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Violence Detection Approach based on Cloud Data and Neutrosophic Cognitive Maps

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Abstract

Violence has remained a momentous problem since time immemorial. Various scientific studies are conducted in the recent past to identify the stimuli causing violent behavior among the masses and to achieve the target of cloud data protection. Given the inherent ambiguity or indeterminacy in human behaviour, this study in the area of violence detection appears to be effective, as it finds a variety of stimuli and character qualities that contribute to violent conduct among masses. This uncertainty of traits causing violence can easily be seen in surveillance data present over the cloud and also from the data collected using academic research. Therefore, for the purpose of identifying violent behavior we have considered the factors (data) from existing research and from data over clouds. The factors that lead to violent behavior and are identified by algorithms running over clouds are termed as determinate or certain factors. The factors that were not considered and least identified by the cloud algorithms and given less importance are termed indeterminate factors or uncertain factors. The indeterminate factors are also considered based on the expert's opinion where the experts are not in a condition to provide a clear stance or when they are neutral in their opinion. Tests are performed using Neutrosophic Cognitive Maps (NCMs) to model the violent behavior taking into consideration both determinate and indeterminate factors. Earlier these tests were performed using Fuzzy Cognitive Maps (FCMs) where indeterminate or uncertain factors were not considered. Therefore, we provide a brief comparison between NCMs and FCMs and show how effective NCMs are when we need to consider the uncertainty of concepts while carrying out tests for identifying violent behavior. Later results are obtained by forming a Neutrosophic adjacency matrix which is evaluated using the concepts of linear algebra. The obtained results in the form of $1 \times n$ vector (1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1) clearly shows the presence of indeterminate factor '1' in the vector which was absent in earlier models when designed using FCMs. This shows how these indeterminate or uncertain factors play a significant role in cultivating violent behavior which was not shown in the previous study. The study is significant since it takes into account factors from cloud data, experts' opinions, and also from literature, and shows how these factors are taken into consideration at the data level itself so that they will not impact the modeling stage, and machine learning algorithms will perform well because uncertain and indeterminate information is taken care of at training phase itself. Hence uncertainty could be reduced in machine learning algorithms and in the overall recognition of violent behavior.

Keywords: Cloud Computing, Violence Analysis, Neutrosophic Cognitive Maps, Unsupervised Data, Fuzzy Logic, Neutrosophy

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Introduction

It has always been an important issue that crime takes over humanity in history. There is an increase in crime statistics which can be inferred from reports presented

by police authorities [1]. A series of studies related to violence in the Latin American context affirms that violence is present in Latin American media [2]. This excess of theming has the effect of building a certain imaginary about violence and producing social attitudes in reference to them. Domestic violence is understood differently in different scenarios within the country and society but most of the time it is associated with violent cases related to women. As a consequence, human rights do not take domestic violence in its category because it does not require the proper response by their governments, organizations, and service providers [3]. The violence that occurs between close partners is inconsistent. Related protocols that define their terms are also inconsistent [4]. Generally, domestic violence deals with the misuse of powers by the life partner and that too a male partner. Most of the time or perhaps always females are not considered as agents of domestic violence [5]. The United Nations gives this statement on the abolishment of violence happening against females, “Any act of gender-based violence that results in, or is likely to result in, physical, sexual or psychological harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or in private life.” The nature of ethnocultural has promoted various issues in the world. Violence is at its peak around the world [6]. As per the Global Status report on preventing violence against children [7], the relational savagery that records for most demonstrations of viciousness against youngsters incorporates kid abuse,

tormenting, different sorts of youth brutality, and personal accomplice viciousness. The report explored that many countries should implement prevention programs against violence, victim services, and develop National action plans, policies, and laws required to support violence prevention. Crime statistics report of Mexico City shows how many crimes are carried out yearly with respect to the types of crime (Fig. 1).

The graph shows how crime is expanding yearly. Here crime is mapped into the top level and low level. Top-level crimes like extortion, kidnapping, and low-level crimes are vehicle theft. Violent behavior among people is motivated not only because of determinate factors but also by many indeterminate factors. There is not a single factor that is enough to define why a person behaves in a violent manner and another person does not. Same as one neighbour getting involved in violent activities while another neighbour believes in peace [1]. UN peace operations examined causality data and used it widely for the implementation of primary elements of mandates because the operations they performed, worked as the main actors in the world monitoring. This monitors death related to conflicts, civilian protection, protection of human rights, and avoidance of conflict. These operations may be the best alternative path of data in conflicts where conflicts related to deaths per 100,000 population, by age, cause, and sex. These operations explored present casualty data after performing operations in high contexts with three UN missions like The United Nations Organization of Mali, Association

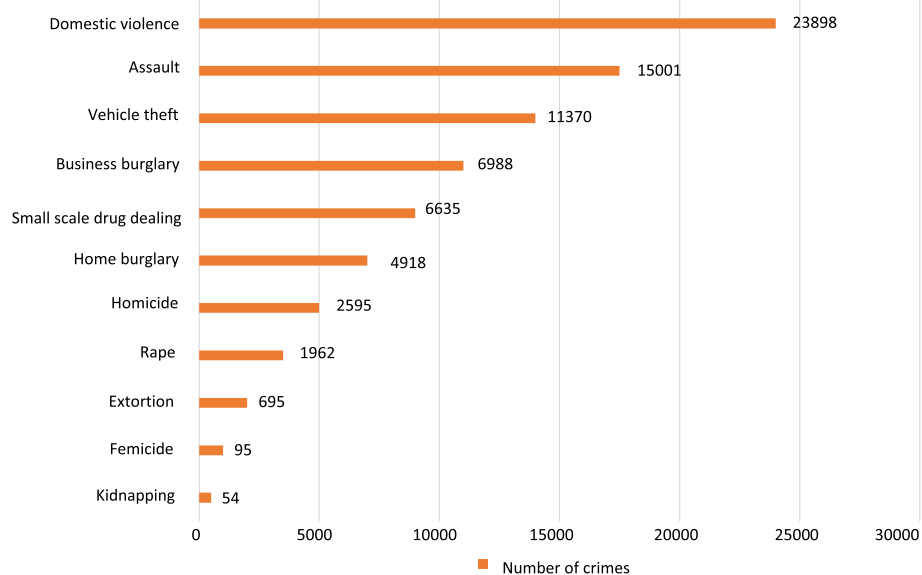


Fig. 1 Crime in Mexico City

Adjustment Commission in the Democratic Republic of the Congo, and The United Nations Mission in South Sudan. These are the areas where organizations and authorities are unable to provide such information. Additionally, monitoring conflict related deaths and casualty recording has turned up as a major tool for performing these operations. This sort of working/monitoring may improve scenario of typical society, and environments. One can get a better understanding of the reasons of the violence that people face and can get a hope of better solution to get rid of [8]. There are many databases that have served as the backbone to control violence [9, 10]. In 2018, there were a slightly higher number of intentional homicides which are given in the following Table 1 [11]:

Violence may be defined as, “A typical phenomenon which has its connections with different factors like economic, social, biological, cultural and political.” Different types of violence have been perceived by world report on violence and health. Data was prepared based on the Ecological model. This was introduced in 1970s for exploration of childhood abuse [12, 13] and used for categorizing different types of violence [14, 15], widely used and still refined as a piece of logical equipment. The main strength is to help in distinguishing between the infinite impacts of violence even at the same moment furnishing a structure for perceiving how do they perform the interaction. Ecological model is given in Figure 2 and that have been categorized in

Table 1 Number of intentional homicides and direct conflict deaths

Year	Victims of International Homicide	Direct Conflict Deaths	Countries
2014	396,000	143,000	Iraq
2015	388,000	127,000	Myanmar
2016	399,000	117,000	SouthSudan
2017	407,000	124,000	Syria
2018	409,000	105,000	Afghanistan

four levels that help in finding the factors which affect human behavior and aids in incrementing the level of committing violence or being a victim.

Before moving on to the analysis of factors, first let us mention all violence types depending on the context in which violence occurs [14, 15]:

i. **Domestic violence:**

Domestic violence includes various categories of violence in which child is exposed in home by family members and relatives towards violence. Violence starts to take place when adults are involved in violence and children are there to see unfortunately.

ii. **School violence:**

This type of violence includes most of the types of violence that happens between or among children, peer violence as well as violence growing against children by seniors.

iii. **Institutional violence:**

Institutional violence covers all forms of violence against children housed in residential childcare facilities (peer as well as adult violence against children).

iv. **Digital violence:**

The violence that starts taking place through digital communications or takes place by various means of digital equipment is called digital violence.

xxii. **Community violence:**

Community violence encompasses different forms of straight violence perpetrated on children by strangers, additionally underlying types of violence that manifest themselves as friendly rejection and segregation.

As we've seen, detecting acts of violence is crucial in the present context. The emergence of data from different sources is also the most significant and vital feature of daily life in this era of tremendous technological advances. There is also a proliferation of low-cost digital cameras and other devices that stream data of high

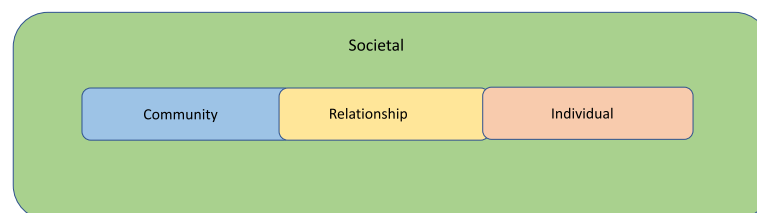


Fig. 2 Ecological model

quality but are otherwise diverse. In order to get useful information from these cameras' video streams, analysis is required. One of the most pressing requirements for crime prevention is the ability to detect violent behaviour in these data streams. Streaming video and other data are useful for detecting violent content, but the data is not necessarily in an ideal format for analysis. There are a number of imperfections such as indeterminacy and unpredictability, which make it difficult to prioritise the causes of violence. As a result, research into the topic is required to eliminate data-based uncertainty and pinpoint relevant characteristics for analysing violent behaviour. The following section explains why cloud data is so crucial in this context.

Cloud Computing

Cloud computing is a model for enabling access to computing resources that evolved in information technology and has become a dominant business model for delivering IT infrastructure, components, and applications [16]. Actually, the term cloud computing first introduced by Eric Schmidt in the conference of Search Engine Strategies in 2006 [17]. There are many definitions of cloud computing, we can say that it is a type of technique where services related to information technology are offered by massive low-cost computing units connected by IP networks. Cloud computing is one of the most popular techniques in current scenario, but security remains a major concern in it [18]. It may use in scenarios where work deals on application basis. Many organizations are involved in promoting cloud computing by its services. John McCarthy explained in his note at MIT in 1961 that the computer utility could become the base of a new and important industry which implied the underlying concepts of cloud computing.

As we know all types of data like, data from different companies, data from government organizations, data from surveillance cameras while recording the events to find out the violence etc. are stored on cloud. Therefore, we are in need to protect this data by finding determinate and indeterminate factors. These factors play an important role in violence detection and prevention. This concept comes in the category of CloudData Protection which is the practice of securing a company's data in a cloud environment, wherever that data is located, whether it's at rest or in motion, and whether it's managed internally by the company or externally by a third party. This work incorporates data from both academia and industry, whether available in literature or over clouds and studies how these factors could be taken into consideration for detecting violence.

The approach adopted in this work holds significance because this not only takes data from the literature, but

data from clouds is also considered for detecting violence. This is done keeping in mind the availability of data over clouds. The current approach entails taking data from both the literature and the cloud, whether certain or uncertain, and maps them using neutrosophic cognitive maps in such a way that relationships between data can be drawn in order to derive meaningful insights from the data for violence detection. This approach is oriented towards solving the problem of real time violence detection and machine learning usage in its detection has been encountered at various occasions [19–21]. The contribution of present work is that, this work uses neutrosophic sets and theories for violence detection. The limitations of existing methods have motivated this study. Earlier approaches were mainly based upon fuzzy cognitive maps for prioritizing the traits of character which cause violence. These approaches were not efficient since they did not take into consideration the indeterminacy associated with data. Also, fuzzy methods take into consideration all those factors where membership functions can be defined. Therefore, cannot represent situation when factors are indeterminate because fuzzy does not define functions for indeterminate membership. These limitations of fuzzy have motivated us to take the task of using neutrosophy for prioritizing factors that are responsible for causing violence.

The other six sections of the study are organized as follows: Section 2 describes research that was done by researchers using various datasets in the field of violence detection. Additionally, it clarifies the issue and the significance of cloud data in this context while mentioning many literary works that make use of cloud data. The concepts and preliminary information needed to carry out this research are introduced in Section 3. The materials and methodology used in this research are summarised in Section 4. The neutrosophic application for modeling the situation utilizing factors affecting violence is highlighted in Section 5. Section 6 presents the results, while Section 7 presents a thorough analysis.

Related Work

This section illustrates various works from literature that are carried out in order to identify traits of character for violence detection. The works are categorized based on factors which have been used for detecting violence. This literature forms the basis for selection of data for modeling stage. The data which is taken comprises of both i.e., data from literature and data from cloud sources. Now let us understand literature as follows:

In this article, we focused on work done by prominent researchers and different case studies of Ghana [22], Police Service of Northern Ireland Statistics and Research Agency (NISRA) [23], Ethiopia [24], Reports

published by World Health Organization (WHO) [25], Fordham University (New York) [26], and Jordan Institute for families [27] to identify the factors resulting in violent behavior and took cloud data [19] to maintain the confidentiality, integrity and availability of an organization. Violence is motivated by several factors. Some of the factors are highly visible and much cited by the researchers termed as determinate or known or certain factors, while some are less cited but having larger effects on the criminal behavior are named as indeterminate or unknown factors or uncertain factors throughout this research. Mapping these determinate and indeterminate factors can help policymakers, professionals and practitioners to identify criminal behaviors and build a surveillance system that may help in violence detection. Now let us understand each of them one by one.

Ebenezer S. OwusuAdjah et al. [22] found in their study that married women from Ghana reported factors that increase the possibility of creating places for domestic violence. Authors analyzed & gathered risk factors by using procedure of forward selection and multivariate logistic model on information provided by Ghana Demographic and Health Survey (GDHS) in 2008. At last, they found in their data that 1525 ever-married lady, and 33.7% had at any point experienced aggressive behavior at home. They observed that the average for confronting aggressive behavior at home was 35% for those ladies who live in metropolitan regions and the average of abusive behavior at home was 41% higher for ladies whose spouses at any point encountered their father beating their mother. So, living place, family history related to crime plays a greater role in determining the criminal behaviors among people which is less noticed by the researchers and hence finds a lower position while formulating the policies by the policymakers. Hence it is an indeterminate factor. Generally, it was noticed that ladies whose spouses drink too much alcohol face domestic violence 2.7 times higher than ladies whose spouses do not drink or do not take too much wine, so it is considered as determinate factor.

Michael A. Koenig et al. [28] found in their studies that violence (physical, sexual, and domestic) associated with individual factors of childlessness, economically not strong persons, some sort of pressure, and transmission of violence intergenerationally are important factors to violence. Hence, they termed as certain or determinate factors. Furthermore, the dowry system of India generates a relation with a higher risk of violence and level of dowry is highly determined by the financial condition of the family which in turn results in crime as pointed out by authors, hence it becomes an indeterminate factor leading to violence.

Sylvie Mrug et al. [29] investigated emotional desensitization which leads violence where external issues played role as a mediator of connection between exposure to violence into two categories like preadolescence and violent behavior in late adolescence. As we have seen some adolescents are exposed to violence in house, community, and college. Hence, they are termed as known, determinate, and certain factors. It has been represented in low levels of internalizing symptoms that high level violence has been linked to emotional desensitization. Even long consequences of desensitization are undefined. Hence on a broader note we take long term emotional of desensitization as an indeterminate factor which has a wider impact on criminal behavior.

As per Fordham University, New York [26], there are many factors that lead to aggressive behavior which contribute to violence, no one can stop by saying that this is the only definition of factors regarding aggressive behavior. General or known factors affected with aggressive behavior includes vandalism or fighting, excessive use of drug, alcoholic abuse, plans for violence, easy access to weapons but there are many factors that may be indeterminate that leads violence like extreme requirement for respect, feeling of low self-esteem, early misbehavior with children, bullied, standing with violence in house, community, or in media.

Lyn Francis et al. [30] explored how ladies judge their experience of abusive behavior at home and also tried to ignore or end violence. There are many complex barriers that create pressure on women to keep silence on disclosing abuse, action to finish domestic violence. Some women did not acknowledge and even some women did not realize that their relationship was indefinite and sometimes tried to deny or minimize the maltreatment to adapt to the aggressive behavior at home. Authors found in their study that woman does not recognise nor even acknowledge abuse in their relationship, this took long time to provide best service. If they acknowledge violence at time then there will be some services on time which may help in minimising violence. Hence "Denying or minimizing the abuse by women" considers as indeterminate factor that leads violence.

Prothrow-Stith et al. [31] explored why manhandled kids experience issues in learning and studied the effect of experiencing childhood in vicious environmental elements and insecure neighbourhoods. Violent surroundings play an important role to grow with bad effects, that's why it encourages more violence. So unsafe neighbourhood may lead to an indeterminate factor that leaves an important impact on violence.

Devadoss et al. [32] analyzed the causes of youth violence. Both deadly and non-deadly assaults involving youth play widely to the weight of early demise, hurt,

and infirmity. Basically, youth violence profoundly hurts not exclusively its causalities, yet in addition their families, companions, and networks. Authors worked on factors like Poor family functioning, Membership of a gang, Poverty in the community, Inequality, Influences of mass media but there are some indeterminate factors that should be considered like Dropping out of school, Denial of opportunities, Hiking of prices related to basic requirements of survival, Long drawn strike, Fake encounter, Run away from home, Violent video games, and Treatment by the teacher.

According to the Police Service of Ireland & NISRA (Northern Ireland Statistics and Research Agency) [23], any type of violence committed online or by Internet-based activities should be flagged. Authorities are involved in finding the reason of violence based on determinant factors like email, social media, websites, messaging platforms, etc., but they should go by the indeterminate factor like gaming platform or smart devices. Figure 3 shows the number and types of online crimes for Northern Ireland by the type of offenses.

Reva et al. [33] found in their study that targeted to examine and to expand the understanding of the working authorities who contribute to this area, to recommend possible ways to stop the imposed marriages. Constrained relationships are relationships where one of the two life partners does not consent to marriage or does not agree to the marriage. Brutality, dangers, or some other type of pressure is involved to realize the relationships and cause various exploitations. So, we can take forced marriages as an indeterminate factor that has an impact of violence happening.

World Report on Violence and Health [34], found that approximately 565 children, adolescents and young people into the age limit of 10 to 29 years die each day just because of interpersonal violence across the world.

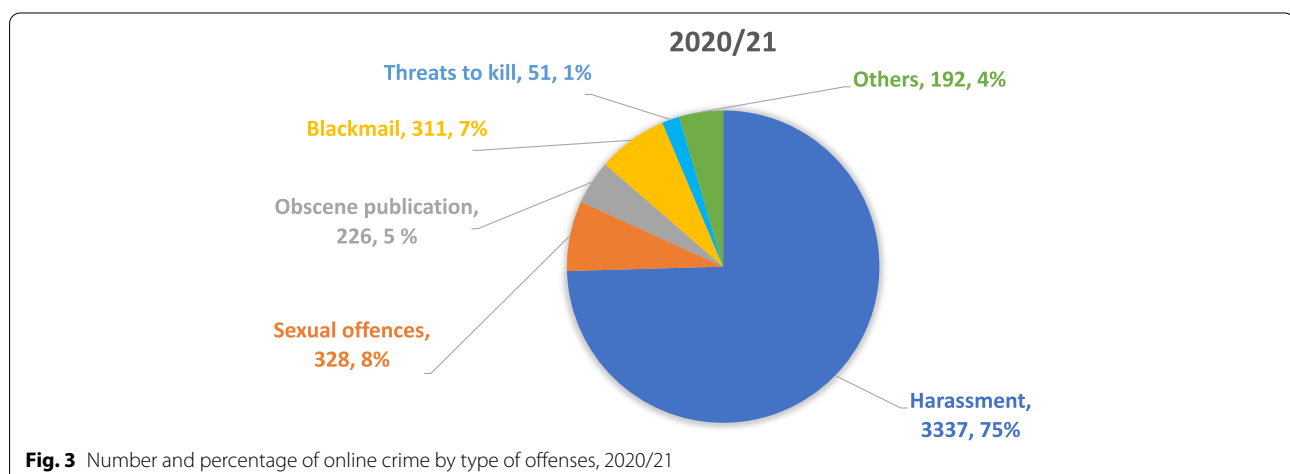
Mostly these cases may be seen from region of South-East Asia and rapid growth of violence escalation among youth in each Nation, culture and community is disturbing.

Kaufman et al. [24] found that violence based on gender is a genuine public concern in Ethiopia. As per author's concern, harassment is known factor for gender-based violence in Ethiopia and there are other serious factors that lead violence as intimidation giving low social status to female students. These should be considered as unknown or indeterminate factors. WHO found in a study about health domestic violence related to women [35] that 71% of Ethiopian women faced physical or sexual brutality by their husband. This type of brutality/violence leaves a bad impact in their country, community and relations.

Pretus et al. [36] found an emotional element in his research that can affect any individual to get involved in violence among different groups for the values that are at stake. Sacred values are related to human emotions, for this people are ready to fight or even ready to die. People are always ready for the defence of these values, and they are very close to the people [37]. It does not matter what is the significance of them. These may be religious or secular like Holy Land, The Nation etc., these examined like critical to draw disputes recalcitrant [38–40]. Hence sacred values may be the indeterminate factor.

Jordan Institute for Families [27] released practice notes for predicting the violence and as usual they found known factors that leads violence like humiliation, access to weapons, experiencing childhood abuse or aggression in the home and found some indeterminate factors like boredom and a sense of powerlessness, feeling a sense of injustice or oppression.

Virginia Saez et al. [41] presented a state-of-the-art of research that addressed the mediatization of the



phenomenon of violence in schools, from the mid-1970s to 2015. Their study showed the advances in research, predominantly Latin American, on the ways in which the media present the phenomenon of violence, its relationship with young people and the school. Authors categorised their work in three states: the contents and forms of violence in the discourses of the media information; informative coverage on young people and their connection with violence; and the school as a privileged setting for the mediatization of violence. Theoretical and methodological aspects involved in the research are examined. Subsequently, a review is made of the dimensions, violent episodes that still remain to be explored so it can be counted as indeterminate factor.

World Health Organization (WHO) [25] prepared data in terms of report on health and violence, found cause for death. As per the report, these death rates vary based on the Gross National Income (GNI). Death rates in low- and middle-income countries are more than twice as high (32.1 per 100,000) as those in high-income countries (14.1 per 100,000). This can be seen in given figure that there is a huge amount of differences in death rates among WHO regions. WHO found in report that rates of Homicides are three times higher than rates of suicide in the regions of Africa and America as shown in Fig. 4. An average rate of suicide is higher than double rate of homicide in the regions of South-East-Asia and Europe. By these findings, we can take the income level of countries as an indeterminate factor.

Labrum Travis et al. [42] reviewed reasons of violence at home towards family members. Authors found about persons who have mental illness, involved in violence, generally they make trouble for caretakers, but not intentionally. As per author, family members faced violence, who have direct contact with mental illness person. Last year victimization was 20% higher.

People living with dysfunctional behavior are at a humbly expanded chance of carrying out viciousness, lopsidedly prone for focus relatives which people really do commit ruthlessly. Authors found known factors behind the violence like recent victimization, mental health treatment, hostility, criticism in their work but there are indeterminate factors that authors talked about like nonadherence to medications and verbal aggression.

According to Rutgers [43] there are several contributing indeterminate factors in violence like penchant for narcissism to treating the casualty with no respect or regard, utilization of a fierce way of behaving, and ability to control the person in question and following. As per the study of Centres For Disease Control and Prevention under the chapter of violence prevention [44], violence related to youth made an understanding of factors that make public more vulnerable to victimization. Aggression in behavior, drug involvement, tobacco, alcohol, poor behavior with community, emotional distress, uncounted beliefs, bad attitudes are the risk factors that lead to youth violence but many violence factors that are too far from agencies they are just like unknown but have a significant role in violence, poor monitoring & supervision of children, parental substance abuse or criminality, and socially disorganized neighbourhoods. Violence is taking over humanity. To overcome violence, many prominent researchers did lots of work [45–47].

Chihlin et al. [48] performed work to overcome domestic violence by taking education as an indeterminate factor with the help of services of cloud computing. Authors considered gender paradigm and much involvement in technology as the factors leading to violence and presented novel method so that public can do legal work for their safety, education on family values, and family therapy supported by professional community members via

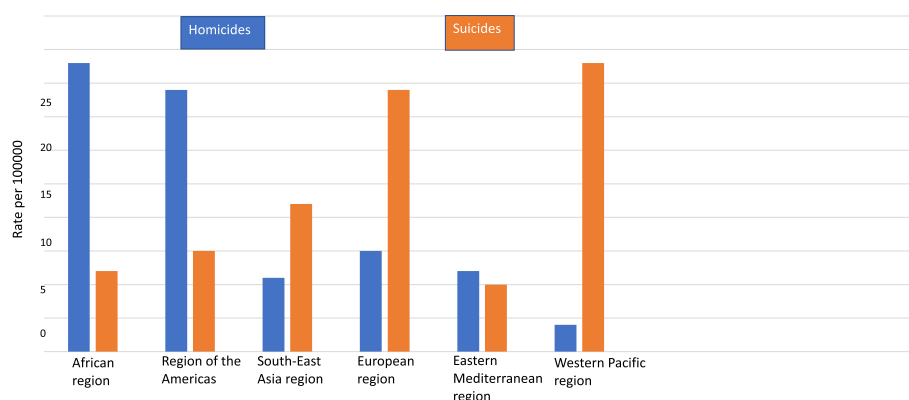


Fig. 4 Homicide and Suicide rates by WHO regions

cloud computing platform. Since cloud computing service can make education accessible to the needy people based on their demand.

Omar Sabri et al. [49] presented pros and cons of each factor and presented plan for picking best answer while selecting cloud computing service to overcome violence with cloud-based data. Authors used two famous models of Information Systems Success, McLean and DeLone [50] model for accessing few elements that should consider by an organization when making the decision of adopting cloud computing services.

Diana Freed et al. [51] presented the role of mobile devices, and services of cloud computing play an important role in intimate partner violence (IPV). These include domestic abuse (determinate factor), stalking, and surveillance of victims by abusive partners. Authors conducted interviews with 40 IPV professionals and nine focus groups with 32 survivors of IPV and revealed a complex set of socio-technical challenges that stem from the intimate nature of the relationships involved and the complexities of managing shared social circles in IPV ecosystem, New York City. Both IPV professionals and survivors felt that they did not possess adequate expertise to be able to identify or cope with technology enabled IPV, and there are currently insufficient best practices to help them deal with abuse via technology. Many prominent researchers did the work regarding security challenges in cloud [52] and influencing factors in the decision to adopt cloud computing in the private sector [53]. Edeh et al. [54] worked on cloud security challenges by considering sacred nature of educational data, authors examined the implications of cloud security challenges on education and found that security [55] is very significant to the successful migration and implementation of cloud technology in the educational sector. It also shows that the growing security limitations associated with cloud computing technology has the tendency to discourage many educational institutions from adopting cloud services.

According to recent research by Palanivinayagam A. et al. [56], conventional crime detection and machine learning-based algorithms are unable to properly forecast crime trends because they are unable to produce essential prime qualities from the crime dataset. Their strategy is geared toward improving the topic machine learning algorithm's precision by extracting the most salient attributes, such as time zones, crime probability, and crime hotspots, and doing vulnerability analysis. Concerns about security and privacy in relation to unmanned aerial vehicles were briefly analysed by Siddiqi M.A. et al. [57]. As a means of addressing these issues, the report also provided solutions and recommendations. In addition to providing a high-level overview of UAVs/drones,

this paper updated the reader on the latest in relevant rules, classification, architecture, and communication protocols. The document also covered use cases, security flaws, countermeasures against various threats, and constraints. The report closed with a discussion of future research directions and some suggestions for bolstering the safety and privacy of UAVs.

Chen Zhi et al. [58] presented violence detection by Unmanned Aerial Vehicle (UAV) on the platform of cloud and used cameras to monitor public places, shoot videos and send them to the cloud platform to detect the violence in the videos, which can discover the violence in public places in time and give early warning to prevent criminal incidents. On the basis of the aforementioned works, many determinate and indeterminate factors that contribute to the environment of violence are identified. These works demonstrate not only how these factors contribute to violence, but also demonstrate how they might be included into future efforts to detect violence in real-time streaming media. Consequently, this research integrates these factors, as well as factors extracted from cloud data based on related works, in order to discover the most influential personality traits that lead to violent behavior. The motivation behind this work is need to address the issue of data imprecision when developing methods for violence identification in videos. This imprecision results from classifiers' reliance on erroneous and incomplete data, which produces an inaccurate decision function. This also occurs when scores generated by many classifiers are fused; this is known as the imperfection problem. This research is also motivated by the belief that algorithms for detecting violence would perform better if they explicitly account for the indeterminacy, uncertainty, and imperfection of data at both the representational and decision levels. In fact, machine learning techniques are inseparable from indeterminacy and uncertainty as data that is used during the training phase is most of the time imprecise, incomplete, indeterminate, and noisy. The problem is also faced in classifier learning because the primary objective of classifier learning is prediction accuracy. Handling indeterminate and uncertain data should be a major concern of classifier learning since indeterminate data may impact not only interpretations of data and designed models but also impacts the sole purpose of the classifier, that is, prediction accuracy. Moreover, the generalization beyond that data, the process of induction, is still affected with uncertainty. This research, which focuses on the study and development of neutrosophic techniques for better handling of uncertain and indeterminate data in designing algorithms, is driven by the growing need for the development of effective and sophisticated techniques for handling data imperfections while designing approaches for violence detection.

Concepts and Preliminaries

Fuzzy logic and Fuzzy Cognitive Maps [59] are used to model the situation of violence. There exists a lot of work that has used these concepts some of them have multiple limitations [60, 61]. Basically, Fuzzy logic depends on membership function and crisp sets that are used for showing the relationship among the concepts. Fuzzy logic is used to map the existence and nonexistence of membership among different concepts, but it does not say anything about the uncertain or indeterminate concepts. It is observed that whenever violent behavior is identified using machine learning we need to address a lot of factors which are indeterminate since most of the time we need to deal with unsupervised data. Since fuzzy sets and theories deal with only certainty of factors, here we employ neutrosophic sets and systems to deal with uncertainty among data representing various factors. There exist research areas where we can deal efficiently with uncertain concepts using Neutrosophy [62, 63]. Neutrosophy is a field that deals not only with determinacy but also deals with indeterminacy. This is an emerging field that plays an important role while dealing with any situation. We can see a number of applications of neutrosophy where it has been used as a tool to resolve number of issues around the world and satisfied with efficient results as we can see in [64, 65], here authors proposed decision making model on multi-criteria for examine sustainable hydrogen production and proposed a system related to decision making and focusing on multi criteria for medical system respectively. Abdel et al. [66] presented Type-2 Neutrosophic Number to explain information related to real cognition by taking multiple case studies. Many authors did the great work by using the concept of Neutrosophy & Fuzzy Cognitive Maps [67], [68], [69]. This motivates us to analyze the violence situation of various case studies and report provided by genuine organizations and authorities. We must understand the methods we are going to apply. These all are as follows:

Neutrosophic Logic

Let us consider a neutrosophic set $N = \{(T, I, F) : T, I, F \in (0, 1)\}$. A mapping $m: P \rightarrow N$ of various propositional formulas into N , i.e., for every $p \in P$ is associated to a value in N , a value in N exists as given in Eq. (1), notifying p is $T\%$ true, $I\%$ indeterminate and $F\%$ false.

$$m(p) = (T, I, F) \quad (1)$$

So, in conclusion, when fuzzy logic is generalized based on some concepts of neutrosophy; it becomes neutrosophic logic according to [62].

Neutrosophic Sets

Let U be a universe of discourse, and M a set included in U . An element x from U is noted with respect to the set

M as $x(T, I, F)$ and belongs to M in the following way: it is $t\%$ true in the set, $i\%$ indeterminate (unknown if it is) in the set, and $f\%$ false, where t varies in T , i varies in I , f varies in F . Statistically, T , I , and F are subsets, but dynamically T , I , and F are functions/operators depending on many known or unknown parameters. Neutrosophic set is a generalization of intuitionistic fuzzy set, inconsistent intuitionistic fuzzy set (Picture fuzzy set, Ternary fuzzy set), pythagorean fuzzy set (Atanassov's intuitionistic fuzzy set of the second type), q-Rung orthopair fuzzy set, spherical fuzzy set, and n-hyper spherical fuzzy set.

Neutrosophic Triplets

Consider a concept, an idea, a statement, or any other sentence represented by $\langle A \rangle$; there always occurs the opposite of that concept, idea, statement, or sentence represented by $\langle \text{anti } A \rangle$. In between the concepts and opposite of concepts, i.e., between $\langle A \rangle$ and $\langle \text{anti } A \rangle$, there always occurs a neutral part which is referred to as $\langle \text{neut } A \rangle$. This neutral concept refers to indeterminacy. This indeterminacy i.e. $\langle \text{neut } A \rangle$ is neither $\langle A \rangle$ or $\langle \text{anti } A \rangle$ but it may be partial $\langle A \rangle$ or $\langle \text{anti } A \rangle$. The set which consists of these three concepts i.e. $\langle A \rangle$, $\langle \text{neut } A \rangle$ and $\langle \text{anti } A \rangle$ is a neutrosophic triplet i.e. $(\langle A \rangle, \langle \text{neut } A \rangle, \langle \text{anti } A \rangle)$ is a neutrosophic triplet.

Neutrosophic Matrix

Generally, a matrix contains number of rows (m) and columns (n). In Neutrosophic Matrix $[a_{ij}]_{n \times m}$, whose entries are of the form $a + lb$ (neutrosophic number), where a, b are elements of the interval $[0, 1]$ and I is an indeterminate such that $I^n = I$, n being a positive integer. So, the difference between the neutrosophic number of the form $a + lb$ and the single-valued neutrosophic numbers is that the generalization of fuzzy numbers and the single-valued neutrosophic components $\langle T, I, F \rangle$ is the generalization of fuzzy numbers and intuitionistic fuzzy numbers. Since the fuzzy number lies between 0 to 1 so the component neutrosophic fuzzy number a and b lies in $[0, 1]$. In the case of single-valued neutrosophic matrix components will be the true value, indeterminacy, and false value with three components in each element of a matrix [70, 71].

$$M = [a_{ij}]_{ij}$$

$$i = 1, 2, 3, 4, \dots, m$$

$$j = 1, 2, 3, 4, \dots, n$$

and every $a_{ij} \in (I)$ where $K(I)$ is neutrosophic ring. Let's explain Neutrosophic Matrix with an example. Assuming

that each and every matrix element is presented by $a+lb$, here a, b denotes real numbers, and I denote indeterminacy.

$$\begin{bmatrix} -3 & 7I & I \\ 5 & 8 & 6 \end{bmatrix} \begin{bmatrix} 4 & 7I & 9 \\ 3 & I & 5 \\ 2 & -4 & 0 \end{bmatrix} = \begin{bmatrix} 11I & -18I & 8I \\ 56 & 19I & 85 \end{bmatrix}$$

Neutrosophic Graph

Neutrosophic graph contains nodes that represents concepts and links among various nodes show which shows the relationship between nodes as in general graph. Some of the nodes of Neutrosophic graph known as Indeterminate node and links are known as Indeterminate edges. After considering reference from the Neutrosophic Matrix, we can say that if $[a_{ij}] = 0$, then there is no relation/connection between nodes i and j , if $[a_{ij}] = 1$, then we can say that there is a relation/connection between nodes i and j , and if $[a_{ij}] = I$, then we can say that relation/connection is indeterminate (unknown). Let us take a Neutrosophic directed graph [72] that have 5 vertices and have edges that are known as neutrosophic edges shown by Fig. 5.

Here, dotted lines represents neutrosophic edges and neutrosophic matrix M related to above graph is given below which is a 5×5 (matrix)

$$M = \begin{bmatrix} 0 & 3 & 0 & 2I & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 4I \\ 0 & 7 & 2 & 0 & 5 \\ 0 & 7 & 0 & 0 & 0 \end{bmatrix}$$

Cognitive Maps

These are network known as cause-effect networks, where nodes represents concepts articulated by individuals, and directional linkages capturing causal dependencies [73]. To address causal thinking, Fuzzy cognitive maps (FCMs) are used which is also known as structure graph for Fuzzy concepts. Their fuzziness allows hazy degrees of causality between hazy causal objects (concepts). Their graph structure allows systematic causal propagation, in particular forward and backward chaining, and it allows knowledge bases to be grown by connecting different FCMs. FCMs are especially applicable to soft knowledge domains. Causality is represented as a fuzzy relation on causal concepts [59].

Neutrosophic Directed Graph

A simple graph contains nodes and edges. A graph is said to be directed when edges of this graph have direction towards nodes. Here nodes work as a concepts and edges show-ingrelations among nodes. Neutrosophic Cognitive Maps, which are neutrosophic directed graphs that can transpose concepts like factors, processes, events, economic policies, as nodes, and indeterminacy as edges [74]. Directed graph is associated with values for each relation, we can see a representation of the relationship between concepts. After construction of the directed neutrosophic graph, the matrix associated with it is written, resulting thereby in the adjacency matrix of the neutrosophic cognitive map [75].

Materials and Methodology

To understand the methodology adopted in current research we need to first understand the concept of FCM [74]. A fuzzy cognitive map (FCM) is a type of knowledge

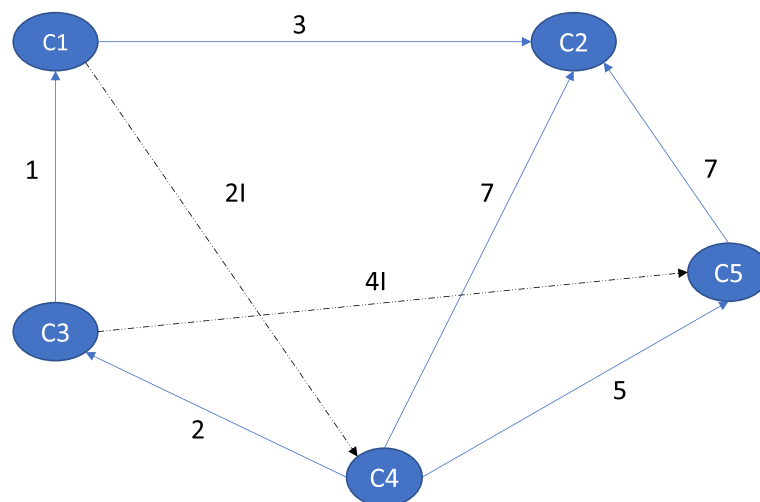


Fig. 5 Neutrosophic Graph

graph made up of nodes that represent various concepts and connections between these nodes is represented by edges [59]. Its popularity is clearly influenced by the introduction of Google's knowledge graph in 2012 [76]. Significantly, big corporations such as Google, Yahoo, Microsoft, and Facebook have developed their own knowledge graphs that enable smarter data processing and delivery: The application of these knowledge graphs is now the rule rather than the exception [77]. The concepts in FCM represent a causal system and they are mostly non-linear. The relationship among these nodes can take values in the range $[0, 1]$. The directed links that define concepts & associations can be positive or negative, with values ranging from -1 to 1 [78]. Though efficient these FCMs do not take into consideration the indeterminate relationship among concepts. Indeterminacy should not only be understood as it is mentioned in the lexical dictionary but it should be understood as something that exists between $\langle \text{concept} \rangle$ and $\langle \text{anti}(\text{concept}) \rangle$, i.e., in between the opposites. This indeterminacy of concepts and relationships among them can be termed as uncertain, unclear, vague, conflicting, neutral, incomplete, unknown, etc. [79]. We would like to use the concept of NCMs to model the situation of determinate and indeterminate factors that affects violence. As we know NCMs are Neutrosophic Graphs and known as directed graphs. This graph contains two types of edges, first type of edge is complete edge as we have seen in normal graph, this edge shows determinacy, and another type of edge is dotted edge which represents indeterminacy. Nodes of the graph are referred as various concepts. For example, $N_1, N_2, N_3, \dots, N_n$ represented as nodes of

Neutrosophic Graph. These nodes referred as concepts that are connected with the help of edges having weights like "0" or "1" or "I", where '0' represents that particular node is in "OFF" state, "1" represents that particular node is in "ON" state, "I" represents indeterminacy. Generally, these types of Neutrosophic Cognitive Maps are called simple NCMs. Corresponding matrix to Neutrosophic Graph is known as Neutrosophic Adjacency Matrix [80, 81]. After that, this matrix will be evaluated by mathematical laws to get the required result. The result we obtained will be interpreted for presenting the significance of the work. Let's take an example of South Africa and affecting factors for violence. Authors tried to prove the effectiveness of NCMs over FCMs for analysing current scenario of violence in the world by Fig. 6.

In this example [82] authors took ten Known or Determinate Factors like $K1, K2, K3, \dots, K10$ and took nine Indeterminate Factors like $U1, U2, U3, \dots, U10$. Authors took Blue Color for showing Determinate Factors and Orange Color for showing Indeterminate Factors respectively. It does not matter whatever the color we chose for the nodes. Straight simple line shows the relationship among Determinate Factors affecting violence and dotted lines show the relationship among Indeterminate Factors. The edges have weight "1" that represents known or determinate factors and the edges having representation "I" shows Indeterminate edges. Actually, Fuzzy Cognitive Map does not take into consideration unknown or indeterminate factors, so we put outside these factors $U1, U2, U3, \dots, U9$. Here we put factors $U1, U7, U8, U9$ separately because they do not have relation and does not

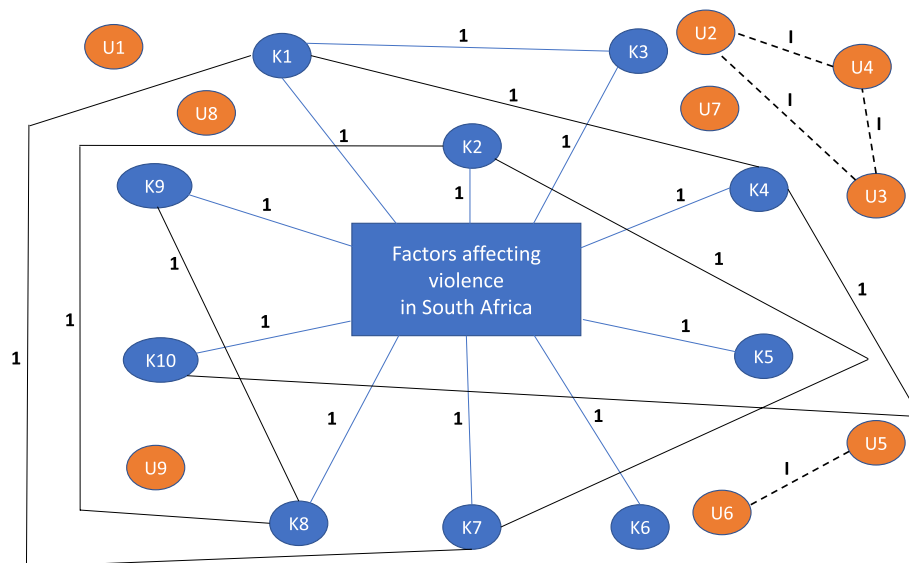


Fig. 6 Fuzzy Cognitive Map based on determinate factors

current sense. Therefore, it has been cleared that Fuzzy Cognitive Maps take no value related to indeterminate factors which could have direct influence on the concepts. So, we must work with situations using Neutrosophy [63], [83, 84].

Neutrosophic application for Modeling the situation using Factors affecting Violence

We found many factors from the literature that will help to design the condition of violence. The following Table 3 shows factors that are considered as

determinate and Table 4 shows factors that are considered as indeterminate.

Results

After taking all these factors & their relationship to violence, we must model the condition of violence based on the concept of Neutrosophic Cognitive Maps. This is the graph for mapping the condition of factors related with violence. Nodes denote factors and edges denote relationship from node to node or from node to factors. Some nodes have representation like $D1, D2, D3, \dots, D26$

Table 3 Determinate or Known Factors

Determinate or Known Factors	Representations	Determinate or Known Factors	Representations
Excessive use of alcohol [22]	D1	Castesam/ inequality [32]	D14
Childlessness [28]	D2	Influences of mass media [32]	D15
Economic pressure [28]	D3	Harassment [24]	D16
Inter-generational transmission of violence [28]	D4	Recent victimization [42]	D17
Emotional desensitization [29]	D5	Mental health treatment [42]	D18
Physical fighting [26]	D6	Hostility [42]	D19
Drug or alcohol abuse [26]	D7	Criticism [42]	D20
Detailed plans to commit violence [26]	D8	Poor behavioural control [44]	D21
Easy access to weapons [26]	D9	Shortfalls in socialism [44]	D22
Email, social media, websites, messaging platform [23]	D10	High emotional distress [44]	D23
Poor family functioning [32]	D11	Antisocial beliefs and Attitudes [44]	D24
Delinquent peers / gang membership [32]	D12	Unemployment [82]	D25
Poverty in the community [32]	D13	Domestic Abuse [51]	D26

Table 4 Indeterminate or Unknown Factors

Indeterminate or Unknown Factors	Representations	Indeterminate or Unknown Factors	Representations
Place of residence [22]	I1	Prizes hike in the basic needs [32]	I16
Family history of violence [22]	I2	Long drawn strike [32]	I17
Demand level of dowry [28]	I3	Fake encounter [32]	I18
Long term emotional of desensitization [29]	I4	Run away from home [32]	I19
Excessive need for attention or respect [26]	I5	Violent video games [32]	I20
Feelings of low self-worth [26]	I6	Treatment by teacher [32]	I21
Early childhood abuse [26]	I7	Intimidation & low social status of female students [24]	I22
Bullied [26]	I8	Sacred values [38]	I23
Witnessing violence at the native place, locally, or in the media [26]	I9	Violent episodes [41]	I24
Denying or minimizing the abuse by women in their relationship [30]	I10	Nonadherence to medications [42]	I25
Unsafe neighbourhood [31]	I11	Verbal aggression [42]	I26
Gaming platform or smart devices [23]	I12	Sense of entitlement to treating the victim with no regard or respect [43]	I27
Forced marriages [33]	I13	Stalking [43]	I28
Dropping out of school [32]	I14	Poor monitoring and supervision of children [44]	I29
Opportunities are denied [32]	I15	Education [58]	I30

Table 5 Adjacency Matrix based on NCM 7

	FA	D1	I1	D2	I2	D3	I3	D4	I4	D5	I5	D6	I6	D7	I7	D8	I8	D9	I9
FA	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
D1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0
I1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
I2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
D5	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
I5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
D6	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
I6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
D7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
I7	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
D8	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
I8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
D9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
I9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

hidden patterns that are used in mapping inferences. These inferences are used to show the joint effect of interacting knowledge. To get the current result we used Neutrosophic Cognitive Map that is (1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1) which shows that when crime is in ON state all the factors such as Excessive use of alcohol, Childlessness, Economic pressure, Inter-generational transmission of violence, Emotional desensitization, Physical fighting, excessive use of drug, alcoholic abuse, plans for committing violence, Email, Social media, Websites, Messaging platform are in ON state. All these factors show that they have a direct effect on crime. Factors like Place of residence, Family history of violence, Demand level of dowry, Long term emotional of desensitization, extreme requirement for respect, feeling of low self-esteem, early misbehave with children, Bullied, standing with violence in house, community, or in media, which does not supposed to have a direct effect on violence by previous researchers or reports presented by many organizations have a significant influence on violence as we did not get '0' in the limit cycle at their place even we obtained '1' that represents they have a relationship with violence. Earlier results obtained using state-of-the-art fuzzy techniques were in the form of a state vector (1 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1) = SA₃. This was obtained with the help of FCMs in example represented by matrix in fig. 6. This clearly shows that uncertain factors are absent when situation is modelled using

earlier approaches, signifying that studies conducted using FCMs are unable to present any situation in an effective way. The results obtained using NCMs are in the form of a fixed state vector (1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1) = FA₆. This shows the presence of indeterminate factors while identifying the traits of character for violence detection, clearly stressing on the importance of these factors. Now, we can say that NCMs are best to model real-life situation than FCMs. Presently, we can say that NCMs are ideal to display genuine circumstance than FCMs and address the meaning of vague elements in managing or breaking down genuine issues or circumstance.

Discussion

The present work is significant in the sense that it identifies various traits of character taken from cloud and literature, leading to violent behaviors among the masses using Neutrosophic Cognitive Maps (NCMs). This is done in order to identify various factors mathematically while analyzing the situation of violence. NCMs are more efficient than FCMs since they work on the basis of Neutrosophic Fuzzy Sets (NFS) which is an extended version of Fuzzy Intuitionistic Sets (FIS), incorporating in itself the notion of indeterminacy or neutrality of facts. For the purpose of modeling, the work takes into account the determinate or certain factors together with indeterminate or uncertain factors,

also uncertain and indeterminate relationship among them is considered. All the factors whether determinate or indeterminate are taken from the cloud-based data, experts' opinions, and previous literature. The results have shown that uncertain, indeterminate, unknown factors and their relationship with certain or among themselves are equally important in order to interpret the violent behavior of the people which has not yet been considered in previous research. If uncertainty and indeterminacy are addressed at the data level itself, it will not impact the modeling stage and machine learning algorithms will perform well.

We conclude that while identifying the violent behavior using unsupervised data over the cloud, we cannot say anything for certain. Most of the time we face the indeterminacy of facts while analyzing this data over cloud and literature. If this uncertainty is not addressed at the data level, it may affect general pattern recognition models and machine learning algorithms. Hence the current work in this regard seems to be much more effective as it has focused on the indeterminacy and uncertainty of facts at the data level itself and has modeled the situation using Neutrosophy which is a powerful technique for handling imperfections in data.

The present work focussed on the limited factors obtained from literature and clouddata. The work has also not considered the various other types of indeterminacies like noise and redundant data that are required to be eliminated while detecting violence from videos. Therefore, these may be taken care of in the future. Also, future work in this regard could be the use of a knowledge graph while detecting violent behavior in video surveillance data over clouds. Also, neutrosophic sets could be extended to Single Valued Neutrosophic Sets and their application could be explored while modeling the data protection algorithms over the cloud. Also, machine learning algorithms can be designed incorporating a large amount of data already present over clouds using neutrosophic sets to reduce the indeterminacy. This will reduce time and space taken by ML algorithms in the learning phase and in return will lead to on-time accurate results and data protection over clouds. If this uncertainty in cloud data is resolved from the outset, an ensemble machine learning approach to feature extraction and fake news classification could be made successful. Additionally, it would improve retrieval technology for the internet of things with cloud assistance.

Acknowledgements

We would like to gratefully acknowledge the CONACYT (Consejo Nacional de Ciencia y Tecnología) & Tecnológico de Monterrey for funding this project.

Authors' contributions

Mohammad Saif Wajid carried out the experiment and wrote the manuscript with support from Dr. HugoTerashimaMarin, Dr.PeymanNajafirad (Paul Rad) and Mohd. Anas Wajid. Dr. HugoTerashimaMarin and Dr.PeymanNajafirad (Paul Rad) supervised the whole project. Mohd. Anas Wajid contributes to results and analysis. All authors have read and agreed to the published version of the manuscript.

Funding

This research was funded by CONACYT (Consejo Nacional de Ciencia y Tecnología) & Tecnológico de Monterrey.

Availability of data and materials

The supporting data may be provided by corresponding author on request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 23 August 2022 Accepted: 12 November 2022

Published online: 30 November 2022

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