Neutrosophic Cognitive Maps for Violence Cause Analysis

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Abstract

Among the most valuable AI methods for modeling complicated things at the moment is the use of fuzzy cognitive mapping (FCMs). Conventional FCMs, on the other hand, can't handle the ambiguity that often arises in decision-making scenarios. A novel expansion of conventional FCMs called neutrosophic cognitive mapping (NCMs) was developed to address this shortcoming. However, the indeterminacy is not well handled by the NCMs stated in the citations since the level of indeterminacy is not quantified. In certain cases, choices should be seen as a series of steps that are only loosely related to one another. This occurs in project assessment when several activities depend on one another. Another difficult aspect of FCMs is that there isn't an appropriate topology for representing these types of decision-making difficulties. To aid in making decisions over several time periods, this research introduces a neutrosophic cognitive map built on triangular neutrosophic values (MS-TrNCM) for violence analysis. Through the use of triangular neutrosophic numbers, the suggested model allows experts to express their choices while considering various extents of truth, indeterminacy, and falsity in the underlying map linkages.

Keywords: Violence; Neutrosophic; Cognitive Maps; Triangular Neutrosophic Numbers

1. Introduction

Research on the impact of family violence on children's growth and development has come a long way in the previous few decades. Many studies utilizing different methodologies have examined the possible connections between domestic abuse and mental health issues. Despite significant progress in this area, the effects of different types of victimization on behavior and development when other factors are considered are still unclear. These types of victimization include being a victim of

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childhood abuse, witnessing physical abuse of a partner, and being a victim and an observer of sexual assault. For instance, it is not known whether the consequences of various types of violence vary according to the age and sexual identity of the child, as to if witnessing violence among family members has various effects compared to being a straightforward perpetrator of violence, but whether somehow being a target and an observer of violence keeps adding to the detrimental consequences of having experienced just one kind of violence. The current investigation was created to probe these issues by analyzing a massive dataset generated by several academics utilizing the mega-analytic approach[1], [2].

To try to make sense of the complex, multifaceted ways in which family violence impacts children's behavior and social well-being, neurodevelopmental psychopathology offers a useful conceptual framework. Since a child's experience with caretakers at one life stage impact their adaptability to succeeding developmental challenges, a child's typical and expected pattern of growth and adaption may be disrupted by abnormal and exceptional situations, notably violence within the family. Children who are abused are more likely to experience psychological and behavioral issues because they miss out on necessary socializing experiences and often fail to create adaptive connection strategies. This is because they do not learn to trust others, receive little affection from everyone else, or have autocratic parents. In addition, children learn how to regulate their emotions via observation and imitation of how their caretakers express and explain their own feelings. The emotional upheaval and swings experienced by children from violent households make it challenging for them to identify and manage their own feelings accurately. Thus, abused children's emotional and behavioral difficulties may result from their inability to control their emotions[3], [4].

When comparing being a victim to being a witness to domestic violence, Sternberg et al. showed that being a victim had more significant unfavorable outcomes. Kitzmann and her coworkers conducted a meta-analysis comparing the results of both victims and witnesses. They concluded that direct victims had lower results than witnesses, but the gap was not statistically significant.

Although research on possible modifiers, like children's gender and age, has been emphasized by the psychosocial developmental method, it has produced conflicting findings. Studies have shown that young children, especially newborns and toddlers, are negatively affected by witnessing domestic violence. Nonetheless, some studies have shown that children who are exposed to intimate partner violence at school show more severe behavioral and emotional issues. In addition, investigators not using the same exhaustive evaluation procedures often struggle to draw meaningful conclusions about the similarities and differences in symptom patterns. School-aged kids from violent families have difficulty adapting to school contexts and establishing meaningful relationships; they perform poorly academically, interact with peers more vigorously, and are more likely to act aggressively toward adults. Different forms and levels of violence, as well as the interplay between a child's stage of development and the sort of violence they are exposed to, all contribute to the wide range of negative outcomes associated with childhood exposure to domestic violence. The developmental approach holds that a person's formative experiences will provide the groundwork for the adjustments that may either buffer or amplify the effects of later adversity. As a result, it is commonly believed that exposure to family violence in young childhood, when the potential for mood control is starting to emerge and children's recognition with their family members is strongest, has more serious and more long-lasting negative consequences for future adjustment than exposure later in childhood. Nevertheless, the data is limited and more suggestive than convincing, and it may be the case that the link between family violence and children's behavioral adjustment varies according to the children's cognitive level at the point of exposure[5]–[7].

Nevertheless, some data suggest that familial violence's consequences may differ for boys and girls. There is evidence from several research studies that males, as opposed to girls, are more susceptible to trauma, such as parental violence. On the other hand, girls are more likely than boys to show internalizing and externalizing behavioral issues after witnessing or experiencing family violence.

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This could be due to girls being more attuned to efficacious cues and the countries of others than boys are; or because identifying with a beaten-up mother causes girls to develop. Other studies report results for both genders.

In 1986, Kosko presented the concept of fuzzy cognitive mapping (FCMs). Today, FCMs are widely considered one of the most influential AI methods for modeling complex systems of any size. In essence, FCMs are cognitive models in the form of graphs, where the "nodes" stand in for cognitive expertise in the area of application, and the "states" capture the behavior of the issue at hand. In an iterative approach, the nodes exert mutual influence; the cycle ends when one node has achieved equilibrium with the others, hence determining the model's output. The significant benefits of FCMs are that they can express the cause-and-effect linkages among the elements in a system using language concepts that people can comprehend and that they can depict feedback interactions.

Different FCM designs and modifications exist because of aspects such as network topology, inference procedure, causal connection representation, map creation technique, and simulation procedure, depending on the activation function. There are many different kinds of FCMs, including competitive FCMs, rule-based FCMs, case-based FCMs, intuitionistic FCMs, fuzzy grey cognitive maps, time-dependent FCMs, fuzzified cognitive networks, and interval-Valued FCMs. Several authors have suggested multiple FCMs (m-FCMs) designs to simulate complex systems; they include dispersed m-FCMs, hierarchy FCMs, concurrent FCMs, and layered FCMs. The core concept of m-FCMs is breaking down large, complicated systems into simpler components. Subsystems are represented by their own FCMs, and the whole network of FCMs cooperates to achieve a common goal[8]–[11].

The use of FCMs has been shown effective in several scientific disciplines, such as data science, architecture, math, technology in the context, aspects of society, project planning, ecology, and medicine. The domain of use, the kind of solution, and the system's complexity are primary considerations when settling on an FCM design[12]–[14].

Still, complicated decision-making difficulties call for judgments to be seen not as standalone instances but as parts of a larger, linked whole. The judgments in such cases must be taken in phases, one after the other, since each step depends on the one before it. The need to make a difficult choice arises in many areas of real life, including the assessment of projects, the administration of businesses and organizations, and the treatment of illnesses. In these cases, several processes may be easily defined, the first is diagnostics, in which specialists ascertain the true nature of the issue at hand. Afterward, the diagnosis findings are used as the foundation for the choices made by specialists. At last, the system's future is forecasted in light of the preceding stage's options. The final answer is not found in any one procedure's output but in accumulating all such outcomes in their proper sequence[15]–[17].

Moreover, FCMs are limited in that they cannot express indeterminacy connections, which are situations in which it is unclear if a link exists between two ideas. To get around this restriction, Smarandache and Kandasamy proposed NCMs in 2003, which combine conventional FCMs with neutrosophic sets (NSs). Many academics have turned to NCMs to solve problems associated with selecting choices. Monda and Pramanik used NCMs to represent the difficulties faced by Hijras in the Indian state of West Bengal. The NCM model developed by Gaurav et al. for medical illness diagnosis was successfully used in speech pathology to identify linguistic disorders. To model the interdependencies between risks in projects, Betancourt, Leyva, and Pérez suggested a technique based on NCMs. Successful IT initiatives may be identified and evaluated using NCMs, as was done by Bhutani et al.. For the purpose of arthritis illness categorization, Shanmugam and Preethi established a novel framework for NCMs using a genetic algorithm (GA). In order to determine how much of an impact technical innovation has on Ecuador's GDP, Mayorga et al. employed NCMs. This paper presents the work of Ramalingam et al., who used NCMs to investigate the root causes of and potential remedies for the city's traffic jams. To explore children's creative thinking, Vasantha et al. turned to NCMs[18]–[21].

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The initial investigation revealed the following restrictions:

One major limitation of FCMs is that they cannot be used to describe or evaluate consecutive decision-making processes with several stages.

Second, a dearth of literature addresses the trifecta of diagnosis, choice, and forecasting inside a single decision-making framework. Amirkhani and Papageorgiou et al. identified this area of inquiry as a potential direction for FCM models' future development[22]–[24].

Using the symbol "I" to express indeterminacy connections among ideas, as done in the NCMs mentioned before, while the remainder of the map's interactions is handled as in typical FCMs, is an insufficient description of the indeterminacy. But the degree of uncertainty in the map's interconnections and corresponding output cannot be determined using this format.

So, this study is novel in the following ways:

One of its main contributions is the suggestion of a novel topology for sequential decision-making issues with several stages that unifies diagnostic, decision, and forecasting steps under a single umbrella.

A novel method of representing uncertainty is presented using TrNNs.

The third significant contribution is introducing a novel decision-making instrument for use in the assessment of projects, namely in the areas of diagnosis, decision, and prediction.

To solve multistage sequential decision-making issues, this work proposes a unique NCM based on TrNNs, an extension of fuzzy cognitive maps.

2. Neutrosophic Cognitive Maps

With ideas such as nodes and calamities or indeterminate lines representing the link between thoughts, a Neutrosophic Cognitive Map (NCM) may be constructed. In addition to having values in the range [1, 1], causal linkages in NCMs may also be undefined. To put it another way, an NCM is just an FCM with an extra indeterminacy connection. Any time the connection or impact of $Ci\ on\ Cj$ is unclear, NCMs set $wij\ =\ I$.

For NCMs, updating the activation rule is as simple as multiplying the starting vectors even by neutrosophic matrix E, where E = (wij), where wij indicates the weight of causal linkages among Ci and Cj, excluding indeterminacy relationships represented by I. Note that the activation of NCMs involves arithmetic calculations in which the letter I plays a role. The steps involved in this method are as follows: Take the ideas of an NCM to be C1, C2,..., Cn, and the neutrosophic matrix associated with it to be E. The data must traverse the neutrosophic matrix E. Thus, we may uncover the hidden pattern by multiplying the starting vector A0 = (1, 0, 0,..., 0) by E. In order to normalize ai 1, 0, I, a threshold procedure is applied to the expression A0(E) = (a1, a2,..., an), with ai replaced by 1 if ai > k and ai replaced by 0 if ai k (k—an appropriate positive integer), and ai replaced by I if ai is not a true figure. Let's pretend A0(E) is less than A1, and then we'll do it all over again, this time taking A1 into account (E). This process is continued until a fixed point, or a limit cycle is achieved. However, this depiction of indeterminacy is limited in that it cannot identify the degree of indeterminacy in either the map's connections or its output nodes; it can only flag the latter. Unfortunately, the threshold operation utilized in this method results in data loss during simulation.

In this study, we propose a novel method for representing this uncertainty in the connections of a map, one that enables us to quantify not just the degree of uncertainty, but also the degrees of truth and falsehood.

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Definition 1:

The truth-factor function TA: U] defines the neutrosophic set $A = (x, TA(X), IA(X), FA(X)) \mid x\, U. 0-, 1+[,$ an indeterminacy-factor function $IA: U \rightarrow]\, 0 >, 1 > +[,$ and a falsity-factor function $FA: U\,]\, 0-, 1+[.$ When added together, $TA(X), IA(X), and\ FA(X)$ might be anything from 0 to 3+.

It is challenging to work with data that falls beyond the range [0, 1+], which is why the single-valued neutrosophic set (SVNS) was developed; SVNS values fall inside the range [0, 1] and may be utilized in practical scientific contexts.

Definition 2:

Let the conversation revolve around you. One definition of an SVNS over a set U is an object of the type $A = (x, TA(x), IA(x), FA(x)) \mid x \in U,$ where $TA: U \rightarrow [0,1], IA: U \rightarrow [0,1], and\ FA: U \rightarrow [0,1]$, and where 0 TA(x) + IA(x) + FA(x) 3 for every xU. Degrees of membership, indeterminacy, and non-membership of x to A are represented $by\ TA(X), IA(X), and\ FA(X)$, respectively.

Definition 3:

A neutrosophic set with a single value is a triangular neutrosophic number A, which is a special neutrosophic set on the real line set R, where $(a1, a2, a3)$ reflect the boundary of a triangular function with a1 a2 a3, and $where\ (A, A, A) \in [0,1]$ denote the maximum truth-member Using the values of A, A, and A, one may determine the values of $TA: R \in [0, A], IA: R \in [A, 1], and\ FA: R \in [0, A].$

$$T_A^-(x) = \begin{cases} \alpha_A^- \left(\dfrac{x - a1}{a2 - a1}\right) & a1 \le x \le a2 \\ \alpha_A^- & (x = a2) \\ \alpha_A^- \left(\dfrac{a3 - x}{a3 - a2}\right) & a2 \le x \le a3 \\ 0 & otherwise \end{cases}$$

$$I_A^-(x) = \begin{cases} \left(\dfrac{a2 - x + \theta_A^-(x - a1)}{a2 - a1}\right) & a1 \le x \le a2 \\ \theta_A^- & (x = a2) \\ \left(\dfrac{x - a2 + \theta_A^-(a3 - x)}{a3 - a2}\right) & a2 \le x \le a3 \\ 1 & otherwise \end{cases}$$

$$F_A^-(x) = \begin{cases} \left(\dfrac{a2 - x + \beta_A^-(x - a1)}{a2 - a1}\right) & a1 \le x \le a2 \\ \beta_A^- & (x = a2) \\ \left(\dfrac{x - a2 + \theta_A^-(a3 - x)}{a3 - a2}\right) & a2 \le x \le a3 \\ 1 & otherwise \end{cases}$$

$According\ to\ this\ approach, causal\ connections\ between\ ideas\ are\ not\ only\ described\ by\ a\ membership\ function$
$- membership\ function, as\ shown\ by\ the\ following\ triangular\ neutrosophic\ number\ (TrNN): A$
$= (a1, a2, a3);\ A, A, A.$

$An\ unknown\ number\ represented\ by\ the\ TrNN\ A$
$= (a1, a2, a3);\ A, A, A\ is\ roughly\ equivalent\ to\ a2. To\ be\ more\ specific, we\ may\ represent\ the\ nebulous\ number$ "
$- membership, indeterminacy - membership, and\ falsity - membership.$

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This indicates that $a2$ *represents the most likely value, with degrees of* A *in truth membership,* A *in indetermina*
$-$ *membership degree equals* 0 *for* $a1$, *and falsity* $-$ *membership degree*
$=$ 1 *for* $a1$. $TA(x), IA(x)$, *and* $FA(x)$ *are the degrees of truth membership, indeterminacy membership, and falsi*

Each map's simulation is run in turn, independently from the others. The procedure begins with the selection of an input vector (called "Ai") to represent the system's current state. First, the input data is normalized by being converted to triangular neutrosophic numbers with error bars added to both the left and right. Experts evaluate the credibility of each data source and assign it a level of truth, indeterminacy, or falsehood. When time t+1 has passed, the starting vector Ait+1 will be determined as follows: figure 1 shows the neutrosophic cognitive map.

$$A_i^{t+1} = f(A_i^t \oplus \sum_{i=1}^{n} w_{ji} \otimes A_j^t)$$

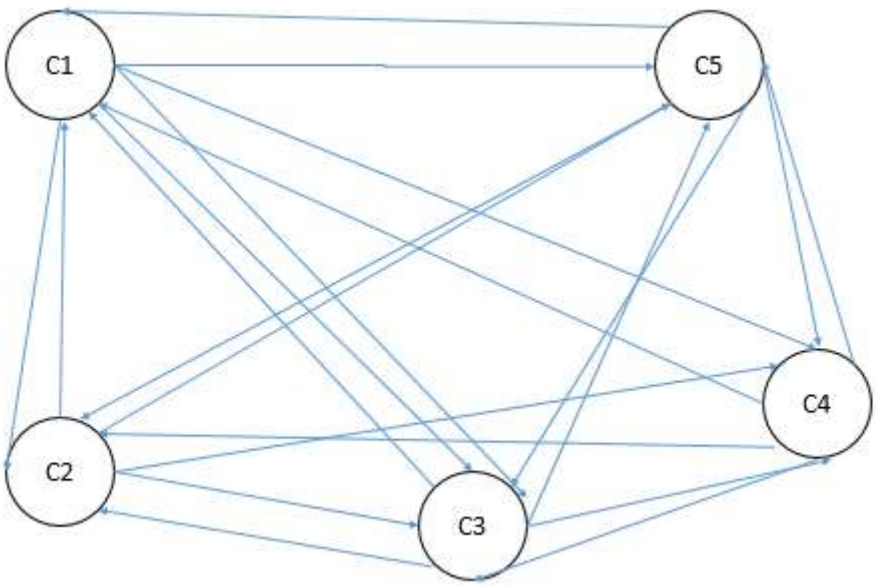

Figure 1: The neutrosophic cognitive map.

3. Simulation of the process

Violence among young people is a primary global health concern. Over 540 teenagers and young adults are killed daily due to physical aggression. Anywhere between 3.5 million and 7.5 million young folks worldwide get injuries from violence each year that need medical attention in a clinic. Death, lasting physical impairments, exorbitant medical therapy and rehabilitation expenses, and unfathomable suffering and discomfort are only some of the medical effects of violence.
We surveyed 100 young people within and around Chennai to acquire data on the causes and consequences of juvenile violence. Then, we converted part of the data into a BAM, with the primary causes of violence represented by eight characteristics and the effects of violence by seven. Below, we've included a quick overview of the most essential features.

Reasons why young people are violent:

I. A1 - Inadequate family functioning

II. A2 - Failing grades or quitting out

III. A3-Association with Juvenile Delinquents and Gangs

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IV. A4-Community poverty

V. Inequality (A5-Castesam)

VI. Topic A6: The Media's Role in Society

VII. The loss of A7-chances

VIII. Cost of living increases by A8 points

Youth violence's repercussions

I. Section B1: Alcohol and Drug Testing

II. Offense category B2: Vandalizing or torching public transportation infrastructure

III. Behaving in a criminal or terroristic manner (B3) includes acts like robbery, bombings, and the like.

IV. Murder/fake encounter (B4)

V. B5 - Protracted blow

VI. B6 - Get the hell out of Dodge

VII. B7 - Aggression on the rise

A second specialist was consulted in order to convert the questionnaire's linguistic language into NCM. Which 8 main characteristics of youth violence are selected, and explained, below. Tables 1:3 show the evaluation by the experts. Table 4 shows the final evaluation of criteria by experts.

I. Domestic violence and illegal behavior by parents constitute Category 1.

II. C2 - School absences and withdrawals

III. Negative treatment from a professor (C-3)

IV. Album: C4 - Bad Company

V. C5 - Low income, but values the dignity

VI. Substance abuse (C6): alcohol and tobacco

VII. C7 -Media violence and video game violence

VIII. Complaint 8: Aggression on the rise.

Table 1: Cognitive map by first decision-makers

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Q1	0.733333	0.572222	0.494444	0.477778	0.561111	0.4	0.544444	0.98
Q2	0.4	0.6	0.638889	0.6	0.663	0.8	0.4	0.98
Q3	0.372222	0.316667	0.6	0.666667	0.4	0.505556	0.294444	0.744444
Q4	0.455556	0.361111	0.4	0.505556	0.316667	0.322222	0.372222	0.45
Q5	0.533333	0.716667	0.588889	0.4	0.666667	0.6	0.4	0.8
Q6	0.4	0.533333	0.533333	0.588889	0.716667	0.8	0.477778	0.98
Q7	0.611111	0.8	0.6	0.322222	0.744444	0.372222	0.588889	0.8
Q8	0.455556	0.361111	0.533333	0.505556	0.4	0.322222	0.372222	0.45

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Table 2: Cognitive map by second decision-makers

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Q1	0.98	0.572222	0.494444	0.477778	0.75	0.4	0.544444	0.98
Q2	0.4	0.6	0.638889	0.6	0.663	0.8	0.4	0.98
Q3	0.372222	0.316667	0.6	0.666667	0.75	0.505556	0.75	0.75
Q4	0.455556	0.361111	0.75	0.505556	0.75	0.322222	0.372222	0.75
Q5	0.533333	0.716667	0.75	0.4	0.666667	0.6	0.4	0.8
Q6	0.4	0.533333	0.533333	0.588889	0.716667	0.8	0.477778	0.98
Q7	0.75	0.75	0.6	0.322222	0.75	0.372222	0.588889	0.75
Q8	0.455556	0.361111	0.75	0.505556	0.4	0.322222	0.75	0.45

Table 3: Cognitive map by third decision-makers

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Q1	0.91	0.4	0.91	0.477778	0.561111	0.91	0.544444	0.91
Q2	0.4	0.4	0.4	0.75	0.663	0.8	0.4	0.98
Q3	0.372222	0.75	0.6	0.8	0.75	0.75	0.294444	0.8
Q4	0.4	0.361111	0.4	0.505556	0.316667	0.322222	0.98	0.45
Q5	0.75	0.716667	0.4	0.4	0.666667	0.6	0.4	0.8
Q6	0.4	0.533333	0.533333	0.588889	0.716667	0.8	0.477778	0.98
Q7	0.75	0.8	0.6	0.322222	0.744444	0.372222	0.98	0.8
Q8	0.45	0.361111	0.533333	0.45	0.4	0.45	0.372222	0.45

Table 4: The final preferences of the experts.

Criteria	Preference
Q1	High
Q2	Very high
Q3	Perfect
Q4	Bad high
Q5	Very bad
Q6	Very bad
Q7	Perfect
Q8	Perfect

4. Conclusion

In this research, we introduce the multilevel serial triangular neutrosophic cognitive map (MS-TrNCM). Neutrosophic cognitive maps (NCMs) published in the literature were improved by adding truth, indeterminacy, and falsity levels into the weights and the map's ideas employing triangular neutrosophic integers TrNNs. Moreover, a novel topology for serial cross judgment issues was developed. Triangular neutrosophic values are used in place of the usual square and rectangular ones in the FCM and NCM modeling processes, respectively, to make the suggested model easier to grasp. We used NCM to examine what factors contribute to violence among young people, and the results show that factors A1, A2, A3, A5, A6, A8, B1, B3, B4, B6, B7, C1, C2, C4, C5, C6, C7, and C8 are significant. That is, The Impact of Dysfunctional Families, Educational failure or abandonment, Juvenile delinquency and gang affiliation, Inequality based on caste, Inflation in necessities prices and media influence Domestic violence and crime among parents, Lack of resources and a desire for independence and Audit for drugs and alcohol is a direct result of the media's use of violence and violent media products. Being involved in other types of criminal activity (such as terror, theft, etc.),

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