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Enhancement Technique For An Unbalanced Assignment Problem In An Intuitionistic Fuzzy Domain

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Abstract

This paper presents an ideal answer for an unbalanced assignment issue in an Intuitionistic fuzzy domain in which expenses are communicated by nanogonal intuitionistic fuzzy number. In this, a new positioning capacity used to transform the nanogonal intuitionistic fuzzy number into a crisp number and further proposed technique to be applied for tracking down ideal arrangement. This technique has been utilized distinctly for unequal task issue without presenting a spurious line (or) column. At long last mathematical examples have been talked about.

Keywords: Unbalanced assignment problem, Nanogonal intuitionistic fuzzy number, Enhancement Technique, Row penalty, column penalty

1. Introduction

Operations Research (OR) is an analytical method of problem solving and decision making which is useful in the management of organizations. In OR linear programming is a method to attain the best consequence in a mathematical model whose specifications are represented by linear relationships. Transportation problem is a special type of linear programming problem. Assignment problem is a subclass of transportation problem, in that jobs are assigning to the workers with the one to one correspondence and the objective is to assign all tasks such that the total assignment cost is minimized. Fuzzy concepts are nowadays used in all fields, which was introduced by Lotfi Zadeh for solving imprecision vagueness problems. Fuzzy sets are sets whose elements have degrees of membership grades. Intuitionistic fuzzy sets was introduced by Krassimir Atanassov which is as an extension of fuzzy set, whose elements have degrees of membership and non-membership grades. A fuzzy number is a generalization of a real number such that it does not refer to one single value but prefer to connected set of possible values. Fuzzy numbers are mainly used for representing the batch of requirements.

Many researchers have been working in the area of intuitionistic fuzzy numbers from the last century. Optimization of an intuitionistic fuzzy environment was proposed by Angelov. PP [1]. The concept of intuitionistic fuzzy set and various properties were explained by Atanassov. K [2, 3]. Then he was extended intuitionistic fuzzy set with new objects and graphical interpretation [4]. The Total opportunity cost method in transportation problem was explained by Azad S.M.A.K,Hossain.Md.B and Rahman Md.M[5]. Diagonal optimal algorithm was used to find optimal solution for fuzzy assignment problem with hexagonal fuzzy numbers. This method was proposed by Dhanasekar. S, Kanimozhi. G and Manivannan. A [6]. Diagonal optimal algorithm to solve an intuitionistic fuzzy assignment problem was proposed by Dhanasekar. S, Manivannan. A and Parthiban. V [7] . Optimum solution of fuzzy assignment problem by using fourier elimination method was introduced by Gurukumaresan. D,Duraisamy. C ,Srinivasan. R and Vijayan. V [8]. Optimal solution of an unbalanced assignment problem by using improved method under fuzzy environment was introduced by Jayaraja. A , Venkatachalapathy. M and Nagarajan. P [9]. Hungarian method which was proposed by Kuhn [10] is mainly used to find the optimal solution to an assignment problem. Unbalanced intuitionistic fuzzy transportation problem with LR flat intuitionistic fuzzy numbers were solved by Narayanamoorthy. S and Ranjitha. S [11]. Finding the optimal solution of the transportation problem by using nanogonal intuitionistic fuzzy number was explained by Santhi. R and Kungumaraj. E [12]. Using penalty method with the graded mean integration used to defuzzification, this method proposed by Samuel. A and Raja. P [13]. A simple method was proposed to find the optimal solution for an unbalanced assignment problem under intuitionistic fuzzy environment by Senthil Kumar. P and Jahir Hussian. R [14]. Optimal solution of an unbalanced assignment problem by using row penalty/column penalty assignment method with triangular fuzzy number was proposed by Venkatachalapathy. M, Nagarajan. P, and Jayaraja. A [15].

Intuitionistic fuzzy set is the generalization of fuzzy set theory which was explained by Zadeh [16].

In this paper, new positioning strategy used to change over nanogonal intuitionistic fuzzy number into a crisp number. In section 1 Introduction and in area 2 a few starters are assessed. In segment 3 calculations for proposed technique has been given. In area 4 mathematical examples have been delineated. In area 5, conclusion has been given.

2 Preliminaries

2.1.Fuzzy set

If X is an universe of discourse and x is a particular element of X, then a fuzzy set A defined on X and can be written as a collection of ordered pairs A = {(x, $\mu_{\bar{A}}(x)$), $x \in X$ }

Where $\mu_{\bar{A}}(x)$ is called the membership function which maps each element of X to a value between 0 and 1.

2.2. Intuitionistic Fuzzy Set

Let X be a non empty set. An intuitionistic fuzzy set I^i of X is defined as

$$I^i = \{(x, \mu_{I^i}(x))(x, \nu_{I^i}(x)); x \in X\}$$

Where the function $\mu_{I^i}(x): X \to [0,1]$ and $\nu_{I^i}(x): X \to [0,1]$ define the degree of membership and the degree of non-membership functions $x \in X$ and $0 \le \mu_{I^i}(x), \nu_{I^i}(x) \le 1, \forall x \in X$

2.3.Intuitionistic Fuzzy Numbers

A subset of intuitionistic fuzzy set $I^i = \{(x, \mu_{I^i}(x), \nu_{I^i}(x): x \in X)\}$ of the real line R is called an intuitionistic fuzzy number if the following conditions hold.

(i) $\exists a \in R$, $\mu_{I^i}(a) = 1$ and $\nu_{I^i}(a) = 0$

(ii) $\mu_{I^i}(x): R \to [0,1]$ is continuous and for every $0 \le \mu_{I^i}(x), \nu_{I^i}(x) \le 1$ holds.

The membership and non-membership function of I^i is defined as follows :

$$\mu_{I^i}(x) = \begin{cases} p_1(x), & x \in [a-\gamma, a] \\ 1, & x = a \\ q_1(x), & x \in (a, a+\delta_1] \\ 0, & otherwise \end{cases}$$

$$\nu_{I^i}(x) = \begin{cases} 1, & x \in (-\infty, a-\gamma_2) \\ p_2(x), & x \in (a-\gamma_2, a) \\ 0, & x = a, x \in [a+\gamma_2, \infty] \\ q_2(x), & x \in (a, a+\gamma_2] \end{cases}$$

Where $p_i(x)$ and $q_i(x)$; $i = 1,2$ which are strictly increasing and decreasing functions in $[a-\gamma_i, a)$ and $(a, a+\delta_i]$ respectively. γ_i and δ_i are the left and right spreads of μ_{I^i} and ν_{I^i}.

2.4 Nanogonal Intuitionistic Fuzzy Numbers

An Intuitionistic fuzzy number A^i in R is said to be a Nanogonal Intuitionistic Fuzzy Number, if its membership function $\mu_{A^i}(x): R \to [0,1]$ and non-membership function $\nu_{A^i}(x): R \to [0,1]$ has the following characteristics.

We denote the Nanogonal Intuitionistic Fuzzy Number as follows,

$A^i = (n_1, n_2, ..n_9, n_1', n_2', ..n_9')$ 1

Where $n_1, n_2, .. n_9$, $n_1^{'}, n_2^{'}, .. n_9^{'}$ are real numbers.

$$\mu_{A^i}(x) = \begin{cases} \frac{1}{4}\left(\frac{x-n_1}{n_2-n_1}\right), & n_1 \le x \le n_2 \\ \frac{1}{4}+\frac{1}{4}\left(\frac{x-n_2}{n_3-n_2}\right), & n_2 \le x \le n_3 \\ \frac{1}{2}+\frac{1}{4}\left(\frac{x-n_3}{n_4-n_3}\right), & n_3 \le x \le n_4 \\ \frac{3}{4}+\frac{1}{4}\left(\frac{x-n_4}{n_5-n_4}\right), & n_4 \le x \le n_5 \\ 1-\frac{1}{4}\left(\frac{x-n_5}{n_6-n_5}\right), & n_5 \le x \le n_6 \\ \frac{3}{4}-\frac{1}{4}\left(\frac{x-n_6}{n_7-n_6}\right), & n_6 \le x \le n_7 \\ \frac{1}{2}-\frac{1}{4}\left(\frac{x-n_7}{n_8-n_7}\right), & n_7 \le x \le n_8 \\ \frac{1}{4}\left(\frac{n_9-x}{n_9-n_8}\right), & n_8 \le x \le n_9 \\ 0, & otherwise \end{cases}$$

$$\nu_{A^i}(x) = \begin{cases} 1-\frac{1}{4}\left(\frac{n_2^1-x}{n_2^{'}-n_1^{'}}\right), & n_1^{'} \le x \le n_2^{'} \\ \frac{3}{4}-\frac{1}{4}\left(\frac{n_3^1-x}{n_3^{'}-n_2^{'}}\right), & n_2^{'} \le x \le n_3^{'} \\ \frac{1}{2}-\frac{1}{4}\left(\frac{n_4^1-x}{n_4^{'}-n_3^{'}}\right), & n_3^{'} \le x \le n_4^{'} \\ \frac{1}{4}\left(\frac{n_5^1-x}{n_5^{'}-n_4^{'}}\right), & n_4^{'} \le x \le n_5^{'} \\ \frac{1}{4}\left(\frac{n_6^1-x}{n_6^{'}-n_5^{'}}\right), & n_5^{'} \le x \le n_6^{'} \\ \frac{1}{4}+\frac{1}{4}\left(\frac{n_7^1-x}{n_7^{'}-n_6^{'}}\right), & n_6^{'} \le x \le n_7^{'} \\ \frac{1}{2}+\frac{1}{4}\left(\frac{n_8^1-x}{n_8^{'}-n_7^{'}}\right), & n_7^{'} \le x \le n_8^{'} \\ \frac{3}{4}+\frac{1}{4}\left(\frac{x-n_9^1}{n_9^{'}-n_8^{'}}\right), & n_8^{'} \le x \le n_9^{'} \\ 1, & otherrwise \end{cases}$$

2.5. Proposed Ranking for Nanogonal Intuitionistic Fuzzy Numbers

$A_N^i(x) = (n_1, n_2, .. n_9; n_1', n_2' .. n_9')$ is defined as,

$$R(A_1(x)) = Max(R(\mu_A(x)), R(\nu_A(x)))$$

Where,

$$R(\mu_A(x) = \int_0^1 4(\alpha)[\alpha(n_3 - n_1) + n_2 - \alpha(n_6 - n_4) + n_5 + \alpha(n_9 - n_7) + n_8]d\alpha \quad \text{and}$$

$$R(\nu_A(x) = \int_0^1 4(\alpha)[\alpha(n_3' - n_1') + n_2' - \alpha(n_6' - n_4') + n_5' + \alpha(n_9' - n_7') + n_8']d\alpha$$

2.6. Intuitionistic Fuzzy Assignment Problem

Consider the situation of assigning 'n' machines to 'n' jobs and each machine is capable of doing any job at different costs. Let $C_{ij}\tilde{I}$ be an intuitionistic fuzzy cost of assigning the j^{th} job to the i^{th} machine. Let X_{ij} be the decision variable denoting the assignment of the machine i to the job j. The objective is to minimize the total intuitionistic fuzzy cost of assigning all the jobs to the available machines (one machine per job) at the least total cost. In this situation number of rows not equal to number of columns then the problem is called unbalanced assignment problem.

The objective function is to,

$$Minimize \;\; Z^{\wedge}\tilde{I} = \sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij}\tilde{I}X_{ij}$$

$$Subject \;\; to \;\; \sum_{j=1}^{n} x_{ij} = 1 \text{ for } i = 1,2..n$$

$$\sum_{i=1}^{n} x_{ij} = 1 \text{ for } j = 1,2..n$$

$$x_{ij} = 0 \text{ or } 1$$

3 Proposed Method – Algorithm

The new technique is proposed to tackle Unbalanced Intuitionistic Fuzzy Assignment Problem. In this new strategy we consider the assignment costs are Nanogonal Intuitionistic Fuzzy Number. This technique is pertinent just for Unbalanced Assignment Problem.

Stage 1

Outline the assignment cost table from the given issue .

Stage 2

Check the given problem is balanced (or) unbalanced. If the problem is unbalanced goto step 3.In the event that the issue is balanced, and then this strategy isn't reasonable.

Stage 3

By utilizing the proposed ranking technique , convert the given Nanogonal Intuitionistic Fuzzy number into the crisp value. In that crisp value, choose the maximum value, which gives the new tabular values.

Stage 4

In the new table , determine row/column penalty. (ie) Subtract minimum cost with next minimum cost in row/column and write it in adjacent side/bottom of the table.

Stage 5

From the penalty value, choose the maximum penalty row/column and allocate the minimum assignment cost and cross out it.

Stage 6

If there is a tie then , choose the maximum value which always leads to the minimum value. If there is tie again then select the best one among that.

Stage 7

Rehash stage 4 and 5 until the ideal arrangement is achieved.

4 Numerical Example

4.1. Row Penalty Allocation Technique

Consider the following unbalanced assignment problem. Find the optimal solution.

TABLE-I

	$W1$	$W2$	$W3$	$W4$
$F1$	(2,3,4,5,6,7,8,9,10) (0,1,2,5,7,9,11,13,14)	(1,3,5,7,9,11,13,15,17) (5,7,9,11,1,15,17,19,21)	(2,4,6,8,10,12,14,16,18) (1,4,7,10,13,16,19,21,24)	(0,3,6,9,12,15,18,21,24) (2,3,4,7,8,10,12,14,16)
$F2$	(2,4,5,6,8,10,11,13,14) (3,5,8,9,10,13,14,15,17)	(4,6,9,13,14,17,19,20,22) (5,7,9,11,12,13,15,17,19)	(1,5,9,11,12,14,17,20,21) (4,7,9,15,19,20,22,24,25)	(3,7,9,11,16,17,20,22,24) (6,7,8,10,11,12,15,19,20)
$F3$	(7,8,9,12,14,16,20,22,24) (9,10,11,13,15,17,19,21,23)	(5,8,10,13,17,18,21,24,27) (6,9,12,15,17,19,22,24,26)	(8,10,12,15,17,19,23,25,27) (10,11,13,15,16,17,18,19,20)	(1,4,7,10,15,17,20,24,27) (3,5,7,10,13,16,21,24,29)

Solution

The given problem is unbalanced fuzzy assignment problem. By applying proposed ranking method, for a_{11} cell,

(2, 3, 4, 5, 6, 7, 8, 9, 10)

$$= \int_0^1 4(\alpha)[\alpha(n_3 - n_1) + n_2 - \alpha(n_6 - n_4) + n_5 + \alpha(n_9 - n_7) + n_8]d\alpha$$

$$= \int_0^1 4(\alpha)[\alpha(4-2) + 3 - \alpha(7-5) + 6 + \alpha(10-8) + 9]d\alpha$$

$$= 38$$

(0, 1, 2, 5, 7, 9, 11, 13, 14)

$$= \int_0^1 4(\alpha)[\alpha(2-0) + 1 - \alpha(9-5) + 7 + \alpha(14-11) + 13]d\alpha$$

$= 43$

Similarly apply the ranking method to all the cells we get the following table values,

TABLE-II

	W_1	W_2	W_3	W_4
F_1	$(38, 43)$	$(58, 82)$	$(64, 80)$	$(78, 53)$
F_2	$(52, 64)$	$(84, 78)$	$(83, 103)$	$(94, 79)$
F_3	$(90, 94)$	$(104, 106)$	$(108, 95)$	$(92, 90)$

Choose the maximum value, from the above table

TABLE - III

	W_1	W_2	W_3	W_4
F_1	43	82	80	78
F_2	64	84	103	94
F_3	94	106	108	92

Applying the proposed method, we get the following row penalty value.

TABLE - IV

	W_1	W_2	W_3	W_4	*RowPenalty*
F_1	43	82	80	78	35
F_2	64	84	103	94	20
F_3	94	106	108	92	02

From the above table maximum row penalty is 35. Here the minimum assignment cost from that corresponding row is 43. Allocate the assignment to that cell and then cross out first row and first column. Hence the remaining cost table values are as follows as.

TABLE - V

	W_2	W_3	W_4
F_2	84	103	94
F_3	106	108	92

Apply the same procedure we get the following table values

TABLE - VI

	W_2	W_3	W_4	*RowPenalty*
F_2	84	103	94	10
F_3	106	108	92	14

Here maximum row penalty value is 14 and the minimum assignment cost is 92. Hence allocate the assignment cost in $[F_3,W_4]$ and cross out the row and column, we get the following values.

TABLE - VII

	W_2	W_3
F_2	84	103

Again apply the procedure,

TABLE - VIII

	W_2	W_3	*RowPenalty*
F_2	84	103	19

Here allocation will be made to $[F_2,W_2]$ cell.

Hence the allocations are,

$F_1 \rightarrow W_1, F_2 \rightarrow W_2,\ F_3 \rightarrow W_4,\ F_4 \rightarrow$ No work

Minimum assignment cost = 43 + 84 + 92

= 219

4.2. Column Penalty Allocation Technique

Consider the following assignment cost table and find the minimum assignment cost.

TABLE - IX

	$M1$	$M2$	$M3$	$M4$
$J1$	(0,4,8,12,16,20,24,28,32) (3,4,7,9,11,13,17,19,21)	(4,6,8,10,12,14,16,18, 20) (5,9,11,13,17,19,21,25, 27)	(2,7,8,12,14,16, 20,21,22) (6,8,12,15,17,20, 23,25,27)	(7,9,10,13,14,15,17,19,20) (8,10,12,17,20,21, 24,27,30)
$J2$	(1,2,3,4,5,6,7,8,9) (0,1,2,3,4,5,6,7,8)	(2,4,6,9,10,11,14,15,16) (3,5,7,9,11,13,15,17,19)	(4,7,9,10,12,14, 17,18,19) (5,8,13,15,16,20, 21,2,25)	(,6,9,12,15,18,21, 24,27) (4,8,12,16,20,24,28,32,36)
$J3$	(2,4,8,10,12,14,16,18,20) (1,3,5,7,9,11,13,15,17)	(8,9,10,12,14,16,21,23,25) (6,7,8,10,11,12,15,16,17)	(4,6,8,16,18,20,22,24,26) (5,7,9,17,19,21,23,25,27)	(9,12,14,18,21,25, 31,33,35) (8,16,24,26,28,30, 32,34,36)
$J4$	(1,5,10,15,20,25,30,35, 40) (6,12,18,24,30,36,42,48, 54)	(2,6,7,8,10,15,16,18, 20) (4,8,10,14,18,20,22, 24,26)	(3,5,7,9,133,15,20,22,27) (7,10,13,16,19, 22,25,28,31)	(1,2,3,6,12,17,20, 24,28) (3,7,9,13,17,20, 23,25,27)
$J5$	(0,8,16,20,28,30,32,4,36) (1,7,14,17,20,23,25, 27,30)	(1,4,5,7,8,9,13,14,15) (3,5,9,12,19,20,23, 27,30)	(2,6,8,12,16,20,24,28,32) (4,7,9,11,13,17, 19,22,27)	(5,9,13,17,21,23,27,31,33) (9,13,15,19,24,25, 29,32,35)

Solution

The given problem is unbalanced fuzzy assignment problem. By applying proposed ranking method, we get the following crisp table.

TABLE- X

	M_1	M_2	M_3	M_4
J_1	104	108	105	120
J_2	32	68	101	128
J_3	74	94	106	162
J_4	192	104	120	101
J_5	150	107	106	144

Choose the maximum value, from the above table

TABLE - XI

	M_1	M_2	M_3	M_4
J_1	104	108	105	120
J_2	32	68	101	128
J_3	74	94	106	162
J_4	192	104	120	101
J_5	150	107	106	144
Columnpenalty	42	26	4	19

Applying the proposed method, we get the following column penalty value

TABLE - XII

	M_2	M_3	M_4
J_1	108	105	120
J_3	94	106	162
J_4	104	120	101
J_5	107	106	144
columnpenalty	10	1	19

From the above table maximum column penalty is 42. Here the minimum assignment cost from that corresponding row is 32. Allocate the assignment to that cell and then cross out second row and first column and repeat the same procedure.

TABLE - XIII

	M_1	M_2	M_3	M_4
J_1	(104, 72)	(76, 108)	(88, 105)	(88, 120)
J_2	(32, 26)	(33, 68)	(57, 101)	(96, 128)
J_3	(74, 58)	(94, 70)	(100, 106)	(134, 162)
J_4	(129, 192)	(70, 104)	(85, 120)	(75, 101)
J_5	(150, 120)	(54, 107)	(106, 91)	(130, 144)

From the previous table allocation will be made to (M_4, J_4) cell and cross out the fourth column and fourth row. Repeat the process we get the following allocations.

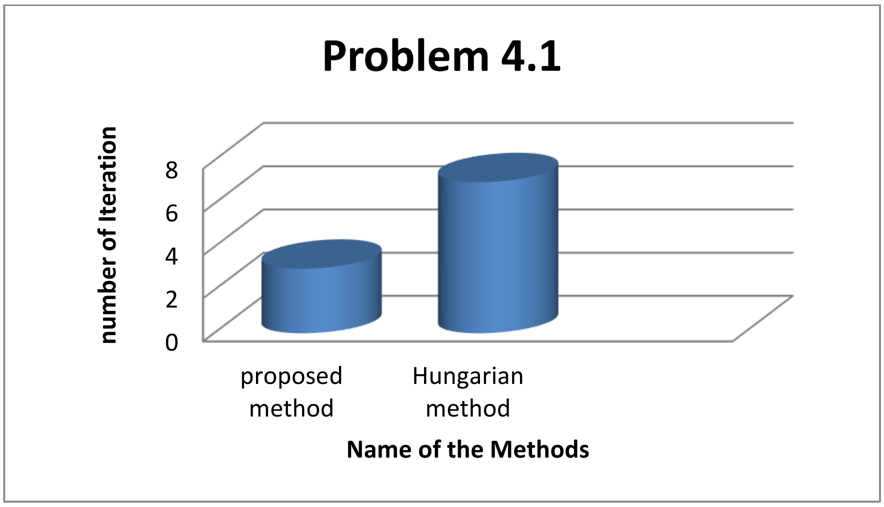
$M_1 \rightarrow J_2\ ,M_2 \rightarrow J_3\ ,M_3 \rightarrow J_1\ ,M_4 \rightarrow J_4\ ,J_5 \rightarrow Nojob$

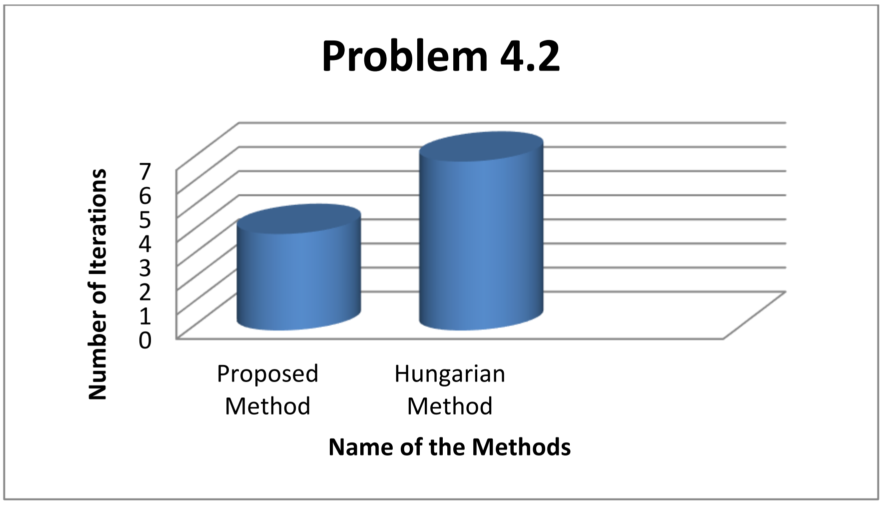
Minimum assignment cost = 32 + 94 + 105 + 101

= 332

4.3. Results

Numerical Examples	Proposed Method	Hungarian Method [9]	ATOC Method [16]
4.1	219	219	250
4.2	332	332	332





From the above result, we get the equal best answer in each the hungarian approach and proposed approach. But there are moderate versions in ATOC approach. Hence in place of Hungarian approach, we will use this proposed approach for fixing unbalanced mission problem. The wide variety of generation taken on this proposed approach could be very lesser than Hungarian approach.

From the graphical representation, number of iterations taken in the proposed system is veritably lower than the Hungarian system. Hence rather of Hungarian system we c an use our proposed method for unbalanced assignment problem.

5 Conclusion

In this paper, the unequal task issue is viewed as an erroneous numeral qualities portrayed by Nanogonal Intuitionistic Fuzzy Number. We had outlined Row penalty allocation strategy and column penalty allocation technique without presenting faker column (or) sham segment. The proposed technique gives the ideal outcome with the least number of cycles and without complexity. This technique is straight forward and simple to continue, which are comes into reasonable life circumstances.

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