

A Comparative Study on Human Values Induced by the Five Elements of Nature Using Intuitionistic Fuzzy Relational Maps

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Abstract

In this paper, an exploration is performed on the fuzzy relational maps by applying the intuitionistic fuzzy sets to it. Firstly the Fuzzy relational maps are applied to study the importance of human values induced by the five elements of nature. Later, an analysis is made by adapting the intuitionistic fuzzy relational maps to the problem of study. A comparison is drawn as to which fuzzy model gives a better solution.

Keywords: Fuzzy Relational Maps, Intuitionistic fuzzy relational maps, hesitation degree, membership degree, non-membership degree

1. INTRODUCTION:

The Fuzzy sets were introduced by L.A.Zadeh in the year 1965 to deal with imprecise and vague information. This fuzzy set has several applications. Several extensions were also proposed by different scientists. One such extension of the fuzzy set theory is the Intuitionistic Fuzzy Sets, proposed by Atanassov in the year 1983. The main advantage of the Intuitionistic fuzzy sets is that they have the characteristic of coping with the hesitancy that may exist due to information imprecision ^[15]. Thus it is an advantage to apply them in the problem of study in order to get better solutions. Thus

in this paper the intuitionistic fuzzy sets are combined with the Fuzzy Relational Maps to make an analysis. Fuzzy Relational Maps are constructed corresponding to Fuzzy Cognitive Maps, which promote the correlation between causal associations among concurrently active units. But in FRM the causal associations are divided into two disjoint units, namely the domain space and the range space i.e., relation between music and emotions or relation between disease and risk factors. The Fuzzy Relational Maps were introduced by W.B.Vasantha Kandasamy and Yasmin Sultana to analyze knowledge processing in the year 2000^[6].

2. INTUITIONISTIC FUZZY RELATIONAL MAPS:

Definition 2.1

If X is a collection of objects denoted generically by x then a fuzzy set A in X is a set of ordered pairs $A = \{(x, \mu_A(x)) / x \in X\}$ where $\mu_A(x)$ is called membership function or grade of membership of x in A .^[13]

Definition 2.2

The Atanassov intuitionistic fuzzy set (A-IFS) for A is given by $A = \{(x, \mu_A(x), \nu_A(x)) / x \in X\}$ where $\mu_A(x): X \rightarrow [0,1]$ and $\nu_A(x): X \rightarrow [0,1]$ such that $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ and $\mu_A(x), \nu_A(x) \in [0,1]$ denote a degree of membership and a degree of non-membership of $x \in A$, respectively^[13].

Definition 2.3

The hesitation margin of an intuitionistic fuzzy index of $x \in A$, is given by $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$ clearly $0 \leq \pi_A(x) \leq 1$ for each $x \in X$, on other hand it is defined as a triplet containing $A = \{(x, \mu_A(x), \nu_A(x), \pi_A(x)) / x \in X\}$ as membership, non-membership and hesitation degree^[13].

2.4 Methods of determining the hidden pattern:

Step-1: Let $R_1, R_2 \dots R_m$ and $D_1, D_2 \dots D_n$ be the nodes of a FRM with feedback.

Step-2: Let M be the relational matrix formulated according to the experts' opinion using the intuitionistic fuzzy sets.

Step-3: Calculate the distance between two intuitionistic fuzzy sets using the

normalized Euclidean distance formula given by $q(A, B) = \sqrt{\frac{1}{n} \sum_{i=1}^n (\mu_A(x_i) - \mu_B(x_i))^2}$.^[12]

Step-4: Let's find the hidden pattern when D_1 is switched on i.e. when an input is given as $A_1 = (1, 0 \dots 0)$ in D_1 , the data should pass through the relational matrix. This is done by multiplying A_1 with the relational matrix M .

Step-5: Let $A_1 M = (r_1, r_2 \dots r_m)$ be considered.

Step-6: After thresholding and updating, $A_1 M \in R$ is the resultant vector obtained.

Step-7: Now let $B = A_1 M$.

Step-8: Pass on B into M^T and obtain BM^T .

Step-9: The vector BM^T is updated and threshold so that $BM^T \in D$. This procedure is repeated till a limit cycle or a fixed point is obtained.

3. DESCRIPTION OF THE PROBLEM:

One among Gods beautiful creation is the nature that a person lives in. This nature teaches one how to live one's life in a disciplined manner. Nature follows certain values and it comprises of different values. Every individual has to learn the art of discipline and values from this nature. The nature is basically made up of the pancha boothangal that is the five elements of nature. They are water, air, earth, fire and space. Each of these five elements possesses certain qualities which induces certain human values.^[11]

Holmes Rolston in his paper "Human Values and Natural Systems" says that, "the natural symbols - light and fire, water or rock, morning and evening, the warmth of summer and the cold of winter, the flowers of spring and the fruits of fall, rain and rivers, seeds and growth, earth and sky. How readily we put these material phenomena to "metaphorical" or "spiritual" use, when we speak of life's "stormy weather," of strength of character "like a rock," or insecurity "like a shifting sand," of the "dark cloud with the silver lining." How profound are the psychological forces stirred within us the gray and misty sky, the balmy spring day, the quiet of a snowfall, the calling of loons. How the height of mountains "elevates" us, and the depths of the sea stimulates "deep" thoughts within!"^[2] Thus values are present in the nature that one lives in. The aim of this paper is to quantify the human values induced by the five elements of nature according to the subjective opinions of the expert's. And the fuzzy logic can be adapted to this problem of study as the uncertainty here lies in the impreciseness of accepting the values that the nature teaches a person.

4. ADAPTATION OF THE FUZZY MODEL TO THE PROBLEM OF STUDY:

4.1 Attributes Related To Human Values

The range space R connected with the attributes of the human values taken from the paper “Human values and natural systems” by Holmes Rolston is given by $R = \{R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8\}$

R₁- Humility

R₂- Simplicity

R₃- Frugality

R₄- Serenity

R₅- Independence

R₆- Self Identity

R₇- Self Actualization

R₈- Unity

4.2 Attributes Related With Nature

The domain space D connected with the attributes of the five elements of nature is given by $D = \{D_1, D_2, D_3, D_4, D_5\}$

D₁- Water

D₂- Air

D₃- Earth

D₄- Fire

D₅- Space

On the basis of the subjective opinion by the expert's, the following relational matrix is formulated by considering the domain space D₁, D₂, D₃, D₄ and D₅ connected with the attributes of the five elements of nature and the range space R₁, R₂, R₃, R₄, R₅, R₆, R₇ and R₈ connected with the attributes of the human values.

$$M = \begin{matrix} & R_1 & R_2 & R_3 & R_4 & R_5 & R_6 & R_7 & R_8 \\ \begin{matrix} D_1 \\ D_2 \\ D_3 \\ D_4 \\ D_5 \end{matrix} & \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \end{bmatrix} \end{matrix}$$

In order to find the hidden pattern the state vector $A = (1\ 0\ 0\ 0\ 0)$ is considered.

Now $AM = (1\ 0\ 0\ 0\ 0)M$

$= (1\ 1\ 0\ 1\ 0\ 0\ 0\ 0) = B$

Now $BM^T = (1\ 1\ 0\ 1\ 0\ 0\ 0\ 0) \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$

$= (3\ 3\ 0\ 0\ 0)$

$\hookrightarrow (1\ 1\ 0\ 0\ 0) = A_I$

$A_I M = (1\ 1\ 0\ 0\ 0)M$

$= (2\ 2\ 1\ 2\ 0\ 0\ 0\ 0)$

$\hookrightarrow (1\ 1\ 1\ 1\ 0\ 0\ 0\ 0) = B_I$

$B_I M^T = (1\ 1\ 1\ 1\ 0\ 0\ 0\ 0)M^T$

$= (3\ 4\ 0\ 0\ 0)$

$\hookrightarrow (1\ 1\ 0\ 0\ 0) = A_2 = A_I$

Let us consider the case in which the state vector is $A = (0\ 0\ 0\ 0\ 1)$.

$$\text{Now } AM = (0\ 0\ 0\ 0\ 1) \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

$$=(0\ 0\ 0\ 0\ 1\ 0\ 0\ 1)=B$$

$$\text{Now } BM^T = (0\ 0\ 0\ 0\ 1\ 0\ 0\ 1) \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$=(0\ 0\ 1\ 0\ 2)$$

$$\hookrightarrow (0\ 0\ 1\ 0\ 1)=A_I$$

$$A_I M = (0\ 0\ 1\ 0\ 1) \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

$$=(0\ 0\ 0\ 0\ 2\ 0\ 0\ 1)$$

$$\hookrightarrow (0\ 0\ 0\ 0\ 1\ 0\ 0\ 1)=B_I$$

$$B_I M^T = (0\ 0\ 0\ 0\ 1001) \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$=(0\ 0\ 1\ 0\ 2)$$

$$\hookrightarrow (0\ 0\ 1\ 0\ 1) = A_2 = A_I$$

Further the problem of study is analysed using the Intuitionistic fuzzy relational maps. The relational matrices using the intuitionistic fuzzy sets are obtained as follows according to two different experts' opinion. Each entry in the matrix is a triplet consisting of the membership function, non membership function and the hesitation function.

$$M_A = \begin{bmatrix} (0.6,0.3,0.1) & (0.5,0.3,0.2) & (0.4,0.4,0.2) & (0.7,0.3,0) & (0.8,0.2,0) & (0.9,0.1,0) & (0.8,0.1,0.1) & (0.9,0.1,0) \\ (0.5,0.4,0.1) & (0.6,0.3,0.1) & (0.7,0.2,0.1) & (0.7,0.3,0) & (0.9,0.1,0) & (0.8,0.2,0) & (0.7,0.2,0.1) & (0.8,0.2,0) \\ (0.5,0.4,0.1) & (0.8,0.2,0) & (0.7,0.2,0.1) & (0.6,0.3,0.1) & (0.8,0.1,0.1) & (0.7,0.2,0.1) & (0.6,0.3,0.1) & (0.8,0.2,0) \\ (0.5,0.3,0.2) & (0.6,0.3,0.1) & (0.7,0.2,0.1) & (0.5,0.2,0.3) & (0.9,0.1,0) & (0.8,0.2,0) & (0.7,0.3,0) & (0.6,0.3,0.1) \\ (0.7,0.2,0.1) & (0.6,0.3,0.1) & (0.5,0.3,0.2) & (0.6,0.2,0.2) & (0.6,0.3,0.1) & (0.7,0.1,0.2) & (0.6,0.3,0.1) & (0.8,0.2,0) \end{bmatrix}$$

$$M_B = \begin{bmatrix} (0.7,0.2,0.1) & (0.6,0.4,0) & (0.5,0.3,0.2) & (0.6,0.2,0.2) & (0.7,0.3,0) & (0.8,0.1,0.1) & (0.6,0.2,0.2) & (0.8,0.1,0.1) \\ (0.6,0.3,0.1) & (0.5,0.4,0.1) & (0.6,0.1,0.3) & (0.6,0.2,0.2) & (0.7,0.2,0.1) & (0.6,0.1,0.3) & (0.6,0.2,0.2) & (0.9,0.1,0) \\ (0.6,0.3,0.1) & (0.8,0.1,0.1) & (0.6,0.3,0.1) & (0.5,0.3,0.2) & (0.7,0.2,0.1) & (0.8,0.1,0.1) & (0.5,0.3,0.2) & (0.7,0.1,0.2) \\ (0.6,0.1,0.3) & (0.5,0.4,0.1) & (0.8,0.2,0) & (0.6,0.4,0) & (0.8,0.2,0) & (0.7,0.3,0) & (0.6,0.2,0.2) & (0.5,0.4,0.1) \\ (0.8,0.2,0) & (0.5,0.4,0.1) & (0.6,0.3,0.1) & (0.5,0.3,0.2) & (0.7,0.3,0) & (0.6,0.2,0.2) & (0.5,0.3,0.2) & (0.7,0.3,0) \end{bmatrix}$$

The distances for the intuitionistic fuzzy sets are calculated using the normalized

Euclidean distance formula $q(A, B) = \sqrt{\frac{1}{n} \sum_{i=1}^n (\mu_A(x_i) - \mu_B(x_i))^2}$. The distance for each entry

is calculated and given in the matrix below.

$$M = \begin{bmatrix} 0.0354 & 0.0612 & 0.0354 & 0.0612 & 0.0354 & 0.0354 & 0.0612 & 0.0354 \\ 0.0354 & 0.0354 & 0.0612 & 0.0612 & 0.0612 & 0.0935 & 0.0354 & 0.0354 \\ 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0612 \\ 0.0612 & 0.0354 & 0.0354 & 0.0935 & 0.0354 & 0.0354 & 0.0612 & 0.0354 \\ 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0354 & 0.0354 \end{bmatrix}$$

$$M^T = \begin{bmatrix} 0.0354 & 0.0354 & 0.0354 & 0.0612 & 0.0354 \\ 0.0612 & 0.0354 & 0.0354 & 0.0354 & 0.0354 \\ 0.0354 & 0.0612 & 0.0354 & 0.0354 & 0.0354 \\ 0.0612 & 0.0612 & 0.0354 & 0.0935 & 0.0354 \\ 0.0354 & 0.0612 & 0.0354 & 0.0354 & 0.0354 \\ 0.0354 & 0.0935 & 0.0354 & 0.0354 & 0.0354 \\ 0.0612 & 0.0354 & 0.0354 & 0.0612 & 0.0354 \\ 0.0354 & 0.0354 & 0.0612 & 0.0354 & 0.0354 \end{bmatrix}$$

Let us consider the initial state vector $A = (1, 0, 0, 0, 0)$. That is considering the attribute *water* to be in the *ON* position.

$$A.M = (0.0354, 0.0612, 0.0354, 0.0612, 0.0354, 0.0354, 0.0612, 0.0354)$$

$$\hookrightarrow (0, 1, 0, 1, 0, 0, 1, 0) = B$$

$$B.M^T = (0.1836, 0.132, 0.1062, 0.1901, 0.1062)$$

$$\hookrightarrow (0, 0, 0, 1, 0) = A_1$$

$$A_1.M = (0.0612, 0.0354, 0.0354, 0.0935, 0.0354, 0.0354, 0.0612, 0.0354)$$

$$\hookrightarrow (0, 0, 0, 1, 0, 0, 0, 0) = B_1$$

$$B_1.M^T = (0.0612, 0.0612, 0.0354, 0.0935, 0.0354)$$

$$\hookrightarrow (0, 0, 0, 1, 0) = A_2 = A_1$$

Let us consider the initial state vector $A = (0, 0, 0, 0, 1)$. That is considering the attribute *space* to be in the *ON* position.

$$A.M = (0.0354, 0.0354, 0.0354, 0.0354, 0.0354, 0.0354, 0.0354, 0.0354)$$

$$\hookrightarrow (1, 1, 1, 1, 1, 1, 1, 1) = B$$

$$B.M^T = (0.3606, 0.4187, 0.309, 0.3929, 0.2832)$$

$$\hookrightarrow (0, 1, 0, 0, 0) = A_1$$

$$A_1.M = (0.0354, 0.0354, 0.0612, 0.0612, 0.0612, 0.0935, 0.0354, 0.0354)$$

$$\hookrightarrow (0, 0, 0, 0, 0, 1, 0, 0) = B_1$$

$$B_1.M^T = (0.0354, 0.0935, 0.0354, 0.0354, 0.0354)$$

$$\hookrightarrow (0, 1, 0, 0, 0) = A_2 = A_1$$

The table given below shows the resulting binary pair for each node respectively.

Table 4.1 Resulting Binary Pairs

| State Vector | Binary Pairs (FRM) | Binary Pairs (IFRM) |
|-----------------|---|---|
| (1, 0, 0, 0, 0) | (1, 1, 0, 0, 0), (1, 1, 1, 1, 0, 0, 0, 0) | {(0, 0, 0, 1, 0), (0, 0, 0, 1, 0, 0, 0, 0)} |
| (0, 1, 0, 0, 0) | (1, 1, 0, 0, 0), (1, 1, 1, 1, 0, 0, 0, 0) | {(0, 1, 0, 0, 0), (0, 0, 0, 0, 0, 1, 0, 0)} |
| (0, 0, 1, 0, 0) | (0, 0, 1, 0, 1), (0, 0, 0, 0, 1, 0, 0, 1) | {(0, 0, 1, 0, 0), (0, 0, 0, 0, 0, 0, 0, 1)} |
| (0, 0, 0, 1, 0) | (0, 0, 0, 1, 0), (0, 0, 0, 0, 0, 1, 1, 0) | {(0, 0, 0, 1, 0), (0, 0, 0, 1, 0, 0, 0, 0)} |
| (0, 0, 0, 0, 1) | (0, 0, 1, 0, 1), (0, 0, 0, 0, 1, 0, 0, 1) | {(0, 1, 0, 0, 0), (0, 0, 0, 0, 0, 1, 0, 0)} |

5. CONCLUSION

Thus, it could be concluded that different solutions have been obtained by adapting FRM and IFRM to the problem of study. It could be very well noticed that when FRM was applied the human values that were induced by the five elements of nature were as follows. Humility, simplicity, frugality and serenity were induced by water and air; independence and unity were induced by earth and space; self-identity and self actualization by fire. On the other hand by adapting IFRM, the human values that are induced by the elements of nature are as follows. Water and fire induces serenity; air and space induces self identity; earth induces unity. Hence, according to this paper, the Intuitionistic Fuzzy Relational Maps provide a better unique solution as to which element induces which human value, as the membership, non membership and the hesitation values are taken into account.

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