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Enhancing Crime Cluster Reliability Using Neutrosophic Logic and a Three-Stage Model

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Abstract

The crime is most effective factor in society. Crime is motivated by criminal behavior. the game theory model has an analytical method that maps various criminal behavior analyzed for individuals. Game theory based on Neutrosophic logic analyzed comprises recognized individual crimes from randomized crimes using clusters randomization together. We apply an estimation of the Intra-cluster/inter-cluster correlation coefficient (ICCC) on criminal data (certainty and uncertainty) to find crime sample sizes on crime. The ICCC results affect the synthesis of the relevant information based on both cluster-randomized tests and individual tests are found. The crime cluster study is an interaction between the effect of the intervention and the choice of randomization unit and will consider it fair to aggregate from both. In randomization unit heterogeneity and conduct a compassion analysis estimate crime cluster reliability.

Keywords: Cluster Reliability, Game Theory, Inter-cluster/Intra-cluster correlation coefficient, Neutrosophic logic.

1. Introduction

A machine learning method Cluster analysis or clustering is various groups of the unlabeled dataset [1], [2] . It is a way of grouping the data points into different clusters like inter-cluster and intra-cluster containing crime data points [1], [3], [4]. The substances with the potential likenesses stay in a gathering that has less or no similarities with another gathering [5], [6]. It does it by discovering some not comparable wrongdoing designs in the unlabeled dataset like size, conduct, and so on, and isolates them according to the presence and nonappearance of those examples[7]. It is an unsupervised learning method; thus, no management is given to the method, and it manages the unlabeled dataset[7], [8]. In the wake of applying this clustering strategy, each cluster or group is furnished with a group ID [9]. Here data should be standardized because otherwise, the range of values in each feature will function as a weight when deciding how to cluster the data, which is usually undesirable [10]. This can increase the effectiveness of clustering approaches because normalization is utilized to minimize redundant data and ensures that good quality and reliability are generated [11]. It becomes a necessary step prior to clustering, as the distance is extremely sensitive to differences [12]. The crime factors clustering is a complex task, and reliability can never be guaranteed with absolute certainty [13]. The machine learning system can utilize this ID to work on the handling of enormous and complex datasets. The grouping strategy is ordinarily utilized for statistical data analysis [9]. In any engineering application, reliability is critical in determining the application's performance [14]. The behavior of the developed application in comparison to the defined requirements is estimated by reliability [14], The effectiveness of selecting the proper estimate model from the available classification of models determines the validity of reliability estimation [1], [4]. We have to find the most commonly utilized identification approaches, which we have divided into two types: deterministic and probabilistic [4]. To begin, deterministic models are used to investigate: a) elements of engineering applications such as crime identification systems; b) the control flow of crime applications by counting the number of clusters and tracing the clustering hierarchy; and c) the flow of crimes and investigation of crime data sets among the identified clusters [8], [15], [16]. Recursively apply the provided methodologies in these models to estimate and then predict application performance [17], [18]. Finally, failure occurrences and fault removals are denoted, as probabilistic events in the probabilistic models are some of the other types of models [10] . The binomial model is immediately applied in real-time application among the models [19]. Most reliability models ignore the development process and focus on the results, faults, and failures [13]. However, to reduce complexity, a proper plan is prepared and new methods are introduced that are applied in certain software development processes. So, the correct model that is suitable for a particular case must be chosen [20]. Moreover, the modelling results cannot be blindly believed and applied. In this paper, we use an estimation model, which can be applied to crime clusters to measure the crime measure process and improve cluster reliability [21]. The Binomial test is conducted and a reliability-testing model is used [21].

The rest of this paper is arranged as follows: Section-2 discussed crime data classification using game theory [22]. In section-3, Applies Neutrosophic Logic to crime data for optimization based on crime factors. Section-4 deals with the Crime Clusters Reliability. Section-5 deals with the Three three-stage model discussed. Section-6 represents the details about the proposed work methods. Section-7 shows the experimental results highlighted. Section-8 presents the

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future perspective and conclusion.

2. Crime Data Classification

The crime data classification process will provide the reliability of the clusters, for that here we used the two-person prisoners' dilemma game theory to predict the label of the cluster data using machine learning with the support of a time series model. Finally, we get the three groups True, False, and Indeterministic from the crime data using Neutrosophic Logic. In addition to the three-stage model for clusters, reliability is achieved on inter and intra-clusters.

2.1. Game Theory model payoff matrix on Crime Data Classification

According to our study, Albert W. Tucker proposed the prisoner's dilemma, which is a decision-making and game theory problem for two prisoners [19].

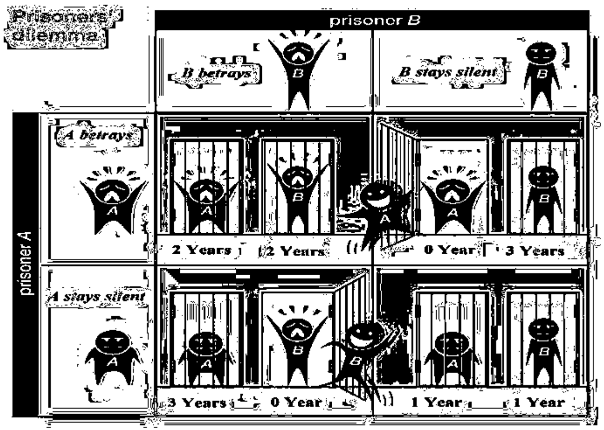

Fig. 1. Two Prisoners' Game Theory.

Here, two prisoners A and B are secluded and overstretched to confess to leading a theft calm. Each is purely afraid with a portion of the lowermost achievable sentence; each must fix whether to agree without knowing his partner's choice. based on both prisoner's sentences, however, are conscious of the consequences of their choices as follows:

1. If both agree, they are punished with 2 years in prison each.
2. If both do not agree, they are punished with 1 year in prison each
3. If one agrees while the further see to not, the confessor is set free even though the neutral one is punished with 3 years in prison.

Heinz S. introduced a two-person game theory, in 1984, the activities of the main player form the lines, even though the activities of the subsequent player comprise the segments. The components in the network are two facts that demonstrate the first and second entertainers' separate qualities. People engaged in wrongdoing are marked as Neutrosophic rationale-based guilty parties in the table beneath [23]. Each suspect is allocated to their own cell and given the choice of conceding. A lawbreaker a valid example for the game hypothesis can be addressed as follows.

The two detainees, X and Y, associated with carrying out wrongdoing together, are segregated and encouraged to admit. Each is concerned exclusively with getting the briefest conceivable jail sentence for himself; each should choose whether to admit without knowing his accomplice's choice. The two detainees, be that as it may, know the outcomes of their choices:

Case-01: If both persons X and Y confess (T) then both persons are 5 years punishable in jail.
Case-02: If neither X nor Y confesses, both are 1-year punishable in jail.
Case-03: If one person confesses (T) even though the other person does Not Confess (F), the confessed person is set free and the Not confesses (F) person is 10 years punishable in jail.
Case-04: If one person confesses even though the other person is Uncertain (i.e., Indeterministic) (T or F), then the confessed person is set as free (i.e. 0), and the uncertain person is 8 years punishable in jail.
Case-05: If one person does not confess even though the other person is uncertain (T or F), then the Not Confessed person is 2 years punishable, and the uncertain person is punishable for 8 years in jail.
Case-06: If both persons are uncertain (T or F), both persons are punishable by 3 years in jail.

The Crime data classification payoff matrix of two prisoners' games is standardized rendering to Neutrosophic Logic True as T, False as F, and Indeterministic (uncertain) as I are standards shown in Table 1:

Table 1. Crime data classification payoff matrix of two prisoners'

Y \ X	Confess (T-True)	Not Confess (F-False)	Uncertainty (I-Indeterministic)
Confess	5, 5	0, 10	0, 8
Not Confess	10,0	10,10	2, 6
Uncertainty	8, 0	6, 2	3,3

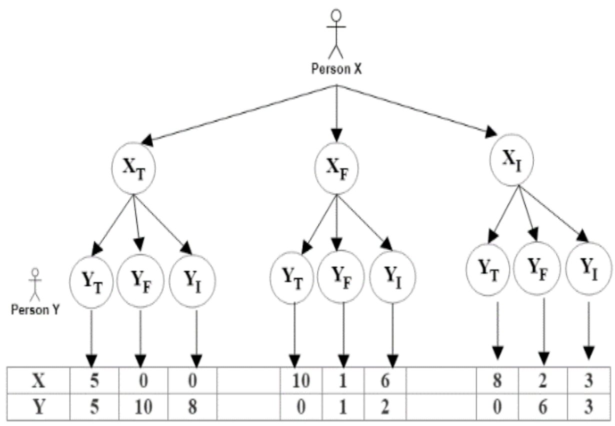

Fig. 2. The Crime data classification payoff matrix of two prisoners' games is standardized rendering to Neutrosophic Logic.

3. Neutrosophic Logic of Crime

Neutrosophic Logic is one of the frameworks for the fusion of many existing logics, such as paraconsistent logic, fuzzy logic (especially intuitionistic fuzzy logic), etc [10]. The core awareness of Neutrosophic Logic is to describe each logical declaration in a 3D Neutrosophic Space, where each dimension of the space denotes respectively the Truth (T), the False (F), and the Indeterminacy (I) of the declaration under through, where T, I, F are real subsets of]-0, 1+[with not necessarily any connection between them and these are standard or non-standard. The standard unit interval [0, 1] is used for software engineering offers. For single-valued Neutrosophic Logic, the summation of the components is:

- 0 ≤ T+I+F ≤ 3 if three components are autonomous;
- 0 ≤ T+I+F ≤ 2 if one is autonomous and the remaining two components are dependent on them;
- 0 ≤ T+I+F ≤ 1 if three components are dependent.

If three or two of the components T, I, and F are independent, one leaves room for partial evidence (sum < 1), paraconsistent and contradictory evidence (sum > 1), or whole evidence (sum = 1). If all three components T, I, and F are dependent, then correspondingly one leaves room for partial evidence (sum < 1), or whole evidence (sum = 1).

Neutrosophic Logic is for a person to identify the crime, which depends on three principal components as specified below:

1. If the person can directly involve crime, then treat (t) as true or t, which can be further, split into subcomponents t_1, t_2, t_3... t_i.
2. If the person is not confessing it will be treated as false (f), which can be split into subcomponents f_1, f_2, f_3... f_s where i+r+s=n ≥1.
3. If a person is neither confessed nor non-confessed it will be treated as Indeterminacy (i), which can be further split into subcomponents i_1, i_2, i_3... i_r.

Identifying the person in the predicted crime classification from which he belongs to which group based on the above principles. The standard unit interval for crime data is [0, 1].

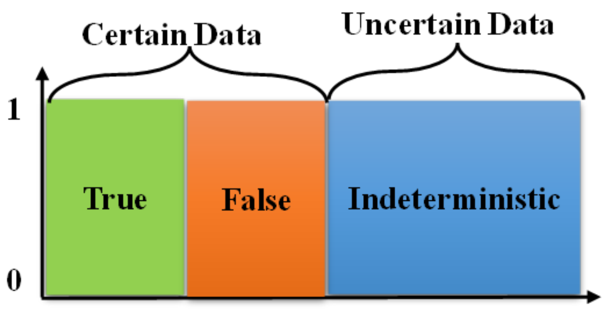

Fig. 3. Neutrosophic Logic Principle of Crime.

3.1. Optimization Procedure-based Crime Factors

The crime facts are the distance between different clusters of the crime factors and the crime factors of the same clusters. We can show reduction ensures that intra-cluster optimal facts are as nearest to the centre as likely and reaming centres are as far away from respectively further as likely, thereby reaching the aim of a cluster. We consume dual kinds of distance as Intra-cluster distance and Inter-cluster distance. The process can evaluate as follows:

Step-01: Load a 2D data set for crime facts.

Step-02: Apply the game theory to the data set, finally resulting in a sub-optimal for both the persons who participated in crime incidents and the outcome will give further fortunate.

Step-03: Usage the Neutrosophic logic to discrete or continuous; confess, non-confess, or uncertainty (intersection of various clusters shown in Figure 2)

Step-04: Next, decide the variables used for the optimization work for each group.

Step-05: Let p, q be two victims in an incident or the points in the cluster, following are the possible conditions to be validated before applying the conditions:

- p is committed and q is not committed
- Both p and q are not committed.
- p said q has committed.
- q said p has committed.
- p accepted that he has committed.
- q accepted that he has committed.

Step-06: Apply the optimization function used to check the affinity for every person in Figure 2 to decide the role for a group is given as:

$$C_i(p,q) = \frac{(p-p_i)^2}{l_i^2} + \frac{(q-q_i)^2}{m_i^2}$$

where p_i , q_i represents cluster center point
l_i , m_i be lengths of the major and minor axis

Step-07: For each point (p, q) in Figure 2 shows $C_i(p,q)$ to narrate through which cluster the fact lies. This procedure supports distributing of the data points between three groups true, false, and Indeterministic.

Step-08: Go to Step11 if (p, q) lies in true, false, and Indeterministic (Figure 3).

Step-09: Apply the subsequent stages when the point (p, q) lies in the joining of two clusters to choose in which cluster the fact is to be placed. Estimate the intra-cluster and inter-cluster distances with respect to the fact that lies in the intersection point. The inter and intra-distance calculation is performed as follows:

$$D_i^{intra} = \frac{1}{|C_i|}\left(\sum_{(p,q\epsilon C_i} \sqrt{(p-p_i)^2 + (q-q_i)^2}\right)$$

$$D_i^{inter} = \frac{1}{\binom{K}{2}}\left(\sum_{i=1}^{K} \sum_{j\neq 1}^{K} \sqrt{(p-p_i)^2 + (q-q_i)^2}\right) = 0$$

where K denotes number of clusters

Calculate and minimize $\frac{D_i^{intra}}{D_i^{inter}}$ focus to $(p_i, q_i) \in$ R, where R-value is lies between 0 and 1 in which the centers of the ellipses are hypothetically laid.

Step-10: The minimization will ensure that intra-cluster facts are as close to the center as likely and all clusters' centers are as far away from each other as likely, thereby reaching the aim of clustering.

Step-11: Prediction is another crime data mining activity, which is used on an every day. Specified that the modelling activity can be reached during an optimization problem cracking as consulted before is the prediction activity can be reached using an optimization procedure.

4. Crime Clusters Reliability

Crime clusters are groupings of similar crimes that share certain characteristics or patterns. Reliability refers to how trustworthy and accurate these crime clusters are. Crime clusters can be helpful in understanding crime patterns and developing strategies to prevent and address criminal activities. While efforts are made to improve reliability, it's important to remember that crime analysis is complex. Interpretations of crime clusters should be done cautiously, considering the limitations of data and uncertainties in criminal behavior. So the study the circumstances in which classification has n crime components, all of which initiate operate at time t=0. The classification continues to purpose accurately as long as at least k of the uncertainty of crime. In further, if n-k+1 cluster components fail in the crime cluster Neutrosophic logic classification fails. This type of component classification is called a crime cluster Neutrosophic logic classification can be modeled as a parallel classification of crime components.

We consider all clusters n crime components are identical and will fail individualistically. If we occupancy T_i be the time to disaster of the i^{th} crime components then the T_i terms are autonomous and identically distributed for i=1 to n incremented by 1. Thus $R_i(t)$, the reliability at time t for crime component i, is identical for all crime components. Recall that our classification operates if at least k crime component functions properly. Now we define the random variables X and T as follows:

X= the quantity of crime components function at time t, and

T=time to the disaster of the entire classification

Then, we take:

$$R(t) = P(T>t) = P(X\geq k).$$

It is calm to get that we do not take n identical and autonomous components through the identical probability of disaster by time t. This circumstance parallels a binominal testing and we can crack for the classification reliability using the normal distribution with crime constraints n and $p=R_i(t)$**.**

5. Three-Stage Model for Crime Clusters

In the view of this system, Crime Cluster consists of Certainty of crime and Uncertainty of crime. Each certainty cluster and uncertainty of cluster is segmented into three nested clusters as proposed by Jagan Mohan, R.N.V, 2022 has given crime classification. In this approach, the expected number of failures against time is made up of three nested clusters for each cluster, in each stage, which means a group of code establishes a configuration for test. To transform these nested clusters to what would have been expected for a stable system requires a two-step method namely Failure and Success. Assume to do this process to be completed in one minute. Now, in the reliability estimation process, three cases are raised.

Case 1: Take the collection of true value of crimes in the first cluster i.e., certainty. The database crime is identifying with each input crime of the first cluster. This process will be completed in 1/3 minute in every case. The number of failures is mentioned and data is shown in the Table-1.1.

Case 2: Execute the reliability process to integrate the first cluster i.e., certainty, second cluster i.e., uncertainty of crimes and do the same process in the above to identify if failures are occurred or not.

Case 3: Again, go through the reliability process, to integrate the first two clusters with the third cluster not in persons who have not involved in crime and we do the same process as in the previous cases, and recognize failures are occurred.

Hence, the number of crimes is increased by each case, the rate of failures are decreased within the time bound of one minute (the process happening in all three cases). Therefore, this concludes that the reliability is more and high in the above process.

5.1. Three-Stage Model for Crime Cluster

The below graph represents crime failure inputs derived from the three stage models. The 1^{st} curve indicates failure crime cases of cluster1 and total amount of code being executing in the stage. It affects how rapidly the program cycles or repeats and hence how rapidly the faults are encountered. The fault content will generally be related to the amount of developed code. After a certain interval of execution t* the remainder of the system is added. The 2^{nd} curve indicates failure cases of both clusters 3. 3^{rd} curve indicates failure crime cases of clusters 1 and 3.

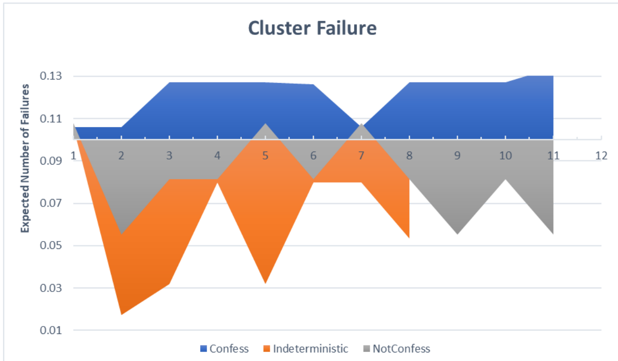

Fig. 4. Crime failure cluster cases.

6. Experimental Result

The reliability of classification refers to the trustworthiness and accuracy of the assigned class labels to the given data instances. It indicates how well the classification model performs in correctly predicting the class or category of unseen or new data points. Reliability can be enhanced by employing cross-validation techniques to evaluate the performance of the classification model. Cross-validation involves splitting the data into multiple subsets and iteratively training and testing the model on different combinations of these subsets. It provides a more robust estimate of the model's performance and helps assess its reliability across different data samples. The reliability of the classification results using an independent dataset or comparing the model's predictions with expert-labelled data. If available, external validation can provide additional evidence of the reliability of the classification model.

In the three group stages of the cluster, crime identification is used by police to interrogate each case by monitoring both sides using Game Theory. To determine who is responsible for the crime based on their actions. The three-step models are considered parallel, meaning that they all fail at the same time.

Assessing the reliability of a complete criminal cluster classification for a 24-hour period involves evaluating the trustworthiness and accuracy of the identified clusters and their corresponding classifications. Involving domain experts, such as criminologists or law enforcement professionals, is crucial for assessing the reliability of the classification. Experts can provide valuable insights into the logical consistency of the classified criminal clusters, validate them against real-world crime patterns, and ensure that the identified clusters align with their understanding of criminal behavior within the given 24-hour period. We can calculate the reliability of the complete criminal cluster classification for 24 hours if we identify that each stage has a 0.6065 likelihood of correctly judging for at slightest 24 hours. We begin by defining the random variable: X= the number of crime instances that have evolved after 24 hours. With n=100 and p=0.6065, the random variable X is clearly binomially distributed. This formula is written as in the clusters of crime identification.

$$X \sim b(100,0.6065)$$

$$or$$

$$X \sim Normal(100,0.6065).$$

Understand that the system criminal cluster is reliable on one day (24 hours).

R(24) = P(X≥15) = P(15≥X≥18)= 0.099.

Therefore, the reliability of the classification on full day hours wise is 0.099.

7. Conclusion

Based on a two-person prisoner dilemma game theory with Neutrosophic logic the crime data classify into three set of groups like confess (T), Not confess (F), and Indeterministic (I) which is Measured the distance among the crime facts of the same cluster and the crime facts of other different clusters using the crime data. We are using the system's three-stage model for criminal cluster reliability. It can achieve two types of distances intra-cluster distance and inter-cluster distance based on reduction ensuring that intra-cluster and inter-cluster facts are as close to the center as likely and all group centers are as far distant away from each other as likely. In future work, implement the n-persons game theory procedure from this two-person game theory for optimizing crime optimization.

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