A Fuzzy Goal Programming Approach to Mobile Application Marketing

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Abstract- This paper presents an application of a fuzzy goal programming approach to mobile application marketing.A special type of membership function (generalized bell membership function) is used to solve the system.Firstly the problem has been formulated with equal priorities and then with unequal priorities. The main goal of this problem is to maximize the profit and sales of the mobile application marketing. Finally, the optimal result has been obtained.

Keywords: Fuzzy goal programming, Bell membership function, Mobile application, Equal and unequal Priority.

I. INTRODUCTION

Now a days, the field of mobile app development offers a great opportunity to make money by creating some interesting mobile applications. In this mobile App marketing, the main objective of such mobile app developer companies is to maximize the profit by maximizing the number of sales of those different mobile apps. In several situations these objectives are conflicting in nature. In order to deal with such conflicting multi objective problem we use fuzzy goal programming. This study is further extended into two cases; one with equal priorities and another with unequal priorities.

II. PRELIMINARIES

Fuzzy Set: - In this section the basic concept of the fuzzy set has been given by Zadeh (1965). It is the mathematical way of representing imprecision or fuzziness or vagueness. A fuzzy set allows partial belongingness of the element in the set and it is explained with the help of membership function i.e. the degree of belongingness is measured by membership function. It can be seen that fuzzy set is the extension of classical set (crisp set) and membership function has analogy with characteristic function. Thus fuzzy set can be defined in the following way:

A fuzzy set Ã in a universe of discourse X is defined as set of order pairs:

Ã = {(x, $\mu_{A:}$ x ∈X}, where μ_A: X → [0, 1] is called membership function or grade of membership of x in Ã.

Fuzzy Goal and Fuzzy Constraint:- Let g $_k$ be the aspiration level of the K-th objective $F_k(X)$,(k=1,2,3,....K).Then the fuzzy goal may appear in the following forms $F_k(X) \geq g_k$ and $F_k(X) \leq gk$,where X >0 is the vector for decision Variables, $g_k(x)$ is the fuzzy aspiration level of k-th objective $F_k(X)$,≥and≤ refer to fuzziness of aspiration level and to be understood as essentially greater than an essentially less than.

In the same manner we can defined fuzzy constraint.

Fuzzy Decision: - A fuzzy decision is defined as the fuzzy set of alternatives resulting from the intersection of goals and constraints. More generally we can define fuzzy decision as, given a fuzzy goal G and a fuzzy constraint C in the space of alternatives X, then it can be defined as a fuzzy set G∩C. The membership functions of the fuzzy decision μ_D is given by $\mu_G \wedge \mu_C$ .This definition is extendible to the cases with multiple goal and multiple constraints.

Fuzzy Goal Programming: - In conventional Goal Programming models decision maker specify a precise aspiration level for each of the objectives. It becomes difficult for decision makers for large scale problem. Applying fuzzy set theory decision maker can specify imprecision aspiration level. Thus any objective with imprecise aspiration can be treated as a fuzzy goal .Narasimhan in 1980 first incorporated the theory of fuzzy set in the study of Goal programming. In fuzzy goal programming, the conventional difference between goals and constraints no longer exists. Goals and constraints enter into the expression for fuzzy decision D. Since the decision D is a fuzzy subset, the optimal decision is any alternative x ∈X which maximizes the membership function for the decision set $\mu_D(x)$. Thus fuzzy goal programming problem can be stated as:

find the optimal decision D s.t

AX≅b with X ≥0 , where v is a fuzzifier representing the imprecision where goals are stated.

The corresponding membership functions are defined as:

μ_i (AX) =1, i f $(AX)_i = b_i$ =f $((AX)_i, b_i)$, otherwise $0 \leq \mu_i (AX) \leq 1$

, where $(AX)_i$ represents i-th equation of AX; bi is the ith component on the right hand side column vector b. From the above discussion, it is clear that membership value for i-th goal is 1 when it is attained precisely otherwise membership value lies between 0 and 1.The right hand side value bi represents the aspiration level of the decision maker. Thus by using the definition of fuzzy decision, the membership function of decision set is given by

$$\mu_D(x) = \mu_1(AX) \wedge \mu_2 (AX) ... \wedge \mu_m (AX) = \min \mu_i (AX)$$

, and the maximizing decision is given by

$$\text{Max } \mu_D (x) = \text{Max Min } \mu_i (AX) \qquad (*_1)$$

Mathematical Formulation:-

Considering the membership function

$$\mu_i (AX) = \frac{1}{1+|\frac{(AXi-ci)}{ai}|^{2b}} \quad ; ai \leq Axi \leq ci \qquad (*_2)$$

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Where a, b, c are parameters.

In order to solve the fuzzy goal programming problem ($*_1$), the membership function ($*_2$) is being used. Now solving this fuzzy goal programming problem is similar to solving following independent problems

Max Min $\frac{1}{1+|\frac{(AXi-ci)}{ai}|^{2bi}}$ ($*_3$)

X≥0 i

With the help of ($*_3$) we formulate the optimization problem as follows

Max η

Subject to

$$\eta \le \frac{1}{1+|\frac{(AXi-ci)}{ai}|^{2bi}}$$

ai≤ Axi ≤ ci

X≥0

Now we will introduce different priorities to different goals.

i. Goals with high priority
ii. Goals with moderately high priority
iii. Goals with moderately low priority
iv. Goals with low priority

In the context of these different priorities, we define the membership function as follows

Goals with high priority

$$\mu w_i\,(AX) = \frac{\mu i\,(AX) - .8}{.2};\ .8 \le \mu_i \le 1$$

Goals with moderately high priority

$$\mu w_i\,(AX) = \frac{\mu i\,(AX) - .6}{.2};\ .6 \le \mu_i \le 1$$

Goals with moderately low priority

$$\mu w_i\,(AX) = \frac{\mu i\,(AX) - .5}{.2};\ .5 \le \mu_i \le 1$$

Goals with low priority

$$\mu w_i\,(AX) = \frac{\mu i\,(AX) - .3}{.2};\ .3 \le \mu_i \le 1$$

Practical problem on Mobile App marketing

The statement of the problem is as follows:

One mobile app developer company launches four mobile applications as a messenger app, a game app, a music app and a photo editor app. The company wants to sell messenger app is “around 20 units”, game app is “around 18 units”, music app is “around 15 units” and photo editor app is “around 10 units” .The unit profit of messenger app is “around $ 100”, unit profit of game app is “around $ 90”, unit profit of music app is “around $ 80” and unit profit of photo editor is “around $ 60”. The company also wants to earn a profit of “around $5320”.

III. MATHEMATICAL FORMULATION OF THE PROBLEM

Suppose x1 be the number of units of messenger app, x2 be the number of units of game app, x3 be the number of units of music app and x4 be the number of units of photo editor app.

First we formulate the problem where equal priorities are attach to each and every goal

The membership functions of this problem are given as follows

μ_1 (profit goal) = $\frac{1}{1+|\frac{(100x1+90x2+80x3+60x4-5420)}{5220}|^{10640}}$;

$5220 \le 100x1 + 90x2 + 80x3 + 60x4 \le 5420$

μ_2 (sales goal of messenger app) = $\frac{1}{1+|\frac{(X1-30)}{10}|^{40}}$

; 10≤ x1 ≤30

μ_3 (sales goal of game app) = $\frac{1}{1+|\frac{(X2-20)}{16}|^{36}}$;

16≤ x2 ≤20

μ_4 (sales goal of music app) = $\frac{1}{1+|\frac{(X3-20)}{10}|^{30}}$;

10≤ x3 ≤20

μ_5 (sales goal of photo editor app) = $\frac{1}{1+|\frac{(X4-15)}{5}|^{20}}$

; 5≤ x4 ≤15

Now the equivalent optimization model is

Max η

Subject to

$$\eta \le \frac{1}{1+|\frac{(100x1+90x2+80x3+60x4-5420)}{5220}|^{10640}}$$

$$\eta \le \frac{1}{1+|\frac{(X1-30)}{10}|^{40}}$$

$$\eta \le \frac{1}{1+|\frac{(X2-20)}{16}|^{36}}$$

$$\eta \le \frac{1}{1+|\frac{(X3-20)}{10}|^{30}}$$

$$\eta \le \frac{1}{1+|\frac{(X4-15)}{5}|^{20}}$$

$5220 \le 100x1 + 90x2 + 80x3 + 60x4 \le 5420$

10≤ x1 ≤30

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$16 \leq x2 \leq 20$

$10 \leq x3 \leq 20$

$5 \leq x4 \leq 15$

Optimal Solution

Number of units of messenger app 22.26816
Number of units of game app 16
Number of units of music app 12.90439
Number of units of photo editor app 12.01388
Total profit is $5420

Now we formulate the problem where unequal priorities are attach to each and every goals

The membership functions are given as follows

μw_1 (profit goal) $= \frac{\mu 1-.8}{.2}$; $.8 \leq \mu_1 \leq 1$

μw_2 (sales goal of messenger app) $= \frac{\mu 2-.6}{.2}$; $.6 \leq \mu_2 \leq 1$

μw_3 (sales goal of game app) $= \frac{\mu 3-.5}{.2}$; $.5 \leq \mu_3 \leq 1$

μw_4 (sales goal of music app) $= \frac{\mu 4-.5}{.2}$; $.5 \leq \mu 4 \leq 1$

μw_5 (sales goal of photo editor app) $= \frac{\mu 5-.3}{.2}$; $.3 \leq \mu_5 \leq 1$

Equivalent optimization model

Max η

Subject to

$$\leq 2\,\frac{\frac{1}{1+|\frac{(100x1+90x2+80x3+60x4-5420)}{5220}|^{10640}}-.8}{}$$

$$\eta \leq \frac{\frac{1}{1+|\frac{(X1-30)}{10}|^{40}}-.6}{.2}$$

$$\eta \leq \frac{\frac{1}{1+|\frac{(X2-20)}{16}|^{36}}-.5}{.2}$$

$$\eta \leq \frac{\frac{1}{1+|\frac{(X3-20)}{10}|^{30}}-.5}{.2}$$

$$\eta \leq \frac{\frac{1}{1+|\frac{(X4-15)}{5}|^{20}}-.3}{.2}$$

$5220 \leq 100x1 + 90x2 + 80x3 + 60x4 \leq 5420$
$10 \leq x1 \leq 30$
$16 \leq x2 \leq 20$
$10 \leq x3 \leq 20$
$5 \leq x4 \leq 15$

Optimal Solution:-

Number of units of messenger app 20.34064
Number of units of game app 10.95485
Number of units of music app 20
Number of units of photo editor app 10
Total profit is $5220.0005

IV. CONCLUSION

This paper clearly explains how fuzzy goal programming can be used to achieve an optimal value to maximize the profit and sales of the respective mobile app developer companies' .It also shows the variation when equal and different weights attached to various goals .This method can easily be applied to raise the profit margin of a mobile app developer company.

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