ALGORITHMIC APPROACH IN FUZZY COGNITIVE MAP TO STUDY THE PREVENTIVE MEASURES TO PROHIBIT CHILD ABUSE

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Abstract

In the current scenario, a novel Fuzzy Cognitive approach is widely used mathematical tool to model complex systems. Fuzzy Cognitive Maps (FCMs) is a graphical model for causal knowledge representation. Nowadays, the child safety is questioned owing to happening of abuses in society. The measures to prevent the child abuse on the social context is accurately undefined. This paper aims to identify the most influential preventive factors of child abuse using the tool Fuzzy CognitiveMap.

Keywords

Fuzzy Cognitive Map (FCM), Digraph,Augmented Adjacency Matrix, Instantaneous state vector, Fixed Point.

1. Introduction

Fuzzy sets are sets whose elements have degrees of membership. Fuzzy sets were introduced by Lofti A. Zadeh [8] in 1965 as an extension of the classical notion of a set. Fuzzy set theory permits the gradual assessment of membership of elements in a set. This is described with the aidof a membership function valued in the real unit interval [0,1]. Fuzzy sets generalize classical sets. The fuzzy sets theory can be used in a wide range of domains in which information is incomplete orimprecise. Fuzzy Cognitive Map (FCMs), which was introduced by Bart Kosko in the year 1986. FCMs have a major role to play mainly when the data concerned is an unsupervised one. Further this method is most simple and an effective one as it can analyse the data by directed graphs and connection matrices [8]. Child abuse is physical, sexual and psychologicalmaltreatment orneglectofachild,especiallybyaparentoracaregiver.Aspartoftheongoing WHOglobalcampaignforviolenceprevention,andasitscontributiontofollow up on the UN secretary general's study on violence against children, WHO has a threefold stake in the prevention of violence against children.[5]

The rate of child abuse is currentlyon the raise. Children are ill defined in the society. The prevention measures of child abuse on the social context is accurately undefined. So this paper aims to detect the most influential factor to prevent the child abuse with the help of Fuzzy CognitiveMap.

2. Preliminaries

Membership Function[8]

Let X be a Universal set. Then the membership function for $\widetilde{A} \subseteq X$ is defined as

$\mu_{\widetilde{A}}: X \to [0, 1]$, where $[0, 1]$denotes the set of all real numbers between 0 and 1 inclusive .

Fuzzy Set[8]

A set $\widetilde{A}$ defined by its membership function $\mu_{\widetilde{A}}$ (x) is called a Fuzzy set. A fuzzy set $\widetilde{A}$ can be

represented as $\widetilde{A} = \{(x, \mu_{\widetilde{A}}(x)): x \in X\}$ where $\mu_{\widetilde{A}}(x)$ denotes a membership grade of x in $\widetilde{A}$.

Digraph

A directed graph [1] (or) digraph D is an ordered pair (V, A) where V is a finite nonempty set and A is a subset of V×V -$\{(x, x)|x \in V\}$. The elements of V and A are respectively called vertices (points) and arcs. If (u ,v) is said to have u as its initial vertex (tail) and v as its terminal vertex (head). Also the arc (u ,v) is said to join u to v.
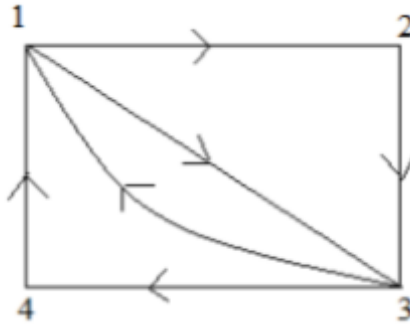

Fig:2.1 Digraph

Fuzzy Nodes

When the nodes of the FCM are fuzzy sets then they are called as fuzzy nodes. [7]

Simple FCMs

FCMs with edge weights or causalities from the set $\{-1,0,1\}$ are called simple FCMs. [7]

Adjacency Matrix

Let $C_1, C_2, \ldots, C_n$ of the FCM. Suppose the directed graph is drawn using edge weight $eij \in \{0, -1,1\}$. The matrix E be defined by E= (e_{ij}) where e_{ij} is the weight of the directed edge $C_i C_j$. Then E is called the adjacency matrix of the FCM, also known as the connection matrix of the FCM. It is important to note that all matrices associated with an FCM are always square matrices with diagonal entries as zero.

Let two FCMs with no common nodes. FCM$_A$ with C^A_i as nodes FCM$_A$ = $\{ C^A_i \}$, and FCM$_B$ with C^B_j as nodes FCM$_B$= $\{ C^B_j \}$. The adjacency matrix of FCM$_A$ is $A_A = w_{ij}{}^A$; and the adjacency matrix of FCM$_B$ is $A_B = w_{ij}{}^B$

The augmented adjacency matrix [6] is $\begin{pmatrix} w_{ij}{}^A & 0 \\ 0 & w_{ij}{}^{Expert\ 2} \end{pmatrix}$. If there are no common nodes then the element $w_{ij}{}^{Aug}$ in the augmented matrix is $w_{ij}{}^{Aug} = \frac{\sum_{k=1}^{n} w_{ij}{}^k}{n}$, n being the number of FCMs added, one by expert, k the identifier of each expert, and i and j the identifier of the relationships.

Instantaneous State Vector

Let $C_1, C_2, \ldots, C_n$ be the nodes of an FCM. A= $(a_1, a_2, \ldots, a_n)$ where $a_i \in \{0, 1\}$. A is called the instantaneous state vector and it denotes the ON-OFF position at an instant.

a_i =0, if a_i is off and a_i =1, if a_i is on for i = 1,2,………n. [7]

Hidden Pattern:

Let $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \ldots, \overrightarrow{C_{n-1} C_n}$ beacycle. When C_i isswitchedonandif thecasualtyflowsthroughtheedgesof acycleandif itagaincauses C_i, wesay thatthedynamicalsystemgoesroundandround. Thisistrueforanynode,

for i = 1,2,3, … n. The equilibrium state for this dynamical system is called the hiddenpattern.[7]

Fixed Point

If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point [7].

2. Fuzzy Cognitive Map

Fuzzy cognitive map (FCM) are more applicable when the data in the first place is an unsupervised one. The FCMs work on the opinion of experts. FCMs model the world as a collection of classes and causal relations between classes. FCMs are fuzzy signed directed graphs with feedback. The directed edge eij from causal concept Ci to concept Cj measures how much Ci causes Cj. The time varying concept function (t) measures the non negative occurrence of some fuzzy event, perhaps the strength of a political sentiment, historical trend or military objective.

An FCM is a directed graph with concepts like policies, events etc. as nodes and causalities as edges. It represents causal relationship between concepts.Here, the Augmented FCM approach has been adopted to validate the willingness of the experts.

3. Thresholding Operation of FCM

Suppose A= $(a1,2,…, an)$ is a vector which is passed into a dynamical system E. then AE= $(a^{'}, a^{'}, …, a^{'})$ after thresholding and updating the vector.

Suppose we get $(b_1, … , b_n)$ we denote that by

$$(a^{'}_1, a^{'}_2,.., a^{'}_n) \rightarrow (b_1, …, b_n)$$

Thus the symbol '$\rightarrow^{'}$' means the resultant vector has been threshold and updated.

FCMs have several advantages as well as some disadvantages. The main advantage of this method it is simple. It functions on expert's opinion. When the data happens to be an unsupervised one the FCM comes handy. This is the only known fuzzy technique that gives the hidden pattern of the situation. As we have a very well known theory, which states that strength of the data depends on, the number of experts' opinion we can use combined FCMs with several experts' opinions.[5].At the same time the disadvantage of the combined FCM is when the weights are 1 and -1 for the same C_iC_j, we have the sum adding to zero thus at all times the connection matrices $E1, …. , Ek$ may not be conformable for addition.

Combined conflicting opinions tend to cancel out and assisted by the strong law of large numbers, a consensus emerges as the sample opinion approximates the underlying population opinion. This problem will be easily overcome if the FCM entries are only 0 and 1.

4. Child Abuse:
Child abuse or child maltreatment is physical, sexual, and/or psychological maltreatment or neglect of a child or children, especially by a parent or a caregiver. Child abuse may include any act or failure to act by a parent or a caregiver that results in actual or potential harm to a child and can occur in a child's home, or in the organizations, schools, or communities the child interacts with.The World Health Organization (WHO) defines child abuse and child maltreatment as "all forms of physical and/or emotional ill-treatment, sexual abuse, neglect or negligent treatment or commercial or other exploitation, resulting in actual or potential harm to the child's health, survival, development or dignity in the context of a relationship of responsibility, trust or power. The nation has a fairly comprehensive policy and legal framework addressing rights and protection for children, providing opportunities to ensure that all children have equal access to quality protection services. The core child protection legislation for children is enshrined in four main laws: The Juvenile Justice Act/Care and Protection (2000, amended in 2015); the Child Marriage Prohibition Act (2006); the Protection of Children from Sexual Offences Act (2012) and the Child Labour Prohibition and

Regulation (1986, amended in 2016).

5. Preventive Measures of Child Abuse and Implementation of FCM

The following preventive measures of child abuse have been considered as a parameters in the problem and among them, the most influential factor has been detected using fuzzy cognitive map.

C1. Parents should create a stable emotional bonding with girl child to share her personal feelings and emotions.

C2. Educate a child on basic sexual knowledge and impart how to react for good and bad touches.

C3. Educate a child on self defence mechanisms.

C4. Nurture the children with moral values, ethics and gender equity.

C5. Moulding the child to be civilized individual through good education and environmental support.

C6.Impart the parents, children and the public on Legal Awareness and rights about safeguarding measures on prevention and punishment for child abuse.

C7. Gender perception of boys and girls should be neutral and parents need to nurture the importance of gender equity to their children to eradicate patriarchy.

Usingthelinguisticquestionnaire such as Strongly agree, Agree, Strongly Disagree and Disagree , the expert'sopinion is being formulated with the help of concepts{C1, C2, ..., C7} considered as nodes.

Let three FCMs with common nodes form each adjacency matrix as follows

$$
A^{Expert\ 1} = \begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \\ C7 \end{array}
\begin{array}{ccccccc} C1 & C2 & C3 & C4 & C5 & C6 & C7 \end{array}
\left[\begin{array}{ccccccc}
0 & 0.75 & 0.75 & 1 & 1 & 0.75 & 1 \\
0.4 & 0 & 0.75 & 1 & 1 & 0.4 & 1 \\
0.75 & 0.4 & 0 & 1 & 0.75 & 1 & 1 \\
1 & 0.75 & 0.4 & 0 & 1 & 0.4 & 1 \\
1 & 0.4 & 0.75 & 1 & 0 & 0.75 & 1 \\
0.75 & 0.75 & 0.75 & 0.4 & 1 & 0 & 1 \\
1 & 0.75 & 0.75 & 1 & 1 & 1 & 0
\end{array}\right]
$$

$$
A^{Expert\ 2} = \begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \\ C7 \end{array}
\begin{array}{ccccccc} C1 & C2 & C3 & C4 & C5 & C6 & C7 \end{array}
\left[\begin{array}{ccccccc}
0 & 1 & 1 & 1 & 1 & 0.75 & 1 \\
1 & 0 & 1 & 1 & 1 & 1 & 1 \\
0.75 & 0.75 & 0 & 1 & 1 & 1 & 1 \\
0.75 & 0.75 & 1 & 0 & 1 & 1 & 1 \\
0.75 & 1 & 1 & 1 & 0 & 1 & 1 \\
0.4 & 0.75 & 1 & 1 & 0.75 & 0 & 0.75 \\
0.4 & 0.4 & 0.75 & 0.75 & 0.4 & 0.4 & 0
\end{array}\right]
$$

$$
A^{Expert\ 3}=
\begin{array}{c}
C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \\ C7
\end{array}
\begin{bmatrix}
0 & 0.75 & 1 & 1 & 0.75 & 1 & 1 \\
0.75 & 0 & 1 & 0.75 & 1 & 1 & 0.75 \\
1 & 0 & 0 & 1 & 0.75 & 1 & 1 \\
1 & 0.75 & 0.75 & 0 & 1 & 0.75 & 1 \\
0.75 & 0.75 & 1 & 1 & 0 & 0.75 & 1 \\
0.4 & 1 & 1 & 0.75 & 0.75 & 0 & 1 \\
0.4 & 0 & 0.75 & 1 & 0.4 & 0.4 & 0
\end{bmatrix}
\begin{array}{cccccc}
C1 & C2 & C3 & C4 & C5 & C6 & C7
\end{array}
$$

The resulting Augmented FCM of the adjacency matrices of the three experts is

$$
A^{Aug}=
\begin{array}{c}
C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \\ C7
\end{array}
\begin{bmatrix}
0 & 0.83 & 0.83 & 1 & 0.83 & 0.83 & 1 \\
0.77 & 0 & 0.83 & 0.92 & 1 & 0.8 & 1 \\
0.83 & 0.38 & 0 & 1 & 0.83 & 1 & 1 \\
0.92 & 0.75 & 0.42 & 0 & 1 & 0.72 & 1 \\
0.83 & 0.72 & 0.97 & 1 & 0 & 0.83 & 1 \\
0.53 & 0.83 & 0.97 & 0.77 & 0.83 & 0 & 0.92 \\
0.6 & 0.38 & 0.75 & 0.97 & 0.6 & 0.6 & 0
\end{bmatrix}
\begin{array}{cccccc}
C1 & C2 & C3 & C4 & C5 & C6 & C7
\end{array}
$$

6. MethodofDeterminingHiddenPattern

- Let C_2, C_2… C_n be the nodes of an FCM, with feedback. Let E be the associatedadjacency matrix.

- Let us find the hidden pattern when C_1 is switched on. When aninput is given as the vector A_1= (1, 0, 0… 0), the data should pass through the relationmatrix E. this is done by multiplying A_1 by the matrix E.

- Let A_1 E= (a_1… a_n) with thethreshold operation that is by replacing a_i by 1 if a_i> k and a_i by 0 if a_i < k (k is asuitable positive integer).

- We update the resulting concept. The concept C_1 is includedin the updated vector by making the first coordinate as 1 in the resulting vector.

- SupposeA_1E→A_2thenconsiderA_2Eandrepeatthesameprocedure.Thisprocedureis repeated till weget a limit cycle or afixed point.

.

The connection matrix obtained from combining the opinions of all three experts is represented as

$$
M=
\begin{array}{c}
C1 \\ C2 \\ C3 \\ C4 \\ C5 \\ C6 \\ C7
\end{array}
\begin{bmatrix}
0 & 0 & 0 & 1 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 1 & 0 & 1 \\
0 & 0 & 0 & 1 & 0 & 1 & 1 \\
0 & 0 & 0 & 0 & 1 & 0 & 1 \\
0 & 0 & 0 & 1 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\begin{array}{ccccccc}
C1 & C2 & C3 & C4 & C5 & C6 & C7
\end{array}
$$

The directed graph shown below is drawn from the above connection matrix C1, C2, C3, C4, C5, C6, and C7 are taken as nodes and causalities as edges .
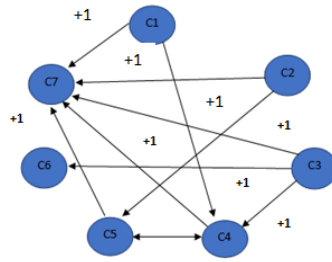

Fig:2

Nowusingthematrix,MoftheFuzzyCognitiveMap(FCM) the hidden pattern is determined by assuming that the concept C_i (for i varies from 1 to 7)is in the on state and anothernodearein theoffstate and the process is repeated till the fixed point is achieved.

1. Let $X = \{1\ 0\ 0\ 0\ 0\ 0\ 0\}$
    i. $X \times M = [0\ \ 0\ \ 0\ \ 1\ \ 0\ \ 0\ \ 1] \rightarrow [1\ \ 0\ \ 0\ \ 1\ \ 0\ \ 0\ \ 1] = X_1$
    b. $X_1 \times M = [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 2] \rightarrow [1\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_2$
    c. $X_2 \times M = [0\ \ 0\ \ 0\ \ 2\ \ 1\ \ 0\ \ 3] \rightarrow [1\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_3$
    d. $\therefore X_2$ is the hidden pattern.

2. Let $X = \{0\ 1\ 0\ 0\ 0\ 0\ 0\}$
    a. $X \times M = [0\ \ 0\ \ 0\ \ 0\ \ 1\ \ 0\ \ 1] \rightarrow [0\ \ 1\ \ 0\ \ 0\ \ 1\ \ 0\ \ 1] = X_1$
    b. $X_1 \times M = [0\ \ 0\ \ 0\ \ 1\ \ 2\ \ 0\ \ 1] \rightarrow [0\ \ 1\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_2$
    c. $X_2 \times M = [0\ \ 0\ \ 0\ \ 1\ \ 2\ \ 0\ \ 3] \rightarrow [0\ \ 1\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_3$
    d. $\therefore X_2$ is the hidden pattern.

3. Let $X = \{0\ 0\ 1\ 0\ 0\ 0\ 0\}$
    a. $X \times M = [0\ \ 0\ \ 0\ \ 1\ \ 0\ \ 1\ \ 1] \rightarrow [0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1\ \ 1] = X_1$
    b. $X_1 \times M = [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 1\ \ 2] \rightarrow [0\ \ 0\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1] = X_2$
    c. $X_2 \times M = [0\ \ 0\ \ 0\ \ 2\ \ 1\ \ 1\ \ 3] \rightarrow [0\ \ 0\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1] = X_3$
    d. $\therefore X_2$ is the hidden pattern.

4. Let $X = \{0\ 0\ 0\ 1\ 0\ 0\ 0\}$
    a. $X \times M = [0\ \ 0\ \ 0\ \ 0\ \ 1\ \ 0\ \ 1] \rightarrow [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_1$
    b. $X_1 \times M = [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 2] \rightarrow [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_2$
    c. $\therefore X_1$ is the hidden pattern.

5. Let $X = \{0\ 0\ 0\ 0\ 1\ 0\ 0\}$
    a. $X \times M = [0\ \ 0\ \ 0\ \ 1\ \ 0\ \ 0\ \ 1] \rightarrow [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_1$
    b. $X_1 \times M = [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 2] \rightarrow [0\ \ 0\ \ 0\ \ 1\ \ 1\ \ 0\ \ 1] = X_2$
    c. $\therefore X_1$ is the hidden pattern.

6. Let $X = \{0\ 0\ 0\ 0\ 0\ 1\ 0\}$

   a. $X \times M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} = X_1$

   b. $X_1 \times M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} = X_2$

   c. $\therefore X_1$ is the hidden pattern.

7. Let $X = \{0\ 0\ 0\ 0\ 0\ 0\ 1\}$

   a. $X \times M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} = X_1$

   b. $X_1 \times M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} = X_2$

   c. $\therefore X_1$ is the hidden pattern.

7. Conclusion

This study mainly investigated the preventive measures of child abuse. The preventive factors on child abuse have been analyzed using algorithmic approach of Fuzzy Cognitive mapping and it has been concluded that theParents should create a stable emotional bonding with girl child to share her personal feelings and emotionsis considered as the most influential preventive measures in prohibiting child abuses in the present situations.

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