A Ranking Analysis/An Interlinking Approach of New Triangular Fuzzy Cognitive Maps and Combined Effective Time Dependent Matrix

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Abstract. This paper aims an interlinking approach of new Triangular Fuzzy Cognitive Maps (TrFCM) and Combined Effective Time Dependent (CETD) matrix to find the ranking of the problems of Transgenders. Section one begins with an introduction that briefly describes the scope of Triangular Fuzzy Cognitive Maps (TrFCM) and CETD Matrix. Section two provides the process of causes of problems faced by Transgenders using Fuzzy Triangular Fuzzy Cognitive Maps (TrFCM) method and performs the calculations using the collected data among the Transgender. In Section 3, the reasons for the main causes for the problems of the Transgenders. Section 4 describes the Charles Spearman coefficients of rank correlation method by interlinking of Triangular Fuzzy Cognitive Maps (TrFCM) Method and CETD Matrix. Section 5 shows the results based on our study.

1. Basics of Triangular Fuzzy Cognitive Maps (TRFCM) and CETD Matrix

This chapter begins with an introduction that briefly describes the scope of Triangular fuzzy Cognitive Maps and CETD Matrix

1.1. Introduction of Triangular Fuzzy Cognitive Maps (TRFCM)

Triangular Fuzzy Cognitive Maps (TrFCM) are more applicable when the data in the first place is an unsupervised one. The TrFCM works on the opinion of three experts. TrFCM models the world as a collection of classes and causal relations between classes. It is a different process when we compare to FCM. Usually the FCM gives only the ON-OFF position. But this Triangular Fuzzy Cognitive Maps is more precise and it gives the ranking for the causes of the problem by using the weightage of the attribute. It is 48 main advantage of the new Triangular Fuzzy Cognitive Maps.

1.2. CETD Matrix

In this research we give the data gathered from these people using linguistic questionnaire and this linguistic questionnaire was transformed into a fuzzy data. It is important to note
while doing fuzzy mathematical models the fuzzy matrix may take its entries from the interval \([-1, 1]\) then also they are known as fuzzy matrices. In which we mainly concentrate the negative emotion among the five dimensions. We analyze these problems using fuzzy matrix, we call the RTD Matrix as fuzzy matrix for that take their entries from the set \([-1, 0, 1]\) which are taken as the columns of the initial raw data matrix the age group in years 20-29, 30-39, 40-49, 50-59.

1.3. Literature Review

The idea of fuzzy set was introduced by Zadeh [1] in 1965. Kosko.B introduced fuzzy cognitive maps as fuzzy-graphs structure for representing causal reasoning. Axelrod proposed cognitive maps as a formal tool for decision making. He used the matrix representation of the directed graph to represent and study the social scientific knowledge. [2] W.B. Vasantha Kandasamy et al constructed the Fuzzy Relational Models and Fuzzy Cognitive Maps and has effectively used the Fuzzy Models in analyzing the problems of the displaced persons, school drop-outs, AIDS patients, Dalits, Rag pickers, PWDs etc [3]. The Triangular Fuzzy Cognitive Maps (TrFCM), introduced by Clement Joe Anand et al an analyzed the causes of divorce thought in family [4]. Using the model Nagoor Gani et al used triangular fuzzy number for Solving Fuzzy Linear Programming Problem [5]. Rajkumar et al studied on Miracles through the Holy Bible using Triangular Fuzzy Cognitive Maps [6]. W.B. Vasantha Kandasamy introduces this method in their study on problems faced by rag Pickers in Chennai city [7]. Selvam et al have studied an interlinking of Triangular fuzzy cognitive maps and Combined effect time dependent data matrix using school dropout [8].

1.4. Mathematical Formulations

Definition 1.1. When the nodes of the TrFCM are fuzzy sets then they are called as fuzzy triangular nodes.

Definition 1.2. Simple Triangular FCMs

Triangular FCMs with edge weights or causalities from the set \([-1, 0, 1]\) are called simple Triangular FCMs.

Definition 1.3. Triangular Fuzzy Cognitive Maps (TrFCM)

A Triangular Fuzzy Cognitive Maps (TrFCM) is a directed graph with concepts like policies, events etc, as nodes and causalities as edges, It represents causal relationships between concepts.

Definition 1.4. Instantaneous State Vectors

Let \(TrC_1, TrC_2 \cdots TrC_n\) be the nodes of an TrFCM. \(A = (a_1, a_2, \cdots a_n)\) where \(Tre_{ij} \in \{-1, 0, 1\}\). \(A\) is called the instantaneous state vector and it denotes the on-off position of the node at an instant.

\[
\text{Instantaneous vector} = \begin{cases} 
Tr_{a_1} = 1 & \text{Maximum(weight)} \\
Tr_{a_1} = 0 & \text{Otherwise}
\end{cases}
\]

Definition 1.5. Feedback

An TrFCM is said to be cyclic is said to have a feedback.

Definition 1.6. Dynamical System

When there is a feedback in an TrFCM, i.e., when the causal relations flow through a cycle in a revolutionary way, the TrFCM is called a dynamical system.

Definition 1.7. Fixed Point

If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point. Consider a TrFCM with \(TrC_1, TrC_2 \cdots TrC_n\) as nodes.

For example let us start the dynamical system by switching on TrC1.

Let us assume that the TrFCM settles down with TrC1 and TrCn is ON i.e., in the state vector remains as \((1, 0, 0, 0)\) is called fixed point.
Definition 1.8. **Limit cycle**

If the TrFCM settles down with a state vector repeating in the form \( A_1 \to A_2 \to \cdots A_i \to A_1 \) then this equilibrium is called a limit cycle.

Definition 1.9. **Degrees of the Triangular Fuzzy Number**

| Table 1: The linguistic values |
|-----------------------------|
| **Very Low**                    | (0, 0, 0.25) |
| **Low**                        | (0, 0.25, 0.50) |
| **Medium**                     | (0.25, 0.50, 0.75) |
| **High**                       | (0.50, 0.75, 1) |
| **Very High**                  | (0.75, 1, 1) |

1.5. **Average Time Dependent (ATD) Matrix**

Raw data transform into a raw time dependent data matrix by taking along the rows the age group and along the columns using the raw data matrix we make it into the Average Time Dependent Data (ATD) matrix \((a_{ij})\) by dividing each entry of the raw data matrix by the number of years i.e., the time period. This matrix represents a data, which is totally uniform. At the third stage we find the average and Standard Deviation (S.D) of every column in the ATD matrix.

1.6. **Refined Time Dependent (RTD) Matrix**

Using the average \( \mu_j \) of each jth column and \( \sigma_j \) the S.D of the each jth column we chose a parameter \( \alpha \) from the interval \([0, 1]\) and form the Refined time dependent Matrix (RTD matrix). Using the formula

If \( a_{ij} \leq (\mu_j - \alpha * \sigma_j) \) then \( e_{ij} = -1 \) else
If \( a_{ij} \in (\mu_j - \alpha * \sigma_j, \mu_j + \alpha * \sigma_j) \) then \( e_{ij} = 0 \) else
If \( a_{ij} \geq (\mu_j + \alpha * \sigma_j) \) then \( e_{ij} = 1 \).

We redefine the ATD matrix into the refined time dependent fuzzy matrix for here the entries are 0 or 1. Now the row sum of this matrix gives the maximum age group.

1.7. **Combined Effective Time Dependent Data (CETD) Matrix**

We also combine the above RTD matrices by varying the \( \alpha \in [0, 1] \), so that we get the Combined Effective Time Dependent Data (CETD) matrix. The row sum is obtained for CETD matrix and conclusions are derived based on the row sums.

2. **Causes of Problems Faced by Transgenders using Fuzzy Triangular Fuzzy Cognitive Maps (TRFCM)**

The data pertaining to the problems of Transgenders was collected from the three main stakeholders viz, Transgenders, their parent and leaders of NGOs who have been working for their cause. A structural questionnaire was prepared and administered among 50 Transgenders, 20 parents and 5 NGO leaders.

*The following 10 concepts are taken based on survey, interview and focus group discussion:*

*TrC*$_1$ - Lack of financial support

*TrC*$_2$ - Deprived of fundamental of rights

*TrC*$_3$ - Lack of Sex Reassignment (SRS) Surgery

*TrC*$_4$ - No ID Proof

*TrC*$_5$ - Lack of relations

*TrC*$_6$ - Lack of joining school and colleges

*TrC*$_7$ - Lack of medical facilities

*TrC*$_8$ - Lack of employment opportunities
$TrC_9$ - Lack of Shelter  
$TrC_{10}$ - No share in property

2.1. Algorithm for Triangular Fuzzy Cognitive Maps:

**Step 1:** Prepare a $n \times n$ connection matrix.

**Step 2:** Prepare the maximum weightage of the matrix using the average matrix $Tr(M)$.

**Step 3:** Find the limit cycle
- Let $TrC_1, TrC_2 \cdots TrC_{10}$ be the nodes of a TrFCM. Here $Tr(M)$ be an adjacency matrix.
- Consider the instantaneous state vector as $A_1 = (1, 0, 0, \cdots 0)$ for $A_1 TrM$ is switched ON.
- $A_1 Tr(M) = a_1, a_2, \cdots a_n$ will get a Triangular vector.
- Adding the corresponding concepts of the three experts opinion, we call it as sum of $A_1 Tr(M)$.
- The threshold operation is denoted by $(\to) A_1 Tr(M)$ Max (weight).
- Suppose $A_1 Tr(M)$ Max (weight) = $A_2$ then consider $A_2 Tr(M)$ weight is the ON attribute Triangular vector.
- Find $A_2 Tr(M)$.
- The threshold operation is denoted by $(\to)$ (i.e.) $A_2 Tr(M)$ Max (weight). That is by replacing $a_i$ by 2 if $a_i$ is the maximum weight of the Triangular node.
- This procedure is repeated till we get a limit cycle or a fixed point.

**Step 4:** Obtain the total weightage and find the Rank of the Triangular Fuzzy Cognitive Maps.

Methods of determination of the Hidden Pattern of Triangular Fuzzy Cognitive Maps (TrFCM):

**Step 1:** In this step prepare a fuzzy matrix is called the Connection matrix by using linguistic variables “Very Low”’ (VL), “Low”’ (L), “Medium”’ (M), “Very High”’ (VH) and “High”’ (H) respectively.

**Step 2:** The following matrix is the Weithtage Matrix related to Connection matrix of $Tr(M)$.

| $Tr(M)$ | $TrC_1$ | $TrC_2$ | $TrC_3$ | $TrC_4$ | $TrC_5$ | $TrC_6$ | $TrC_7$ | $TrC_8$ | $TrC_9$ | $TrC_{10}$ |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----------|
| $TrC_1$ | O       | H       | VH      | L       | H       | VL      | L       | H       | M       | L         |
| $TrC_2$ | M       | O       | H       | VH      | L       | H       | M       | H       | H       | L         |
| $TrC_3$ | H       | L       | O       | L       | VL      | H       | VH      | M       | L       | VL        |
| $TrC_4$ | H       | VH      | L       | O       | M       | H       | H       | L       | L       | M         |
| $TrC_5$ | M       | VL      | L       | VL      | O       | H       | L       | M       | VH      | VL        |
| $TrC_6$ | H       | M       | L       | M       | L       | O       | VL      | M       | H       | VH        |
| $TrC_7$ | M       | H       | VH      | M       | VL      | L       | O       | VL      | M       | H         |
| $TrC_8$ | L       | H       | VL      | M       | VL      | H       | M       | O       | H       | VH        |
| $TrC_9$ | H       | L       | VL      | H       | M       | VL      | L       | L       | O       | VH        |
| $TrC_{10}$ | L       | H       | VL      | H       | M       | L       | VL      | VH      | O       |           |
Matrix 2: Average Matrix Tr(M)

\[
\begin{bmatrix}
PC_1 & 0 (0.75) & (0.92) & (0.25) & (0.75) & (0.08) & (0.25) & (0.75) & (0.5) & (0.25) \\
PC_2 & (0.5) & 0 (0.75) & (0.92) & (0.25) & (0.75) & (0.5) & (0.75) & (0.75) & (0.25) \\
PC_3 & (0.75) & (0.25) & 0 (0.25) & (0.75) & (0.08) & (0.75) & (0.92) & (0.5) & (0.25) \\
PC_4 & (0.75) & (0.92) & (0.25) & 0 (0.5) & (0.75) & (0.75) & (0.75) & (0.25) & (0.5) \\
PC_5 & (0.5) & (0.08) & (0.25) & (0.25) & 0 (0.75) & (0.25) & (0.5) & (0.92) & (0.08) \\
PC_6 & (0.75) & (0.5) & (0.25) & (0.08) & (0.25) & 0 (0.08) & (0.5) & (0.75) & (0.92) \\
PC_7 & (0.5) & (0.75) & (0.92) & (0.5) & (0.08) & (0.25) & 0 (0.08) & (0.5) & (0.75) \\
PC_8 & (0.25) & (0.75) & (0.08) & (0.5) & (0.08) & (0.75) & (0.5) & 0 & (0.75) & (0.92) \\
PC_9 & (0.75) & (0.25) & (0.08) & (0.75) & (0.5) & (0.08) & (0.25) & (0.25) & 0 & (0.92) \\
PC_{10} & (0.25) & (0.75) & (0.08) & (0.75) & (0.5) & (0.75) & (0.25) & (0.08) & (0.92) & 0 \\
\end{bmatrix}
\]

Step 3: Find the limit cycle

Case (i): Let the lack of provide the financial support is ON state

Let \( A^{(1)} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \)

\( A^{(1)} Tr(M)_{\text{weight}} = \begin{bmatrix} (0, 0.5, 0.75, 1), (0.75, 1, 1), (0, 0.25, 0.5), (0.5, 0.75, 1), (0, 0.25), (0.25, 0.5, 0.75), (0.25, 0.75, 0.75), (0, 0.25, 0.5) \end{bmatrix} \)

\( A^{(1)} Tr(M)_{\text{average}} = \begin{bmatrix} 0, 0.75, 0.92, 0.25, 0.75, 0.08, 0.25, 0.92, 0.5, 0.25 \end{bmatrix} \)

\( A^{(1)} Tr(M)_{\text{Max.weight}} = \begin{bmatrix} 0, 0, 1, 0, 0, 0, 0, 0, 0, 0 \end{bmatrix} = A^{(1)}_1 \)

2.2. Results for TrFCM

From the above table, using a new fuzzy model Triangular Fuzzy Cognitive Maps (TrFCM) we get the ranking for the major problems of Transgender as follows; RANK 1-Lack of provide the financial support(0.625), RANK 2-Deprived in fundamental rights(0.59167), RANK 3-No share in property(0.55834), RANK 4-Deprived of fundamental of rights(0.44167), RANK 5-Lack of joining to school and colleges(0.38332), RANK 6-Lack of shelter(0.34999), RANK 7-Lack of
medical facilities (0.34167), RANK 8-Lack of Sex Reassignment Surgery (SRS)(0.32999), RANK 9- Lack of employment opportunities (0.32319) and RANK 10-No share in property (0.31667).

3. Reasons for the Main Causes for the Problems of the Transgenders

The following concepts are taken as the main reasons of our problem

(i) Lack of provide the financial support [R1]
(ii) Deprived of fundamental of rights [R4]
(iii) Lack of SRS services for free in public hospitals in various parts of India (SRS Sex Reassignments Surgery) [R8]
(iv) No proof of ID and address [R2]
(v) Lack of relations [R6]
(vi) Lack of admission to school and colleges [R5]
(vii) Lack of medical facilities [R7]
(viii) Lack of employment opportunities [R10]
(ix) Lack of shelter [R9]
(x) No share in property [R3]

The reason for problems of Transgenders are taken as the column and the above attributes are classified as four categories as 1-3 [Education], 4-5[Social], 6-8[Facilities] and 9-10 [Family] are taken as the row of the initial raw data matrix.

3.1. Algorithm for CETD Matrix Method

**Step 1:** Prepare an Initial Raw Time Matrix.
**Step 2:** Prepare an ATD Matrix.
**Step 3:** Prepare an RTD Matrix.
**Step 4:** Prepare the CETD Matrix.

**Step 1:** Prepare an Initial Raw Time Matrix:
In the first stage we give the matrix representation of the raw data. Entries corresponding to the intersection of rows and columns are values corresponding to the live network. The above concepts are taken as the column of the initial raw data matrix. The age groups in the years 20-29, 30-39, 40-49, 50-59 are taken as the row of the matrix.

| Age/Reasons | R1, R2 | R3, R4 | R5, R6 | R7, R8 | R9   | R10 |
|-------------|--------|--------|--------|--------|------|-----|
| 20-29       | 8      | 9      | 6      | 6      | 8    | 6   |
| 30-39       | 6      | 8      | 7      | 7      | 7    | 7   |
| 40-49       | 4      | 6      | 5      | 7      | 8    | 5   |
| 50-59       | 3      | 7      | 5      | 8      | 6    | 5   |

**Step 2:** Prepare an ATD Matrix:
In order to obtain an unbiased uniform effect on each and every data so collected, transform this initial matrix into an Average Time Dependent Data (ATD) matrix.
Table 4: ATD Matrix

| Age/Reasons | R1, R2 | R3, R4 | R5, R6 | R7, R8 | R9 | R10 |
|-------------|--------|--------|--------|--------|----|-----|
| 20-29       | 1.143  | 1.5    | 0.857  | 0.857  | 1.143 | 0.857 |
| 30-39       | 0.857  | 1.143  | 1      | 1      | 1   |     |
| 40-49       | 0.571  | 0.857  | 0.714  | 1      | 1.143 | 0.714 |
| 50-59       | 0.5    | 1      | 0.714  | 1.143  | 0.857 | 0.714 |
| Average     | 0.708  | 1.126  | 0.821  | 1      | 1.036 | 0.821 |
| S.D         | 0.3321 | 0.0352 | 0.821  | 0.4330 | 0.449 | 0.356 |

Step 3: Prepare an RTD Matrix:
In the third stage using the simple average techniques convert the above average time dependent data matrix into a matrix with entries \{1, 0, -1\}, \epsilon_{ij} \in 1. We name this matrix as the Refined Time Dependent Data Matrix (RTD Matrix) or as the fuzzy matrix. We have taken the values are \(\alpha = 0.25\), \(\alpha = 0.3\), \(\alpha = 0.35\), \(\alpha = 0.40\) and \(\alpha = 0.45\) to find the CETD matrix.

Case (i): The RTD Matrix for \(\alpha = 0.25\) and Row Sum Matrix.

\[
\begin{bmatrix}
1 & 1 & 0 & -1 & 1 & 0 \\
1 & 1 & 1 & 0 & 0 & 1 \\
-1 & -1 & -1 & 0 & 1 & -1 \\
-1 & -1 & -1 & 1 & -1 & -1 \\
\end{bmatrix}
\] and

\[
\begin{bmatrix}
2 \\
4 \\
-3 \\
-4 \\
\end{bmatrix}
\]

Figure 1. The above Graph Depicting the Maximum age Group for \(\alpha = 0.25\)

Case (ii): The RTD Matrix for \(\alpha = 0.35\) and Row Sum Matrix.

\[
\begin{bmatrix}
1 & 1 & 0 & 0 & 0 & 0 \\
0 & 1 & 1 & 0 & 0 & 1 \\
-1 & -1 & 0 & 0 & 0 & 0 \\
-1 & -1 & 0 & 0 & -1 & 0 \\
\end{bmatrix}
\] and

\[
\begin{bmatrix}
2 \\
3 \\
-2 \\
-3 \\
\end{bmatrix}
\]

Figure 2. The above Graph Depicting the Maximum age Group for \(\alpha = 0.35\)
Case (iii): The RTD Matrix for $\alpha = 0.40$ and Row Sum Matrix.

\[
\begin{bmatrix}
1 & 1 & 0 & 0 & 0 & 0 \\
0 & 1 & 1 & 0 & 0 & 1 \\
-1 & -1 & 0 & 0 & 0 & 0 \\
-1 & -1 & 0 & 0 & -1 & 0 \\
\end{bmatrix}
\] and

\[
\begin{bmatrix}
1 \\
4 \\
-2 \\
-3 \\
\end{bmatrix}
\]

Figure 3. The above Graph Depicting the Maximum age Group for $\alpha = 0.40$

Similarly Draw the Graph using the parameter $\alpha = 0.30, \alpha = 45$ and so on.

Step 4: Prepare the CETD Matrix : Using the fuzzy matrices we obtain the Combined Effect Time Dependent Data Matrix (CETD Matrix), which gives the cumulative effect of all these entries. In the final stage we obtain the row sums of the CETD matrix.

Figure 4. The Combined CETD Maximum age Group of Transgender

Results
The maximum age group of Transgender 30-39 as they face like all issues Fears about finding a partner, Impact on family relationships with parents, children, partners and other relatives,
Impact on family relationships at work and with friends, feelings about hormones, frustration of having to change or explain legal documents etc. But some of the symptoms start in the age 20-29. When they are more conscious about future and finding partners, they face numerous at the stage psychological problems during the year 30-39.

4. Charles Spearmans Coefficients of Rank Correlation Method by Interlinking of Triangular Fuzzy Cognitive Maps (TRFCM) and CETD Matrix

Assessing the correlation between different ranking patterns obtained by Triangular method and CETD Matrix or different decision makers and/or different scenarios for a given set of alternative forms a major part of comparative study. The range of the correlation coefficient is between -1 and +1. If the correlation coefficient is negative, then the variable are inversely proportional and it is maximum when it is -1; if the coefficient is 0, there is no association between the variable. If the coefficient is positive, then the variables are associated directly and it is maximum, when it is +1.

**Charles Spearmans Coefficients of Rank Correlation Method**

Charles Spearmans coefficients of rank correlation method are the technique of determining the degree of correlation between ranks achieved by TrFCM method and CETD matrix method or different decision-makers and/or different scenarios for a set of alternatives. This coefficient is determined as under

\[ r_s = 1 - \left( \frac{6 \sum d_i^2}{n(n^2 - 1)} \right) \]

where \( d_i \) = difference between ranks of ith pair of the two variable. \( N \) = number of pairs of observations. Various critical values for Charles Spearman’s coefficients of rank correlation for various significance levels is provided.

| Characteristic of co-efficients | Nature of correlation | Remarks               |
|---------------------------------|-----------------------|-----------------------|
| 0.9 - 1.0                       | Very High             | Very Strong Relationship |
| 0.7 - 0.9                       | High                  | Marked Relationship    |
| 0.4 - 0.7                       | Moderate              | Substantial Relationship |
| 0.2 - 0.4                       | Low                   | Definite Relationship  |
| < 0.2                           | Slight                | Small Relationship     |

**Table 6: Procedure to find \( d \)**

| Rank of TrFCM | Rank of CETD Matrix | \( d = r_1 - r_2 \) | \( d^2 \) |
|---------------|---------------------|---------------------|----------|
| 1             | 1                   | 0                   | 0        |
| 4             | 4                   | 0                   | 0        |
| 8             | 8                   | 0                   | 0        |
| 2             | 2                   | 0                   | 0        |
| 6             | 3                   | 3                   | 9        |
| 5             | 5                   | 0                   | 0        |
| 7             | 7                   | 0                   | 0        |
| 10            | 10                  | 0                   | 0        |
| 9             | 9                   | 0                   | 0        |
| 3             | 6                   | -3                  | 9        |

\[ \sum d_i^2 = 18 \]
\[ r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \]
\[ r = 1 - \frac{6 \times 18}{100(100 - 1)} = 1 - \frac{108}{10 \times 99} \]
\[ = 1 - \frac{108}{990} = \frac{990 - 108}{990} = \frac{882}{990} = 0.89090 = 0.9 \]

5. Conclusion
In the course of this study, fuzzy data was converted to raw data applying the Triangular Fuzzy Cognitive maps and the CETD Matrix, and the causes of problems of transgenders were correlated by using two methods and it was found that the nature of correlation was identified as Very High bearing a numerical value of 0.9 indicating a marked relationship between the two - both methods are interlinked. From the above mentioned data, it is found that the mentioned causes are the main reason for Transgenders.

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