Comments on Modeling of Gauss Elimination Technique and AHA Simplex Algorithm for Multi-objective Linear Programming Problems by Sanjay Jain and Adarsh Mangal

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ABSTRACT

An excellent research contribution was made by Sanjay and Adarsh in using Gauss Elimination Technique and AHA simplex method for solving multi-objective optimization (MOO) problems. The method was applied for solving MOO problems using Chandra Sen's technique and several other averaging techniques. The formulation of multi-objective function in the averaging techniques was not perfect. The example was also not appropriate.

KEYWORDS: Gauss Elimination Technique, AHA Simplex Algorithm, Multi-Objective Optimization, Chandra Sen's MOO Technique.

I. INTRODUCTION

The linear programming problems can be solved using various methods. The Gauss Elimination Technique and AHA simplex method was used by Sanjay and Adarsh [1] in solving MOO problems. The method has been applied to solve an example using Chandra Sen's MOO technique [2] and other averaging techniques [3]-[18]. The multi-objective functions in the averaging techniques have not been formulated appropriately [19]-[23]. The use of example with non conflicting objectives was not appropriate.

II. METHODOLOGICAL CONFLICTS

Chandra Sen's MOO technique and several averaging techniques have been used for solving

MOO problems. The formulation of multi-objective function has been explained below:

2.1 Chandra Sen's MOO Technique

A multi-objective optimization problem may have multiple objectives of different dimensions. The combined objective function is formulated by weighting the each objective by the inverse of its optimal value. This makes the combined objective function dimensionless. The formulation of combined objective function is described below:

$$\text{Maximize } Z = \frac{\sum_{j=1}^r Z_j}{|\Theta_j|} - \frac{\sum_{j=r+1}^s Z_j}{|\Theta_{r+1}|}$$

Subject to:

$$AX = b \quad \text{and } X \geq 0 \\ \Theta_j \neq 0 \quad \text{for } j=1, 2, \dots, s.$$

Where,

Θ_j is the optimal value of j^{th} maximizing objective and Θ_{r+1} is the optimal value of $(r+1)^{\text{th}}$ minimizing objective.

2.2 Averaging MOO Techniques

The study under review has scalarized the objectives by the several averages of the optimal values of different objectives. The formulation of multi-objective function combining the values of different dimensions seems illogical. The multi-objective function has been formulated as detailed below:

$$\text{Maximize } Z = \frac{\sum_{j=1}^r Z_j}{|\Theta_1|} - \frac{\sum_{j=r+1}^s Z_j}{|\Theta_2|}$$

Subject to:

$$AX = b \quad \text{and } X \geq 0$$

$$\Theta_j \neq 0 \quad \text{for } j=1, 2, \dots, s.$$

Where,

Θ_1 is the scalarizing factor as arithmetic, geometric, harmonic, new arithmetic, new geometric and new harmonic averages of optimal values of the maximization objectives and

Θ_2 is the scalarizing factor as arithmetic, geometric, harmonic, new arithmetic, new geometric and new harmonic averages of optimal values of the minimization objectives.

III. NUMERICAL EXAMPLE

The following example used in the studies [3], [8] have been used by Sanjay and Adarsh.

$$\text{Max. } Z_1 = X_1 + 2X_2$$

$$\text{Max. } Z_2 = X_1$$

$$\text{Min. } Z_3 = -2X_1 - 3X_2$$

$$\text{Min. } Z_4 = -X_2$$

Subject to:

$$6X_1 + 8X_2 \leq 48$$

$$X_1 + X_2 \geq 3$$

$$X_1 \leq 4$$

$$X_2 \leq 3$$

$$X_1, X_2 \geq 0$$

IV. SOLUTION

The example was first solved for optimizing all the objectives individually. The solution is presented in table 1. All the four objectives have been optimized by a single solution. This reveals the absence of conflicts amongst objectives and therefore, the example is not suitable for using MOO techniques.

Table 1: Individual Optimization

Particular	Individual Optimization			
	Max. Z_1	Max. Z_2	Min. Z_3	Min. Z_4
X_1, X_2	4, 3	4, 3	4, 3	4, 3
Z_1	10	10	10	10
Z_2	4	4	4	4
Z_3	-17	-17	-17	-17
Z_4	-3	-3	-3	-3

This has been further reflected in the solution of multi-objective optimization presented in table 2. The solution of all the methods are unique with the values of decision variables $X_1 = 4$ and $X_2 = 3$. The achievements of the basic objectives Z_1, Z_2, Z_3 , and Z_4 are same as in the individual optimization.

Table 2: Solution of MOLPP after applying AHA simplex algorithm and Gauss Elimination Technique.

Item	Chan dra Sen's technique	Arith metic average technique	Geom etric average technique	Harm onic average technique	New arith metic average technique	New geom etric average technique	New harm onic average technique
X_1, X_2	4, 3	4, 3	4, 3	4, 3	4, 3	4, 3	4, 3
Z_1	10	10	10	10	10	10	10
Z_2	4	4	4	4	4	4	4
Z_3	-17	-17	-17	-17	-17	-17	-17
Z_4	-3	-3	-3	-3	-3	-3	-3
Z^*	3.9998	3.9999	5.0141	6.3710	9.7141	9.8150	9.9164

Z^* - Multi-objective function

The MOO techniques have been ranked according to the values of the multi-objective function which is not logical. The multi-objective functions have been formulated using different methods. Hence, the values of multi-objective functions should not be compared.

V. SUMMARY

It is clear from the analysis that proposed technique has not been formulated appropriately. The numerical example used was also not suitable. The solution has not been interpreted correctly.

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