Max. Z = \sum_{i=1}^{m} wi \frac{Zi}{|\Theta i|} - \sum_{j=m+1}^{n} wj \frac{Zj}{|\Theta j|}$$

Subject to;

AX ≥ / ≤/ = b

X ≥ 0

Where;

$|\Theta i|$ is arithmetic mean of the coefficients of i^{th} maximization objective function and $|\Theta j|$ is arithmetic mean of the coefficients the of j^{th} minimization objective function. The objective functions can also be scalrized using optimal values of objective functions, geometric, harmonic means of coefficients of the decision variables or optimal and sub optimal values of objectives.

IV. EXAMPLE

The existing and improved WSMOP methods has been used to solve the following problem:

Max. $Z_1 = 12X_1 + 17X_2 + 10X_3 + 21 X_4 + 19 X_5$

Min. $Z_2 = 500X_1 + 700X_2 + 300X_3 + 900X_4 + 400X_5$

Subject to:

$X_1 + X_2 + X_3 + X_4 + X_5 = 2.5$

$3X_1 \geq 1.5$

X_1 & $X_2 \geq 0$

V. SOLUTION

There can be numerous weight options to both the objective functions. A limited number of weight options have been used for solving the example 1.The relative weights w_1 and w_2 have been fixed as(1, 0), (0.9, 0.1), (0.8, 0.2), (0.7, 0.3), (0.6,0.4), (0.5, 0.5), (0.4, 0.6) (0.3, 0.7), (0.2, 0.8), (0.1, 0.9) and (0, 1). The first and the last weight options are purely single objective optimization. The example was solved using both existing and improved WSMOP methods. The results are presented in Table 1.

Table 1: Optimal Solution of Existing and Improved WSMOP

Weights		Existing WSMOP			Improved WSMOP		
W_1	W_2	X_i	Z_1	Z_2	X_i	Z_1	Z_2
1	0	X_1=0.5, X_4= 2	48	2050	X_1=0.5, X_4= 2	48	2050
0.9	0.1	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_4= 2	48	2050
0.8	0.2	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_5= 2	44	1050
0.7	0.3	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_5= 2	44	1050
0.6	0.4	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_5= 2	44	1050
0.5	0.5	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_5= 2	44	1050
0.4	0.6	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_5= 2	44	1050
0.3	0.7	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_5= 2	44	1050
0.2	0.8	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_3= 2	26	850
0.1	0.9	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_3= 2	26	850
0	1	X_1=0.5, X_3= 2	26	850	X_1=0.5, X_3= 2	26	850

The first and last options of single objective optimization have resulted in the achievements of objective 1 and 2 respectively. The maximum value of the first objective was 48 and the minimum value of the second objective was 850 achieved by single objective optimization method. In the existing WSMOP method, the solutions of all the weight options are the same as the single goal achievement of the second objective. This is due to the domination of the coefficients of decision variables of the second objective. However, the improved WSMOP has optimized both the objectives according to the weights assigned to them. The value of the first and second objectives were 48 and 2050 respectively due to higher weight of 0.9 in comparison to lower weight of 0.1 to the second objective. The achievements of first and second objectives have been further improved with the values 44 and 1050 respectively in the weight options of (0.8, 0.2), (0.7, 0.3), (0.6, 0.4), (0,5, 0.5), (0.4, 0.6), (0.3, 0.7) to first and second objectives respectively. The last two solutions were in the favor of the second objective with the values of first and second objective 26 and 850 respectively due higher weights of 0.8 and 0.9 to second objective. The above results reveals that the improved WSMOP method is efficient in providing the desirable solutions of the multi objective optimization problems.

VI. CONCLUSION

The present study presented an improved weighted sum method for solving the multi objective optimization problems. An example of two objectives has been solved using both existing and improved weighted sum method of multi objective programming. The achievements of both the objectives using improved weighted sum method were superior over the existing weighted sum method of multi objective programming.

Compliance with ethical standards

Conflict of interest: The author declares that there is no conflict of interest.

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