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A Shortcut Model for the Suggested Approach in Mixed Zero-One Fuzzy Goal Programming

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Abstract

In this short paper, an equivalent model to the one that has been provided by Iskander [1] is presented. The required linearization constraints and variables in the equivalent model are much fewer than that in the initially provided one. Hence, the proposed shortcut model can be easily utilized according to Iskander's approach, especially for large-scale problems.

JEL classification numbers: C61, C63.
Keywords: Alternative fuzzy goals, Zero-one fuzzy goal programming, Mixed zero-one fuzzy goal programming.

1. Introduction

Iskander [1] provided an approach in fuzzy goal programming where the original fuzzy goals can be replaced by their corresponding alterative ones based on the satisfaction of certain situation conditions. Therefore, with reference to his stated fuzzy goal programming problem as well as all the definitions, the crisp non-linear mixed zero-one goal program has been presented as follows:

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$$\text{Lexicographically minimize } \{ \sum_{i \in I_p} d_i + \sum_{\substack{i \in I_p \\ i \in G}} d_i^{o} \ : p = 1, 2, \ldots, P \} \qquad (1)$$

subject to:

$$L_i f_i (X, Y) - L_i u_i + d_i \geq 1, \ \ i = 1, 2, \ldots, m_1; \ i \notin G, \qquad (2)$$

$$K_i v_i - K_i f_i (X, Y) + d_i \geq 1, \ \ i = m_1+1, m_1+2, \ldots, m; \ i \notin G, \qquad (3)$$

$$r_j = R_j (X), \ \ j = 1, 2, \ldots, J, \qquad (4)$$

$$L_i f_i (X, Y) r_j - L_i u_i r_j + d_i \geq r_j, \ \ i \in G_j; \ i = 1, 2, \ldots, m_1; \ j = 1, 2, \ldots, J, \qquad (5)$$

$$K_i v_i r_j - K_i f_i (X, Y) r_j + d_i \geq r_j, \ \ i \in G_j; \ i = m_1+1, m_1+2, \ldots, m; \ j = 1, 2, \ldots, J, \qquad (6)$$

$$L_i^{o} f_i^{o}(X, Y) (1-r_j) - L_i^{o} u_i^{o} (1-r_j) + d_i^{o} \geq (1-r_j), \ \ i \in G_j; \ i = 1, 2, \ldots, m_1; \ j = 1, 2, \ldots, J, \qquad (7)$$

$$K_i^{o} v_i^{o} (1-r_j) - K_i^{o} f_i^{o}(X, Y) (1-r_j) + d_i^{o} \geq (1-r_j), \ \ i \in G_j; \ i = m_1+1, m_1+2, \ldots, m; \ j = 1, 2, \ldots, J, \qquad (8)$$

$$\Phi_s(X, Y) \leq 0, \ \ s = 1, 2, \ldots, S, \qquad (9)$$

$$0 \leq d_i \leq 1, \ \ i = 1, 2, \ldots, m, \qquad (10)$$

$$0 \leq d_i^{o} \leq 1, \ \ i \in G, \qquad (11)$$

$$X, r_j \in \{0, 1\}, \ \ j = 1, 2, \ldots, J, \qquad (12)$$

$$Y \geq 0. \qquad (13)$$

2. The Equivalent Shortcut Model

Iskander’s model (1)-(13) has been linearized by two approaches. The first is used to linearize the product of binary variables. The second (Chang’s approach) is utilized when a non-negative variable is multiplied by a binary variable [2].
The proposed equivalent shortcut model requires that in the above model (1)-(13), constraints (5)-(8) should be, respectively, replaced by the following constraints:

$$\theta(1-r_j) + L_i f_i (X, Y) - L_i u_i + d_i \geq 1, \ \ i \in G_j; \ i = 1, 2, \ldots, m_1; \ j = 1, 2, \ldots, J, \qquad (14)$$

$$\theta(1-r_j) + K_i v_i - K_i f_i (X, Y) + d_i \geq 1, \ \ i \in G_j; \ i = m_1+1, m_1+2, \ldots, m; \ j = 1, 2, \ldots, J, \qquad (15)$$

$$\theta r_j + L_i^{o} f_i^{o}(X, Y) - L_i^{o} u_i^{o} + d_i^{o} \geq 1, \ \ i \in G_j; \ i = 1, 2, \ldots, m_1; \ j = 1, 2, \ldots, J, \qquad (16)$$

$$\theta r_j + K_i^o v_i^o - K_i^o f_i^o(X, Y) + d_i^o \geq 1,\ i \in G_j;\ i = m_1+1, m_1+2, \ldots, m;\ j = 1, 2, \ldots, J, \qquad (17)$$

where θ is a large positive number. It is obvious that the non-linear constraints (5)-(8) are, respectively, replaced by the linear constraints (14)-(17). Hence, the Chang's linearization approach is not required to linearize the shortcut model, just the first approach is utilized to linearize constraint set (4).

3. Illustrative Implementation

In this section, the same numerical example, considered by Iskander [1], is used to illustrate the implementation of the shortcut model. This example assumed the following mixed zero-one fuzzy goal program:

(g_1) $50x_1 + 30x_2 + 40x_3 + 4y_1 + 6y_2 \underset{\sim}{>} 60,$

(g_2) $20x_1 + 40x_2 + 10x_3 \underset{\sim}{<} 40,$

(g_3) $10y_1 + 6y_2 \underset{\sim}{<} 30,$

$x_1 + x_2 + x_3 \geq 1,$

$3y_1 + 2y_2 \geq 11,$

$x_1, x_2, x_3 \in \{0, 1\},$

$y_1, y_2 \geq 0.$

The alternative fuzzy goals for the original three ones (g_1, g_2, g_3) are, respectively, as follows:

(g_1^o) $40x_1 + 35x_2 + 40x_3 + 5y_1 + 5y_2 \underset{\sim}{>} 65,$

(g_2^o) $20x_1 + 30x_2 + 20x_3 \underset{\sim}{<} 50,$

(g_3^o) $7y_1 + 8y_2 \underset{\sim}{<} 25.$

The tolerance limits for the original fuzzy goals and the alternative ones are, respectively, (50, 45, 35) and (60, 55, 35). Two priority levels are used. The first is assigned to the first goal, while the second is assigned to the second and third goals. Finally, one situation condition is stated, whereas the original three fuzzy goals are considered if both x_1 and x_3

are equal to one, otherwise the alternative ones are considered. Then, the linearized crisp shortcut mixed zero-one goal program is stated as follows:

Lexicographically minimize { $d_1 + d_1^o$, $d_2 + d_2^o + d_3 + d_3^o$ }

subject to:

$\theta(1-r) + 5x_1 + 3x_2 + 4x_3 + 0.4y_1 + 0.6y_2 - 6 + d_1 \geq 0$,

$\theta(1-r) + 8 - 4x_1 - 8x_2 - 2x_3 + d_2 \geq 0$,

$\theta(1-r) + 6 - 2y_1 - 1.2y_2 + d_3 \geq 0$,

$\theta r + 8x_1 + 7x_2 + 8x_3 + y_1 + y_2 - 13 + d_1^o \geq 0$,

$\theta r + 10 - 4x_1 - 6x_2 - 4x_3 + d_2^o \geq 0$,

$\theta r + 2.5 - 0.7y_1 - 0.8y_2 + d_3^o \geq 0$,

$x_1 + x_3 - 1 \leq r \leq (x_1 + x_3) / 2$,

$x_1 + x_2 + x_3 \geq 1$,

$3y_1 + 2y_2 \geq 11$,

$0 \leq d_1, d_2, d_3, d_1^o, d_2^o, d_3^o \leq 1$,

$r, x_1, x_2, x_3 \in \{0, 1\}$,

$y_1, y_2 \geq 0$.

However, there is only one situation condition, the number of constraints and variables in this shortcut numerical model is less than that in its equivalent original one which has been presented by Iskander [1].

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