

A Study on the Causes for Child Trafficking using Indeterministic Trapezoidal Fuzzy Cognitive Maps

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ABSTRACT

According to UNICEF, Child trafficking is defined as “any person under the age 18 who is recruited, transported, transferred, harboured or received for the purpose of exploitation, either within or outside a country”. It has been mentioned in the article that children were missing overnight, as many as one every eight minutes, according to the National Crime Records Bureau. Children were trafficked for varied reasons. In this paper, we analyse the major causes for Child Trafficking and ranking the causes using the newly proposed fuzzy model Indeterministic Trapezoidal Fuzzy Cognitive Map . This model has an advantage of ranking the causes by the calculated membership value also showing the indeterminacy relation between the nodes obtained from the expert’s. This paper has four sections. Section one deals with the overall existing problem of child trafficking. Section two deals with the description of the model. Section three gives the study and analysis of the problem using the prescribed model. Section four gives the conclusion and suggestion based on the study.

Keywords

FCMs, NCMs, TpNCMs, Hidden pattern, fixed point, Child Trafficking.

1. INTRODUCTION

The government of India figured out that for the year 2011-2012, about 126,321 trafficked children were rescued from the domestic service and an increase of nearly 27% was seen year after year. The parents of the rescued children have no idea about their daughters what has happened to them. According to India’s national Crime Record Bureau, a child goes missing in India every eight minutes, and more than a third are never found. The great difficulty is that most traffickers live one among the other people and many of the traffickers are women so that they find easy to move with the girls and get them trafficked. [10,11]

The newly proposed model helps in ranking the attributes in a refined manner. It involves the basis of FCM, NCM and TpFCM. FCM deals with the on-off state of the attributes. NCM deals with the indeterminacy condition between the attributes. TpFCM ranks the attributes based on the membership value obtained from Tp average. TpFCM relies on giving interrelationship degree value between the attributes though indeterminacy is seen between them. But this model have an advantage of using indeterminate condition by denoting I so that the membership value obtained from TpNCM average shows the minute difference in ranking than TpFCM.[6, 3]

2. PRELIMINARIES

The membership function of the Trapezoidal Fuzzy number $\tilde{A} = (a,b,c,d)$ is given by, where $a \leq b \leq c \leq d$, Fuzzy Cognitive Maps has been introduced by Lotfi. A. Zadeh (1965). After a decade, Political scientist Axelord (1976) used this fuzzy model to study decision making in social and political systems. Later, Kosko (1986, 1988 and 1997) extended the cognitive maps using membership values and causalities between the nodes. FCM works on unsupervised data. It is a simple and effective tool to analyze social, economic, political problems etc. In this section we gives the basic definitions of Trapezoidal fuzzy number and its algebraic operations. And definitions of Trapezoidal Neutrosophic Cognitive Maps (TpFCM) are given.[1,2]

2.1 Trapezoidal Fuzzy number and the Algebraic Operations

2.1.1 Trapezoidal Fuzzy number

It is a fuzzy number represented with four points as follows. The membership function defined as

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a < x \leq b \\ 1, & b < x < c \\ \frac{d-x}{d-c}, & c \leq x < d \\ 0, & x > d \end{cases}$$

2.1.2. Operation of Trapezoidal Fuzzy Number

The following are the four operations that can be performed on triangular fuzzy numbers: Let $\tilde{A} = (a,b,c,d)$ and $\tilde{B} = (e,f,g,h)$ then,

1. $\tilde{A} + \tilde{B} = (a+e, b+f, c+g, d+h)$
2. $\tilde{A} - \tilde{B} = (a-h, b-g, c-f, d-e)$
3. $\tilde{A} \times \tilde{B} = (ae, bf, cg, dh)$
4. $\frac{1}{\tilde{A}} = (\frac{1}{d}, \frac{1}{c}, \frac{1}{b}, \frac{1}{a})$

2.1.3 Degrees of the Trapezoidal Fuzzy Number

The linguistic values of the trapezoidal fuzzy numbers are

Table 1. Table captions should be placed above the table

Very Low	(0, 0.11, 0.21, 0.31)
Low	(0.21, 0.31, 0.41, 0.51)
Medium	(0.41, 0.51, 0.61, 0.71)
High	(0.61, 0.71, 0.81, 0.91)
Very High	(0.81, 0.91, 1, 1)

2.2 Basic Definitions of Indeterministic Trapezoidal Fuzzy Cognitive Maps (TpNCMs)

2.2.1 Definition: In the neutrosophic logic every logical variable x is described by an ordered triple $x = (T, I, F)$ where T is the degree of truth, F is the degree of false and I level of indeterminacy.

2.2.2 Definition: A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts like policies, events etc. as nodes and causalities or indeterminates as edges. It represents the causal relationship between concepts.

Let C_1, C_2, \dots, C_n denote n nodes, further we assume each node is a neutrosophic vector from neutrosophic vector space V . So a node C_i will be represented by (x_1, \dots, x_n) where x_k 's are zero or one or I (I is the indeterminate) and $x_k = 1$ means that the node C_k is in the on state and $x_k = 0$ means the node is in the off state and $x_k = I$ means the nodes state is an indeterminate at that time or in that situation. Let C_i and C_j denote the two nodes of the NCM. The directed edge from C_i to C_j denotes the causality of C_i on C_j called connections. Every edge in the NCM is weighted with a number in the set $\{-1, 0, 1, I\}$. Let e_{ij} be the weight of the directed edge $C_i C_j$, $e_{ij} \in \{-1, 0, 1, I\}$. $e_{ij} = 0$ if C_i does not have any effect on C_j , $e_{ij} = 1$ if increase (or decrease) in C_i causes increase (or decreases) in C_j , $e_{ij} = -1$ if increase (or decrease) in C_i causes decrease (or increase) in C_j . $e_{ij} = I$ if the relation or effect of C_i on C_j is an indeterminate. [3]

2.3. Basic Definitions of Trapezoidal Neutrosophic Cognitive Maps (TpNCMs)

2.3.1 Definition: Trapezoidal NCMs with edge weights or causalities from the set $\{-1, 0, 1, I\}$ are called simple Trapezoidal NCMs.

2.3.2 Definition: A TpNCM is a directed graph with concepts like policies, events etc, as nodes and causalities as edges, It represents causal relationships between concepts.

2.3.3 Definition: Consider the nodes/concepts $TpC_1, TpC_2, \dots, TpC_n$ of the Trapezoidal NCM. Suppose the directed graph is drawn using edge weight $Tp_{eij} \in \{-1, 0, 1, I\}$. The Trapezoidal neutrosophic matrix M be defined by $TpN(M) = (Tp_{eij})$ where Tp_{eij} is the Trapezoidal neutrosophic weight of the directed edge $TpC_i TpC_j$. $Tp(M)$ is called the adjacency matrix of Trapezoidal Neutrosophic Cognitive Maps, also known as the connection matrix of the TpNCM. It is important to note that all matrices associated with a TpNCM are always square matrices with diagonal entries as zero.

2.3.4 Definition: Let $TpC_1, TpC_2, \dots, TpC_n$ be the nodes of an TpNCM. $A = (a_1, a_2, \dots, a_n)$ where $Tp_{eij} \in \{-1, 0, 1, I\}$. A is called the instantaneous state vector and it denotes the on-off position of the node at an instant.

Instantaneous vector

$a_i = 0$ if a_i is off (has no effect)

$a_i = 1$ if a_i is on, (has effect)

$a_i = I$ if a_i is indeterminate, (effect cannot be determined) where $i = 1, 2, \dots, n$.

2.3.5 Definition: Let $TpC_1, TpC_2, \dots, TpC_n$ be the nodes of TpNCM. Let be the edges of the TpNCM ($i \neq j$). Then the edges form a directed cycle a TpNCM is said to be cyclic if it possesses a directed cycle. A TpNCM is said to be acyclic if it does not possess any directed cycle.

2.3.6 Definition: A TpNCM is said to be cyclic is said to have a feedback.

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

2.3.8 Definition: Let $TpC_1 \xrightarrow{\text{edge}} TpC_2 \xrightarrow{\text{edge}} TpC_3 \xrightarrow{\text{edge}} \dots \xrightarrow{\text{edge}} TpC_n \xrightarrow{\text{edge}} TpC_1$ be a cycle. When TpC_i is switched ON and if the causality flows through the trapezoidal edges of a cycle and if it again causes C_i , we say that the dynamical system goes round and round. This is true for any trapezoidal node TpC_i for $i = 1, 2, \dots, n$. The equilibrium state for this dynamical system is called the hidden pattern.

2.3.9 Definition: If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point. Consider a TpNCM with $TpC_1, TpC_2, \dots, TpC_n$ as nodes. For example let us start the dynamical system by switching on TpC_1 . Let us assume that the TpNCM settles down with TpC_1 and TpC_n ON i.e., in the state vector remains as $(1, 0, 0, \dots, 0)$ is called fixed point.

2.3.10 Definition: If the TpNCM settles down with a state vector repeating in the form $A_1 \rightarrow A_2 \rightarrow \dots \rightarrow A_i \rightarrow A_1$ then this equilibrium is called a limit cycle.

2.4 Algorithm used to manipulate TpNCM

Step 1: Consider the attributes given by the experts for the problem as $TpC_1, TpC_2, \dots, TpC_n$. According to the feedback given by the expert directed graph is drawn.

Step 2: Let $TpN(M)$ denotes the connection matrix with $\{-1, 0, 1, I\}$ as causalities.

Step 3: Let the instantaneous state vector be $A_1 = (1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$. It is passed into $TpN(M)$. The on state vector $TpN(M)_{avgweight}$ is obtained.

Step 4: Maximum membership value is threshold as 1 and other as 0 and I . Consider the threshold and updated vector as A_2 .

Step 5: A_2 is passed into $TpN(M)$ the above said calculation is performed, threshold and updated until the same fixed point is obtained. [5]

3. ANALYSIS OF THE PROBLEM

A study on the problem has been made by interviewing the trafficked children and the members of NGO in India. The following ten attributes obtained from the experts were considered for the analysis of the problem. [7]

TpC_1 - Entertainment

TpC_2 - Illiteracy

TpC_3 - Unemployment

- TpC₄- Poverty
- TpC₅-Sexual Exploitation
- TpC₆- Bonded Labour
- TpC₇- Political Uprising
- TpC₈- Illegal Activities
- TpC₉- Social Factor
- TpC₁₀- High profit at low risk

Now we reformulate a different format of the questionnaire where we permit the expert to give answers like the relation between certain nodes is indeterminable or not known. Now based on the expert's opinion also about the notion of indeterminacy we obtain the following Trapezoidal Neutrosophic connection matrix TpN(E) from Fig 1. [9,8]

	TpC1	TpC2	TpC3	TpC4	TpC5	TpC6	TpC7	TpC8	TpC9	TpC10
TpC1	0	VH	L	M	H	H	M	VL	I	VL
TpC2	M	0	VH	H	M	H	M	L	VL	L
TpC3	VH	M	0	H	M	L	VL	M	H	L
TpC4	L	M	L	0	H	H	M	I	VL	VH
TpC5	VL	L	L	H	0	M	L	VH	I	H
TpC6	VL	L	H	M	VH	0	H	L	VL	H
TpC7	M	H	L	M	VL	H	0	M	VH	H
TpC8	VL	M	H	H	M	L	VL	0	L	VH
TpC9	H	H	L	VL	M	L	VL	VH	0	M
TpC10	VL	M	L	H	H	M	L	VH	VL	0

Fig 1: Trapezoidal Neutrosophic Connection Matrix

The corresponding Trapezoidal Average weight matrix (TpN(M)_{avweight}) is given below in Fig 2.

	TpC1	TpC2	TpC3	TpC4	TpC5	TpC6	TpC7	TpC8	TpC9	TpC10
TpC1	0	0.93	0.36	0.56	0.76	0.76	0.56	0.16	I	0.16
TpC2	0.56	0	0.93	0.76	0.56	0.76	0.56	0.36	0.16	0.36
TpC3	0.93	0.56	0	0.76	0.56	0.36	0.16	0.56	0.76	0.36
TpC4	0.36	0.56	0.36	0	0.76	0.76	0.56	I	0.16	0.93
TpC5	0.16	0.36	0.36	0.76	0	0.56	0.36	0.93	I	0.76
TpC6	0.16	0.36	0.76	0.56	0.93	0	0.76	0.36	0.16	0.76
TpC7	0.56	0.76	0.36	0.56	0.16	0.76	0	0.56	0.93	0.76
TpC8	0.16	0.56	0.36	0.76	0.56	0.36	0.16	0	0.36	0.93
TpC9	0.76	0.76	0.36	0.16	0.56	0.36	0.16	0.93	0	0.56
TpC10	0.16	0.56	0.36	0.76	0.76	0.56	0.36	0.93	0.16	0

Fig 2: Trapezoidal Average weight matrix

3.1 First Process

When the node TpC₁ i.e “Entertainment” is in on state and other nodes in off state we carry the above said procedures to obtain the fixed point as the result.

$$A_0 = (1000000000)$$

$$A_0 \text{ TpN}(M)_{\text{avweight}} = (0 \ 0.93 \ 0.36 \ 0.56 \ 0.76 \ 0.76 \ 0.56 \ 0.16 \ I \ 0.16)$$

$$\longrightarrow (0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ I \ 0) = A_1$$

$$A_1 \text{ TpN}(M)_{\text{avweight}} = (0.56 + 0.76I \ 0 + 0.76I \ 0.93 + 0.36I \ 0.76 + 0.16I \ 0.56 + 0.56I \ 0.76 + 0.36I \ 0.56 + 0.16I \ 0.36 + 0.93I \ 0.16 + 0I \ 0.36 + 0.56I)$$

$$\longrightarrow (0 \ I \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) = A_2$$

$$A_2 \text{ TpN}(M)_{\text{avweight}} \longrightarrow (1 \ 0 \ I \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) = A_3$$

$$A_3 \ A_2 \text{ TpN}(M)_{\text{avweight}} \longrightarrow (I \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ I \ 0) = A_4$$

$$A_4 \ A_2 \text{ TpN}(M)_{\text{avweight}} \longrightarrow (0 \ I \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) = A_5 = A_2$$

Therefore A₂ is the fixed point i.e (0 I 1 0 0 0 0 0 0 0 0).

3.2 Second Process

When the node TpC₄ i.e “Poverty” is in on state and other nodes in off state, we obtain the following instantaneous state vector.

$$A_0 = (0001000000)$$

$$A_0 \text{ TpN}(M)_{\text{avweight}} \longrightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ I \ 0 \ 1) = A_1$$

$$A_1 \ \text{TpN}(M)_{\text{avweight}} \longrightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0 \ I) = A_2$$

$$A_2 \ \text{TpN}(M)_{\text{avweight}} \longrightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ I \ 0 \ 1) = A_3 = A_1$$

Therefore A₁ is the fixed point i.e (0 0 0 0 0 0 0 0 I 0 1).

The following table shows the weightage of the attributes calculated using the above said algorithm of TpNCM.

Table 2: Weightage of the attributes

Attributes	Tp ₁	Tp ₂	Tp ₃	Tp ₄	Tp ₅	Tp ₆	Tp ₇	Tp ₈	Tp ₉	Tp ₁₀
TpC ₁	0.56	I	0.93	0.76	0.56	0.76	0.56	0.36	0.16	0.36
TpC ₂	0.56	I	0.93	0.76	0.56	0.76	0.56	0.36	0.16	0.36
TpC ₃	0.56	I	0.93	0.76	0.56	0.76	0.56	0.36	0.16	0.36
TpC ₄	0.16	0.56	0.76	0.76	0.56	0.16	0.16	I	0.36	0.93
TpC ₅	0.16	0.56	0.76	0.76	0.56	0.16	0.16	I	0.36	0.93
TpC ₆	0.16	0.56	0.76	0.76	0.56	0.16	0.16	I	0.36	0.93
TpC ₇	0.16	0.56	0.36	0.76	0.76	0.36	0.36	0.93	0.16	0
TpC ₈	0.16	0.56	0.36	0.76	0.76	0.36	0.36	0.93	0.16	0
TpC ₉	0.16	0.56	0.36	0.76	0.76	0.36	0.36	0.93	0.16	0
TpC ₁₀	0.16	0.56	0.76	0.76	0.56	0.16	0.16	0.93	0.36	0.93
Total Weight	2.8	3.92	6.91	7.6	6.2	4	3.4	4.8	2.4	4.8
Average value	0.28	0.392	0.691	0.76	0.62	0.4	0.34	0.48	0.24	0.48

4. CONCLUSIONS AND SUGGESTIONS

From the above table it is clear that the indeterminate relation between the nodes play a vital role in calculating the accurate total weight of the attributes in correspondence with the other. From the calculated average value ranking of the dominant causes are done. Poverty -0.76, Unemployment-0.691, Sexual Exploitation -0.62, High profit at low risk and Illegal Activities-0.48, Bonded Labour- 0.48, Illiteracy-0.392, Political Uprising- 0.34, Entertainment - 0.28, Social Factor-0.24.

The government can conduct awareness program to develop and make each individual to realize their responsibilities and duties to the society. Volunteers can organize an anti-trafficking committee and collect fund for the welfare measures against trafficking.

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