Advances in Nonlinear Variational Inequalities
ISSN: 1092-910X
Vol 27 No. 2 (2024)

An Analysis of Anesthesia for C - Section Patients Using Neutrosophic Approach

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Article History:

Received: *01-02-2024*

Revised: *31-03-2024*

Accepted: *24-04-2024*

Abstract:

This paper vividly describes the multiple object linear integer programming problem, using imprecision method which is applied to solve the mundane life problems, diagnosis and survey-based studies-with the help of neutrosophic fuzzy environment. The empirical intention of the article is to single out the most apt anaesthesia for c- section out of three categorized anaesthesia namely general, regional and local that fulfils the nominal four constraints such as preference of patients, safety, duration of pain tolerance and cost effective. The objectives and constraints to define a problem are created using the data surveyed from authentic anaesthesiologist's and derived in the Neutrosophic number form.

Keywords: Neutrosophic fuzzy set, Neutrosophic soft set, vague fuzzy set, imprecision method.

1. Introduction

Multi-objective linear programming technique took its modest growth in the year 1970 and started developing slowly, that gave many optimal solutions for real life-based problems and application-based issues, on discrete variables which is undeniable in this technical method. Considering that as a case, recent researches created integer linear programming which is associated with multi-objective linear programming to give a multi-objective integer linear programming problem with solution. Also, it can be solved by using simple combination of integer linear programming and multi objective linear program in techniques but it has its own particular and certain difficulties.

In 1986, Atanassov conducted a study on intuitionistic fuzzy sets. In 1994, he introduced operators for interval-valued intuitionistic fuzzy sets. Bowman (1976) established a link between the T-chebycheff norm and the efficient boundary of multi-criteria objectives. Burkard (1981) discussed the correlation between optimality and efficiency in multi-criteria 0-1 programming problems. Gonzalez et al (1985) proposed an interactive approach for multi-objective integer linear programming. Kiziltan et al (1983) developed an algorithm for multi-objective zero-one linear programming. Klein et al (1982) devised an algorithm for multi-objective integer linear programming. Lhoir et al (1995) pursued the portfolio selection by MOLP using an interactive branch and bound. Marcotte et al (1986) has given an interactive branch and bound algorithm for multiple criteria optimizations. Solairaju et al. (2018) introduced a method for converting neutrosophic fuzzy sets into fuzzy sets using an imprecision approach. Steuer (1986) formulated a theory for optimizing multiple criteria. Steuer et al. (1983) proposed an interactive, weighted T-chebycheff procedure for multiple-objective programming. Teghem et al. (1986) developed an interactive method for multi-objective integer linear programming. They also provided a review of methods for finding efficient solutions in this context. Zhang et al. (2004) developed an approach to measure similarity between vague sets.

- The article is catalogues as follows: some basic definitions has been discussed in section 2.
- Section 3 analyses and discuss about anesthesia for C-Section delivery patients.
- Section 4 provides problem procedure and mathematical modelling of the problem.
- Section 5 deals with an application of multi-objective integer linear programming problem in Neutrosophic fuzzy set.
- Finally, result & discussions, conclusion of this paper are given in section 6 &7.

2. Preliminaries

2.1. Vague Set [10]

A vague set V_S in a set U is {u, $H_V(u)$, $K_V(u)$: u in U} where U is characterized by a true membership function H_V, and a false membership function K_V such that T: U $\rightarrow$[0,1] and F: U $\rightarrow$[0,1] with $0 \le H_V(u) + K_V(u) \le 1$. $H_V(u)$ is the lowest estimate of how likely u is to be true based on the evidence supporting it. $K_V(u)$ is the lowest estimate of how likely the opposite of u is to be true based on the evidence against it.

2.2. Neutrosophic fuzzy set [13]

A Neutrosophic fuzzy set A^N of X can be defined as

$$A^N = \{(x, H_{A^N}(x), I_{A^N}(x), K_{A^N}(x))/x \in X\}$$

Where $H_{A^N}(x)$ is truth-membership, $I_{A^N}(x)$ is indeterminacy membership $K_{A^N}(x)$ is falsity-membership function such that $H_{A^N}(x), I_{A^N}(x), K_{A^N}(x)$: X$\rightarrow$ [0,1] for all $x \in X$ and $0 \le H_{A^N}(x) + I_{A^N}(x) + K_{A^N}(x) \le 3$.

2.3. Neutrosophic soft set [12]

Given a set U with elements and a set of parameters E, a subset A of E is defined. The set of all neutrosophic subsets of U is represented by P(U). The tuple (F, A) is called a soft neutrosophic set over U, where F is a mapping that assigns to each element a in A a neutrosophic subset F(a) of U.

3. Anesthesia For C-Section Delivery Patients

In this module, we discuss about the types of anaesthesia and particular anaesthesia drug prescribed for C-section delivery patients with the help of anaesthesiologist. With the thorough understanding and learning, we state that, anaesthesia will stave off a patient from pain and malaise ache during surgery. It restricts the signals of nervous system. Anaesthesiologist prefers anaesthesia based on the type of surgery and age of the patient.

General Anaesthesia

General anaesthetic drug will make a patient, completely unconscious. After in taking a single dose, one could not feel any pain and doesn't feel or have conscious in the atmospherically actions including touch sense. Patients will get this type of anaesthesia through vein or inhale it through nose or oral breathing. While patient is under general anaesthesia, a conduit will be placed in patient's throat for the purpose of induced breathing.

Regional Anaesthesia

Regional anaesthesia, sometimes known as Bier block, is a technique that involves injecting an anaesthetic medication directly into a vein at the furthest point from the body's core in either an arm or leg. A tourniquet is then applied to the anesthetized limb to prevent the medication from entering the bloodstream and spreading throughout the body. The medication is typically injected near a group of nerves located in the spine. This will create some numbers in a large area of the body and makes us to feel no pain generally, epidural and spinal block anaesthesia is often used for C-section. It will block the feelings of pain in a particular area of the body.

Local Anaesthesia

Local anaesthesia is injected to a small area of the body. It will be given as an ointment, spray or shot. It will be mostly used for a dental based work, stitches or to reduce the pain level of injection.

Based on the types of anaesthesia, it can be given through an IV mask or breathing tube. Here, the objectives with respect to the constraints are provided in Neutrosophic fuzzy set to define one of the suitable anaesthesia for C-section. Anaesthesiologist helped in defining the following problem. The objectives are general, regional, and local with respect to the constraints such as preference of patient, safe, duration of pain level and cost.

4. Mathematical Modelling of MOILPP in Neutrosophic Fuzzy Set

Supposing the probability, if there are m objectives (Types of anaesthesia) A = $\{a_1, a_2, \ldots, a_q\}$ and the decision maker (anesthesiologist) have taken some selection constraints as X = $\{x_1, x_2, \ldots, x_r\}$ for preference evaluation of the types of anesthesia. The performance evaluation is expressed as Neutrosophic fuzzy soft set, where F: X→P(U), for each decision maker (anaesthesiologist).

From anaesthesiologist (D)

$$
= \begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ \vdots \\ a_q \end{array}
\begin{array}{c}
\begin{array}{ccccc} x_1 & x_2 & x_3 & \dots & x_r \end{array} \\
\begin{bmatrix}
(a_{11}, b_{11}, c_{11}) & (a_{12}, b_{12}, c_{12}) & (a_{13}, b_{13}, c_{13}) & \cdots & (a_{1r}, b_{1r}, c_{1r}) \\
(a_{21}, b_{21}, c_{21}) & (a_{22}, b_{22}, c_{22}) & (a_{23}, b_{23}, c_{23}) & \cdots & (a_{2r}, b_{2r}, c_{2r}) \\
(a_{31}, b_{31}, c_{31}) & (a_{32}, b_{32}, c_{32}) & (a_{33}, b_{33}, c_{33}) & \cdots & (a_{3r}, b_{3r}, c_{3r}) \\
\vdots & \vdots & \vdots & \cdots & \vdots \\
(a_{q1}, b_{q1}, c_{q1}) & (a_{q2}, b_{q2}, c_{q2}) & (a_{q3}, b_{q3}, c_{q3}) & \cdots & (a_{qr}, b_{qr}, c_{qr})
\end{bmatrix}
\end{array}
$$

Then, above Neutrosophic fuzzy set $D = (T_D,\ I_D, F_D)$ are converted as intuitionistic fuzzy values/vague values $\Gamma(D) = (T_D, f_D)$ where f_D is calculated by the formula mentioned [14] below

$$f_D = F_D + [1 - F_D - I_D][1 - I_D]/F_D + I_D \quad if\ F_D = 0$$

$$= F_D + [1 - F_D - I_D][F_D]/F_D + I_D \quad if\ 0 < F_D \leq 0.5$$

$$= F_D + [1 - F_D - I_D][0.5 + [F_D - 0.5]/(F_D + I_D)]\ if\ 0.5 < F_D \leq 1$$

$$
\begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ \vdots \\ a_q \end{array}
\begin{array}{c}
\begin{array}{ccccc} x_1 & x_2 & x_3 & \dots & x_r \end{array} \\
\begin{bmatrix}
(a_{11}, b_{11}) & (a_{12}, b_{12}) & (a_{13}, b_{13}) & \cdots & (a_{1r}, b_{1r}) \\
(a_{21}, b_{21}) & (a_{22}, b_{22}) & (a_{23}, b_{23}) & \cdots & (a_{2r}, b_{2r}) \\
(a_{31}, b_{31}) & (a_{32}, b_{32}) & (a_{33}, b_{33}) & \cdots & (a_{3r}, b_{3r}) \\
\vdots & \vdots & \vdots & \cdots & \vdots \\
(a_{q1}, b_{q1}) & (a_{q2}, b_{q2}) & (a_{q3}, b_{q3}) & \cdots & (a_{qr}, b_{qr})
\end{bmatrix}
\end{array}
$$

After that, converting the vague fuzzy values $\Gamma(D) = (T_D, f_D)$ into fuzzy values, a formula is applied.as follows

$$\langle N(D) \rangle = \langle T_D/(T_D + f_D) \rangle$$

$$
\begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ \vdots \\ a_q \end{array}
\begin{array}{c}
\begin{array}{ccccc} x_1 & x_2 & x_3 & \dots & x_r \end{array} \\
\begin{bmatrix}
(a_{11}) & (a_{12}) & (a_{13}) & \cdots & (a_{1r}) \\
(a_{21}) & (a_{22}) & (a_{23}) & \cdots & (a_{2r}) \\
(a_{31}) & (a_{32}) & (a_{33}) & \cdots & (a_{3r}) \\
\vdots & \vdots & \vdots & \cdots & \vdots \\
(a_{q1}) & (a_{q2}) & (a_{q3}) & \cdots & (a_{qr})
\end{bmatrix}
\end{array}
$$

Consider the following multi-objective integer linear programming technique for the problem is as follows

$$\max Z_1(x) = (c^1)^T x$$

$$\dots\dots\dots..$$

$$\max Z_k(x) = (c^k)^T x$$

$$\dots\dots\dots..$$

$$\max Z_p(x) = (c^p)^T x$$

$$Subject\ to: x \in X$$

Where $X = (x_1, \dots, x_j, \dots, x_n)$ is a n-vector of non-negative and integer decision variables and $(c^k)^T = (c_1^k, \dots, c_j^k, \dots, c_n^k)$ is a n-row vector composed of the coefficients of the decision variables in the objective functions, $k = 1,2, \dots, p$.

Or the problem can be written in a more compact form as follows

$$\max Z(x) = C\,x$$
$$Subject\ to: x \in X$$

Where max denotes that all the functions are to be maximized, $Z(x) = (Z_1(x), \dots, Z_k(x), \dots, Z_p(x))$ is the vector of the objective functions (p) and C is a $n \times k$ matrix, each line composed of the coefficients of the decision variables in each objective functions.

Finally, comparison of optimal solutions of objectives is done to get a suitable type of anaesthesia for C-Section patients.

4.1 Problem Procedure for MOILPP in Neutrosophic Fuzzy Set

George Dantzig created the simplex algorithm in 1947 to address linear programming issues like daily life diagnosis issues. This successful outcome, lead to the introduction of integer programming, which was formed by modifying the branch and cut algorithm. The transformation of a Neutrosophic fuzzy set into a fuzzy set using the imprecision membership method was covered by Solairaju et al. (2018).

Following the algorithm and ideas, we reconstructed a new technique and applied in MOILPP as follows.

- Define a problem in a Neutrosophic set.
- Convert Neutrosophic set into vague fuzzy values by using imprecision membership method for both objectives and constraints of the problem.
- Vague fuzzy values are converted to defuzzified values.
- Constructed multi-objective of the problem.
- Solve it by using Multi- objective Integer Linear Programming Problem (MOILPP)

5. Application of Multi-Objective Integer Linear Programming Problem

The preference of anaesthesia by C-Section patients are analysed using MOLPP in Neutrosophic fuzzy set. The objective and constraints to define a problem are created using the values given by anaesthesiologists, which was in the form of Neutrosophic number and is given in TABLE V and TABLE VIII

The objectives of the problem are General (a_1), Regional (a_2), and Local (a_3). The constraints of the problem are Patient's preference (x_1), Safe (x_2), Duration of pain (x_3), and Cost (x_4).

TABLE I DENOTATIONS OF OBJECTIVES

General (a_1)	Intravenous (IV) anesthetics, Inhalational anesthetics, IV sedatives, Synthetic opioids, and Neuromuscular blocking drugs

Regional (a_2)	Spinal anesthesia, Epidural anesthesia and Nerve blocks
Local (a_3)	Lignocaine, Prilocaine and Bupivacaine

TABLE II DENOTATIONS OF CONSTRAINTS

Patient's preference (x_1)	Quality
Safe (x_2)	Low risk to use
Duration of pain (x_3)	Less pain
Cost (x_4)	Reasonable

Neutrosophic scales are defined for linguistic variables.

TABLE III LINGUISTIC VARIABLES OF NEUTROSOPHIC SET

Linguistic Term	Neutrosophic Set
Extremely Highly Preferred (EXHP)	(0.90,0.10,0.10)
Extremely Preferred (EXP)	(0.85,0.20,0.15)
Very Strongly Preferred (VSP)	(0.85,0.25,0.20)
Strongly Preferred (SP)	(0.75,0.20,0.20)
Moderately Highly Preferred (MHP)	(0.70,0.30,0.30)
Moderately Preferred (MP)	(0.65,0.30,0.35)
Moderately Lowly Preferred (MLP)	(0.60,0.35,0.40)
Lowly Preferred (LP)	(0.55,0.40,0.45)
Equally Preferred (EP)	(0.50,0.50,0.50)

TABLE IV LINGUISTIC VARIABLES FOR OBJECTIVES WITH RESPECT TO CONSTRAINTS

	x_1	x_2	x_3	x_4
a_1	SP	EP	EXP	MP
a_2	EXHP	EHP	EXP	EXP
a_3	MHP	EP	EXP	MLP

TABLE V NEUTROSOPHIC DECISION MATRIX

	x_1	x_2	x_3	x_4
a_1	(0.75,0.20,0.20)	(0.50,0.50,0.50)	(0.85,0.20,0.15)	(0.65,0.30,0.35)
a_2	(0.90,0.10,0.10)	(0.90,0.10,0.10)	(0.85,0.20,0.15)	(0.85,0.20,0.15)
a_3	(0.70,0.30,0.30)	(0.50,0.50,0.50)	(0.85,0.20,0.15)	(0.60,0.35,0.40)

Using imprecision membership method, the Neutrosophic fuzzy sets are converted into vague fuzzy values as shown in TABLE VI.

TABLE VI VAGUE FUZZY VALUES

	x_1	x_2	x_3	x_4
a_1	(0.75,0.50)	(0.50,0.50)	(0.85,0.43)	(0.65,0.54)
a_2	(0.90,0.49)	(0.90,0.49)	(0.85,0.43)	(0.85,0.43)
a_3	(0.70,0.50)	(0.50,0.50)	(0.85,0.43)	(0.60,0.53)

Using defuzzification method, the above table is defuzzified as follows

TABLE VII DEFUZZIFIED MATRIX

	x_1	x_2	x_3	x_4
a_1	0.6	0.5	0.66	0.55
a_2	0.65	0.65	0.66	0.66
a_3	0.58	50.	0.66	0.53

A pair wise comparison is done and by using imprecision membership method as well as defuzzification the single valued matrix is created as shown in TABLE VIII.

TABLE VIII A PAIR WISE COMPARISON MATRIX

	x_1	x_2	x_3	x_4
x_1	EP	SP	MHP	SP
x_2	$\frac{1}{SP}$	EP	EXP	EXHP
x_3	$\frac{1}{MHP}$	$\frac{1}{EXP}$	EP	EXHP
x_4	$\frac{1}{SP}$	$\frac{1}{EXHP}$	$\frac{1}{EXHP}$	EP

TABLE IX SINGLE VALUED DECISION MATRIX

	x_1	x_2	x_3	x_4
x_1	0.50	0.6	0.58	0.6
x_2	1.67	0.50	0.66	0.65
x_3	1.72	1.52	0.50	0.65
x_4	1.67	1.54	1.54	0.50

TABLE X WEIGHTAGE OF CONSTRAINTS

x_1	x_2	x_3	x_4
(0.60,0.35,0.40)	(0.90,0.10,0.10)	(0.75,0.20,0.20)	(0.90,0.10,0.10)

TABLE XI NEUTROSOPHIC SET TO DEFUZZIFIED WEIGHTAGE OF CONSTRAINTS VALUES

x_1	x_2	x_3	x_4
0.53	0.65	0.6	0.65

Objective function and subject to the constraints of the problem is as follows

$$Max\ Z_{a_1} = 0.6x_1 + 0.5x_2 + 0.66x_3 + 0.55x_4$$

$$Max\ Z_{a_2} = 0.65x_1 + 0.65x_2 + 0.66x_3 + 0.66x_4$$

$$Max\ Z_{a_3} = 0.58x_1 + 0.5x_2 + 0.66x_3 + 0.53x_4$$

Subject to the constraints

$$0.50x_1 + 0.6x_2 + 0.58x_3 + 0.6x_4 \leq 0.53$$

$$1.67x_1 + 0.50x_2 + 0.66x_3 + 0.65x_4 \geq 0.65$$

$$1.72x_1 + 1.52x_2 + 0.50x_3 + 0.65x_4 \geq 0.6$$

$$1.67x_1 + 1.54x_2 + 1.54x_3 + 0.50x_4 \geq 0.65$$

To apply Integer Linear Programming method, the following 4 constraints have to be added to the LP model.

$$x_1 \leq 1; x_2 \leq 1; x_3 \leq 1\ and\ x_4 \leq 1$$

$$Max\ Z = 0.6\,x_1 + 0.5\,x_2 + 0.66\,x_3 + 0.55\,x_4$$

$$Subject\ to$$

$$\begin{aligned}
&0.5\,x_1 + 0.6\ x_2 + 0.58\ x_3 + 0.6\ x_4 \leq 0.53 \\
&1.67\ x_1 + 0.5\ x_2 + 0.66\ x_3 + 0.65\ x_4 \geq 0.65 \\
&1.72\,x_1 + 1.52\ x_2 + 0.5\ x_3 + 0.65\ x_4 \geq 0.6 \\
&1.67\ x_1 + 1.54\ x_2 + 1.54\ x_3 + 0.5\ x_4 \geq 0.65 \\
&x_1 \leq 1;\ x_2 \leq 1;\ x_3 \leq 1;\ x_4 \leq 1 \\
&and\ x_1, x_2, x_3, x_4 \geq 0
\end{aligned}$$

The problem is converted to canonical form by adding slack, surplus and artificial variables as appropriate.
After introducing slack, surplus, artificial variables

$Max\ Z = 0.6\,x1 + 0.5\,x2 + 0.66\,x3 + 0.55\,x4$ + 0 S_1+ 0 S_2+ 0 S_3+ 0 S_4+ 0 S_5 + 0S_6 + 0 S_7+ 0 S_8- M A_1- M A_2- M A_3

$Subject\ to$

$$\begin{aligned}
&0.5\,x_1 + 0.6\ x_2 + 0.58\ x_3 + 0.6\ x_4 + S_1 = 0.53 \\
&1.67\ x_1 + 0.5\ x_2 + 0.66\ x_3 + 0.65\ x_4 - S_2 + A_1 = 0.65 \\
&1.72\,x_1 + 1.52\ x_2 + 0.5\ x_3 + 0.65\ x_4 - S_3 + A_2 = 0.6 \\
&1.67\ x_1 + 1.54\ x_2 + 1.54\ x_3 + 0.5\ x_4 - S_4 + A_3 = 0.65 \\
&x_1 + S_5 = 1 \\
&x_2 + S_6 = 1 \\
&x_3 + S_7 = 1 \\
&x_4 + S_8 = 1
\end{aligned}$$

$and\ \ x_1,\ x_2,\ x_3,\ x_4, S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, A_1, A_2, A_3 \geq 0.$

Solving this, we get an optimal solution (when $Z_j - C_j \geq 0$) with value of variables as

$$x_1 = 1, x_2 = 0, x_3 = 0.0517, x_4 = 0$$

and $$Max\ Z_{a_1} = 0.63\ , Max\ Z_{a_2} = 0.68, Max\ Z_{a_3} = 0.61$$

6. Result and Discussions

In coherence with the optimal solution and survey-based understanding for the patience of different age group, maternal experience and child birth count, it clearly shows that the regional anaesthesia is the best choice of C-section patients. Harmlessness of both the mother and baby is the first thing we need to concentrate. Considering the welfare and safety, we analysed and provided a best exceptional solution for them.

Every woman, who is approaching labour will undergo multiple thinking psychologically, so a conceived mother should not hesitate to enquire regarding the type of pain relief with their gynaecologist. With this, she could take a right decision for painless labour. By spinal block anaesthesia, we can successfully have a C-section without pain in a reasonable cost and live a happy life with her baby and beloved one.

7. CONCLUSION

In the concluding note, MOILPP in Neutrosophic fuzzy set is helped to solve a situation based decision making problem. This modified approach provides us a more effective and practical way to deal a real life decision making and problems.

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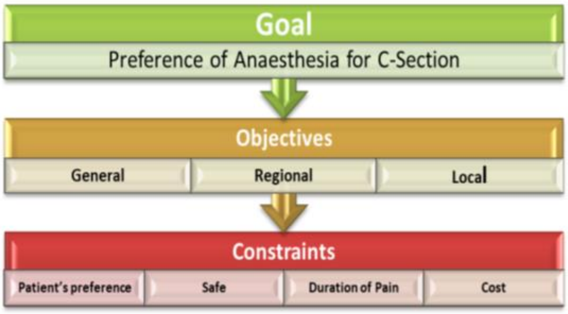

Fig. 1. Hierarchical Structure of a Defined Problem

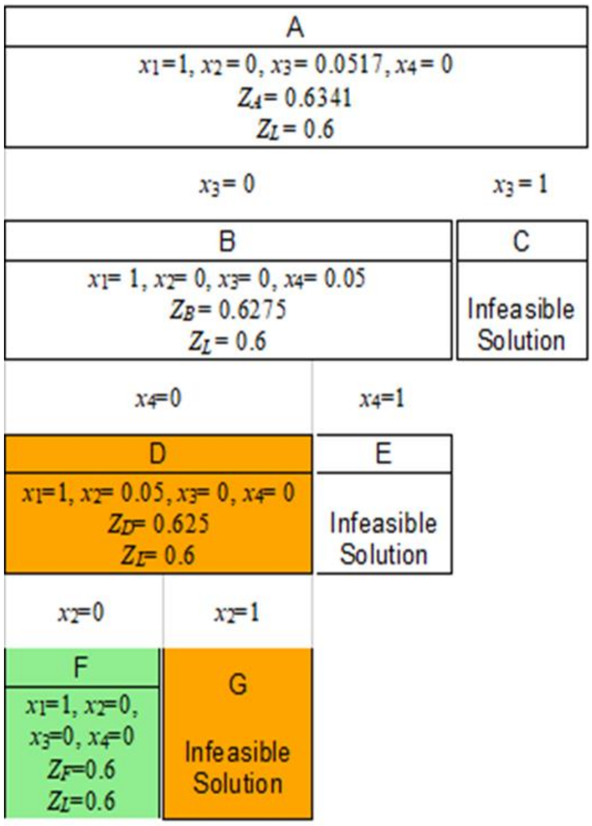

Fig. 2. The Branch and Bound Diagram

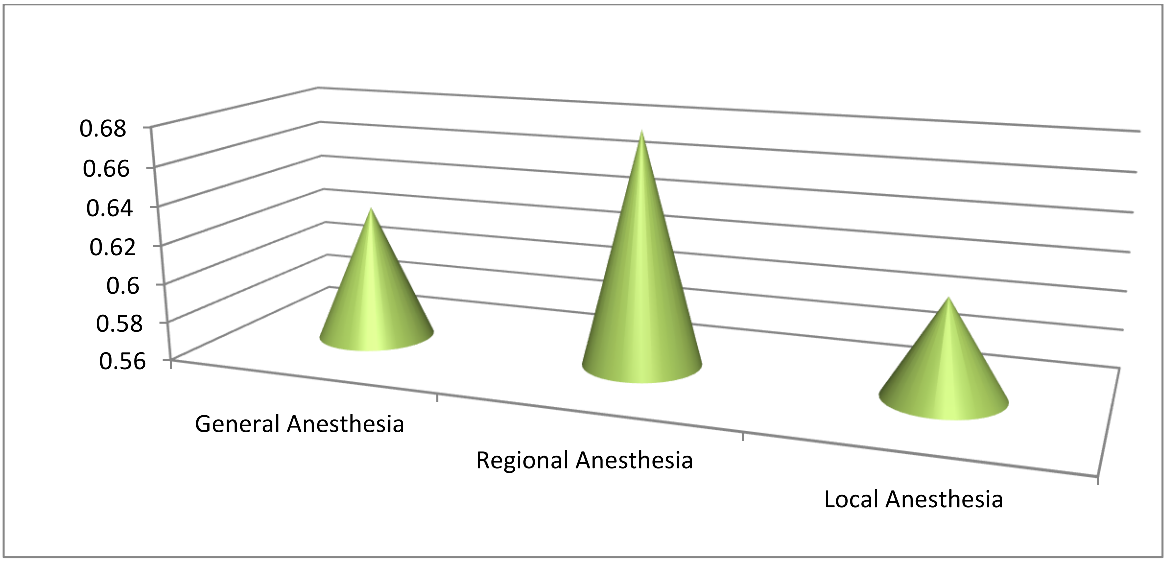

Fig. 3. Optimal Solutions of Objectives