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Neutrosophic Cognitive Maps for Situation Analysis

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Abstract. There are various factors which lead to the criminal behaviour in humans. Prominent researchers monitoring the situation of crime in Nigeria cite poverty, unemployment, family-breakdown, bribing & corruption, lack of co-operation from public and negative perception of police to be the major causes behind criminal behaviour. The factors like underemployment, inadequate equipment, NGOs are not taken into account by the researchers because these are considered to be indeterminate. To show how these indeterminate factors are actually related to crime in Nigeria we model the situation mathematically using FCMs and NCMs. The work also shows how efficient is the technique of Neutrosophic Cognitive Maps (NCM) against Fuzzy Cognitive Maps (FCM) to deal with the uncertainties and indeterminacy in Situation Analysis. The obtained results are interpreted which demonstrate the importance of indeterminate factors in analysing the situation of crime in Nigeria. This shows how indeterminate factors when taken into consideration could enhance the accuracy and efficiency of mathematical models using the concept of Neutrosophic Cognitive Maps.

Keywords: Fuzzy logic, Fuzzy Cognitive Maps, Neutrosophy, Neutrosophic Cognitive Maps, Situation Analysis, Crime in Nigeria.

1. Introduction

The term situation from situation (Medieval Latin) is defined as placed in certain location. Situation also represents dispositions of a person, set of circumstances and surrounding environment. According to Pew (2000), a situation is "a set of environmental conditions and system states with which the participant is interacting that can be characterized uniquely by a set of information, knowledge, and response options". For Roy (2001) "Situation Analysis is a process, the examination of a situation, its elements, and their relations, to provide and maintain a product, i.e. a state of Situation Awareness (SAW) for the decision maker". Situation analysis plays a vital role in deciding our actions which are needed to progress further based on our current situation. It is important since it forecast results based on current decisions being taken by the agent. Situation analysis though appears to be simple in predicting the results based on current scenario, but on the other side there exist challenges that are being faced by the agent who is analyzing the situation.

An agent who analyses an event for Situation Analysis apprehends data from various sources like reports, databases, various devices, surroundings and people etc. Based on the data collected together with expert's opinion, conclusions have been drawn by the agent. These conclusions are of great importance in Situation Analysis. The problem arises where raw, conflictual and paradoxical datum is being transformed into statements which are understood by man and machine. Hence measuring the world i.e. quantitative measurement of factors that affect any situation and reasoning about the world i.e. qualitative inferences being drawn from information, co-exists in Situation Analysis. It poses a great challenge to combine these two important aspects in logical and mathematical frame-

works. Hence a framework general enough is needed to take into account various uncertainties and indeterminacies arising during information processing, being done in Situation Analysis.

Netrosophic theory is not limited to the field of situation analysis but it is spreading its wings in various other fields. The researchers around the globe have employed the neutrosophic techniques to solve a number of problems prevailing in current scenario i.e. in [23] [29] [30] it is being used to solve the problem in multi-criteria decision making. In this authors have proposed a hybrid technique to detect disease based on certain criteria. In [28] authors have used Bipolar neutrosophic sets in solving the multi-attribute decision making problem. The applications of neutrosophy is not confined as the authors in [24] [25] have used this to obtain solutions to a given mathematical problem. In [24] it is used to find an optimal solution to a given linear programming problem and in [25] it is used in solving the differential equation in neutrosophic environment. In [26] authors have used neutrosophic time series in forecasting the different phenomenon happening all around us. Authors in [27] have used neutrosophic sets in understanding and enhancing the supply chain sustainability in current scenario. The proposed approach claims to be efficient in solving decision making problems while meeting the supply chain sustainability requirement. Authors in [31] have used IoT and Fog computing to propose a health care system for the prediction and diagnosis of diseases. For this purpose they have introduced a neutrosophic multi-criteria decision making technique. The above work by prominent researchers proves that the application of neutrosophic theory in various fields of research is the need of the hour. Some of the problems are discussed below:

1.2 Obstacles in situation analysis

A lot of hurdles exist in prediction and estimation of Situation Analysis described by Anne-Laure Jousselme and Patrick Maupin (2004). These hurdles comprises of ontological limits i.e. due nature of objects, epistemic limits that originate because of cognitive limitation of agents, anarchy when situation is not governed by law, ignorance, vagueness of concepts, Chance and Chaos as per exact estimation is sought, data ignorance and of course uncertainty which is an unavoidable obstacle. Indeterminacy arises from paradoxical conclusions to a given inference from impossible physical measurements. Uncertainty is regarded as discoloration of information, as misconception in measurement and does not rely on state of mind. G´erald Bronner a sociologist (1997) regards uncertainty as a mind's state that depends on our potential to bypass it. He proposes two types of uncertainties: uncertainty in finality (or uncertainty in material) and uncertainty of sense. The first one is defined as "state of mind of a person, who wants to achieve a desire, and is in opposition with the open possibilities" (e.g. Will my rail ticket get confirm?) or it is our understanding of the world, whereas the other one is "state of a person where a part or whole of its system of representation is deteriorated or may be" or it refers to the representation of the world. Agents in situation analysis tackle with uncertainty of sense (i.e. data driven) and uncertainty in finality (i.e. goal driven) from the bottom-up and the top-down perspective respectively.

The rest of this paper is organized as follows: Section 2 presents related work. Section 3 gives a brief description of proposed solution. In section 4 we illustrate proposed work. Section 5 interprets the results obtained. In section 6 we have compared previous solution to proposed work and section 7 concludes the work.

2 Related works

A lot of research work is carried out by the researchers where they needed modelling of real life situations and representing them mathematically for interpretation and drawing conclusions. We present the work done by well-known researchers in this field. Igor Bagány and Márta Takács [12] explored the correlations among various factors being involved in education system so that its functionality can be modelled. It is being done to effectively examine various education systems. Here authors have employed fuzzy cognitive map (FCM) technology, since it aids in determining qualitative illus-

tration of the relationships and parameters. C. Enrique Peliez and John B. Bowles [13] seek to determine the behavior of a system in case of device failure. It requires the combination of various tasks by the expert to choose components for the purpose of analysis, find out failure modes, predict effects and put forward the corrective actions etc. Fuzzy Cognitive Maps and Fuzzy Set Theory provide foundation for automating the reasoning that is required to do a Failure Modes Effects Analysis on a system. The information processing model described by G. Jiang et al. [14] is cantered on the cognitive behavior of human brains. They have recommended two ways of modelling situation cognitively, which are representation and reasoning about Situation Analysis with ontology and using fuzzy cognitive maps (FCM) to develop a Situation Analysis model. Mentioned work done by prominent authors revolves around the factors which govern a particular situation, they accordingly have simulated behavior of the system. This shows that factors or sources play an important role in describing the situation and accordingly system is modelled and various inferences are drawn. If all the factors are not taken into consideration the results can be fatal. Almost all work by researchers in analyzing a situation employs Fuzzy Cognitive Maps (FCMs) introduced by B. Kosko [11]. These fuzzy structures resemble neural networks and mathematically model complex systems where situation analysis is needed. We briefly describe the FCM in the next section.

Though all the above mentioned approaches have significantly achieved wonderful results but these all lack somewhere in considering the indeterminate factors while modelling the situation. These indeterminate factors are of same importance as the determinate factors. When all these are taken into consideration it would aid in achieving the desirable goals. Later in the paper it is being proved mathematically.

2.1 Fuzzy Cognitive Maps

Fuzzy Cognitive Map (FCM) is a directed graph introduced by Bart Kosko [11]. Nodes are represented as concepts and relationship among them as edges. It portrays relationship among concepts. FCMs with weights assigned to the edges are in the set {-1, 0, 1} are known as simple FCMs. Let us assume that $C_1,\ldots, C_n$ are the nodes of FCM. Using edges $e_{ij} \in \{0, 1, -1\}$, a graph that is directed is drawn. The matrix E where $E = (e_{ij})$ is called the adjacency matrix (connection matrix) of the Fuzzy Cognitive Map. Fuzzy cognitive maps (FCMs) are employed in case of unsupervised data. FCMs perform on expert's opinion. FCMs are used to model the world as the set of different classes together with the relationship among these classes. An edge that is directed from concept C_i to C_j ascertains the extent of C_i causing C_j. FCMs aid in modeling various problems varying from socio-economic to popular political developments etc. The edges e_{ij} are in the set [-1, 0, 1], $e_{ij} = 0$ shows that casualty is absent, $e_{ij} > 0$ shows that C_j increments as C_i gets incremented (or C_j decrements as C_i decrements), $e_{ij} < 0$ shows negative causality i.e. C_j gets decremented as C_i decrements (or C_j increments as C_i gets decremented). Now let us consider a real life situation to further understand the application of FCM in Situation Analysis.

2.2 Application of FCM in Situation Analysis

To analyze the situation we have taken into consideration the factors nourishing crime in Nigeria, put forward by various researchers. Anthony Abayomi Adebayo [17] has examined the increasing wave of crime in Nigeria. Study reveals that factors such as inadequately equipped police, unemployment, and breakdown of family values, poverty, Bribery and corruption have made it difficult to prevent and control crime in Nigeria. Ime Okon Utuk [19] has studied the effect of NGO on economic development which in turn has effect on crime. Recent facts from the 'Nigeria Economic Report' of World Bank [20] reveal that the challenge to country's employment is more in line with underemployment than unemployment. Taking into account all factors which nourish crime in Nigeria, a representational model has been shown in following figure 1.

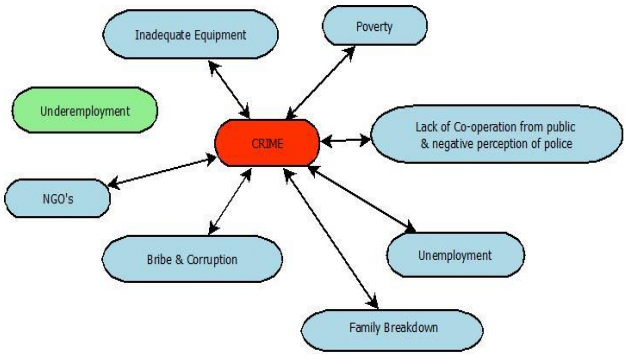

Figure 1: Factors effecting crime

Let us consider the following nodes:

$$A = Inadequate\_equipment$$

$$B = Lack\_of\_co-operation\_from\_public\_\& \_negative\_perception\_of\_police$$

$$C = Poverty$$

$$D = Unemployment$$

$$E = Family\_breakdown$$

$$F = Bribery\_\& \_corruption$$

$$G = Underemployment$$

$$H = NGOs$$

$$I = Crime$$

These factors govern a situation that is being analyzed by the agent. In Situation Analysis using FCMs, experts present their views about the existence of relationship or non-existence of relationship. Based on the expert's opinion together with his own knowledge, agent draws the inferences. Now we model the problem of crime prevailing in Nigeria by using the technique of FCM in the following figure 2.

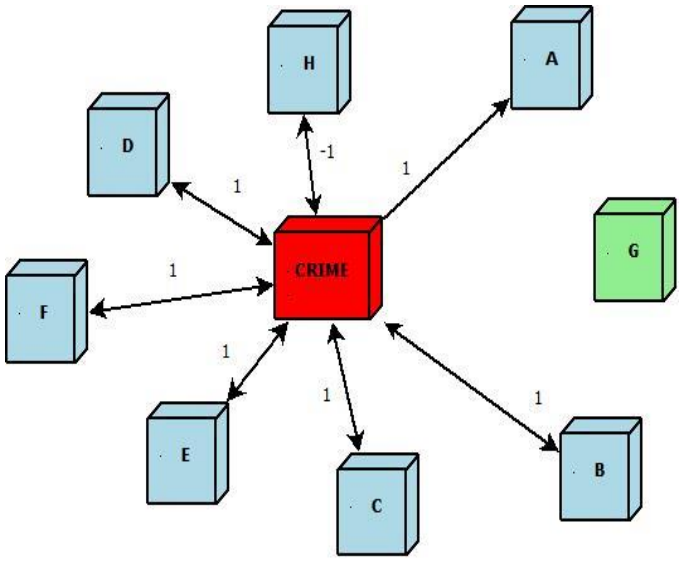

Figure: 2 An instance of FCM model

Here casual increase (or decrease) of A increases (or decreases) I and is marked with "1" as allowed in FCMs. Similarly casual increase (or decrease) of H decreases (or increases) I and is marked with "-1". As indicated in above figure neither anything about the effect of G on I, D on G, nor G on E is mentioned. The Fuzzy Adjacency matrix (E) that is the representation of above Situation is presented in Figure 3.

$$E = \begin{pmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 0 & -1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Figure: 3 Related connection matrix of the graph in Figure 1

Suppose we have taken the state vector X_1i.e. $X_1=(1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$. Now we will see its effects on E. The following resultant vector is obtained after thresholding and updating. The symbol '$\rightarrow$' symbolizes the updating and thresholding of the resultant vector.

$X_1E = (0\ 1\ 1\ 1\ 1\ 1\ 0\ -1\ 1) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1) = X_2$

$X_2E = (6\ 1\ 1\ 1\ 1\ 1\ 0\ -1\ 1) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1) = X_2$

Thus crime has affect or is affected by lack of co-operation from public & negative perception of police, poverty, unemployment, family breakdown, bribing & corruption but underemployment, Inadequate equipment, NGOs are absent in this plot. This means crime flourishes with lack of co-operation from public & negative perception of police, poverty, unemployment, family breakdown and bribing & corruption. The state vector gives fixed point.

2.3 Role of Indeterminacy in Situation Analysis

Practically speaking, when Situation Analysis is being done in real life, the unpredictability and indeterminacy of things happening in life, affects every sphere almost as determined factors. It is a restriction of mathematical modeling that it assigns weightage to only known concepts; and is unconcern about indeterminate relationships between concepts; thereby our views are sometimes biased and skewed. Keeping in mind all factors we present an indeterminate model. Authors Anne-Laure Jousselme and Patrick Maupin [3] have studied situation analysis, various obstacles, governing principles and methods. Authors have described Kripke model [16] that assumes ϕ to be a propositional atom. This *model* is represented by triple structure<*S, Π, R*>where

- *S* is collection of worlds which is non-empty;
- $\Pi: S \rightarrow (\phi \rightarrow \{0,1\})$ represents truth assigned to atoms of world;
- $R \subseteq S \times S$ is the accessibility relation.

Here'*0*','*1*' represents 'True' , 'False'.

Authors have introduced Neutrosophy in Kripke model [16] and presented a new model that has taken into account the indeterminacy. Earlier in Kripke model 'ϕ' can only have TRUE or FALSE as values. In Neutrosophic logic 'ϕ'can be True (*T*%), False (*F*%) and Indeterminate (*I*%). Therefore 'ϕ' is having triplet of truth values referred to as *neutrosophical values*.

Indeterminacy plays a crucial role in real life as stated by W. B. Vasantha Kandasamy [5][3], therefore when Situation Analysis is being done using FCMs, it does not reflect the true picture since fuzzy theory evaluates the existence or non-existence of associateship but it has failed to attribute the

indeterminate relations among concepts. Therefore in Situation Analysis, when data under scrutiny contains concepts which are indeterminate, we are not able to formulate mathematical expression using FCMs.

3 Proposed Solution

The proposed solution to indeterminacy uses the concept of Neutrosophic Cognitive Map (NCMs). It is a technique in Neutrosophy introduced by W. B. Vasantha Kandasamy [5]. The concept of Neutrosophic logic introduced by Florentine Smarandache [6 - 8], which is a merger of the fuzzy logic together with the inclusion of indeterminacy. When data under scrutiny contains concepts which are indeterminate, we are not able to formulate mathematical expression. Presentation of Neutrosophic logic by Florentine Smarandache [6][7][8] has put forward a panacea to this problem. It is the reason Neutrosophy has been introduced as an additional notion in Situation Analysis. Fuzzy theory evaluates the existence or non-existence of associateship but it has failed to attribute the indeterminate relations among concepts. Therefore one can say that the indeterminate situation together with fuzzy will result in Neutrosophic logic. Further we have employed Neutrosophic Cognitive Maps (NCMs) in place of Fuzzy Cognitive Maps (FCMs) to represent the real life situation in Situation Analysis. Earlier researches in Situation Analysis have not included the indeterminacy which is a part and parcel of real life. Hence when working on Situation Analysis, indeterminacy need to be considered. Contemplating the importance of indeterminacy we propose to use NCM in Situation Analysis.

4 Proposed Work

This research work assesses the power of Neutrosophic logic proposed by Florentin Smarandache to tackle hindrances encountered while performing Situation Analysis. An agent observing a scene for situation analysis gathers information from various sources. Here agent tries to reach at the level where he can make decisions about the situation under consideration. While dealing with unsupervised data there always comes a point where no relation can be determined among the concepts. Here person faces Neutrosophic questions like "can you find any relation among concepts" or "are you not in a position to determine any relationship among concepts" and so on. In this way we try to introduce an idea of indeterminacy to them. We have underlined one basic principle that guides the modernization in Situation Analysis by introducing the concept of uncertainty by A.L. Jousselme et al. [15].

4.1 Stating uncertainty

a. Uncertainty as a mind state refers to an agent not having enough information to make a decision i.e. "Agent is not sure about the object".
b. Uncertainty as a tangible feature of information representing the loopholes of perception system i.e. "The dimension of this object is uncertain".

4.2 Methodology used in proposed work

Now indeterminacy has been introduced in Fuzzy Cognitive Maps (FCMs) and the generalized structure so obtained is referred as Neutrosophic Cognitive Maps (NCMs) by W. B. Vasantha Kandasamy [5]. NCM is a neutrosophic directed graph (a directed graph with dotted edge representing indeterminacy) with concepts represented as nodes of the directed graph and relationship or indeterminacy as edge of the graph. Let us suppose C_1, C_2,……,C_n are n nodes from Neutrosophic vector space V. The nodes of graph are represented by (x_1,x_2,…..,x_n) where x_i's can be'0' or '1' or 'I' (I shows indeterminacy) where x_i= 1 indicates the ON state of the node whereas x_i=0 indicates the OFF state and x_i= I indicates the indeterminate state of node in that situation. Suppose C_i and C_j are two nodes in this model (NCM), a directed edge from C_i to C_j represents the relationship of C_i and C_j. The edges of directed graph in NCM are weighted having value in set {-1, 0, 1, I}. When e_{ij} is the weight assigned to the directed edge from C_i to C_j then if the value of e_{ij} is '0' it shows C_i does not affect C_j, it is '1' repre-

senting increase (or decrease) of C_i leads to increase (or decrease) of C_j, when it is '-1' representing increase (or decrease) of C_i leads decrease (or increase) of C_j and when the value is 'I' it shows effect of C_i on C_j is indeterminate. These NCMs are called simple NCMs. Let N (E) be a matrix defined as N (E) = (e_{ij}) then N (E) is called as Neutrosophic adjacency matrix.

4.3 Reformulating Problems encountered in Situation Analysis using NCM

Now we present a graphical model of situation by considering the factors which nourish crime in Nigeria. This was earlier represented by FCM. The recent facts from the 'Nigeria Economic Report' of World Bank [20] reveal that employment challenge faced by the country is more in line with underemployment than presumed unemployment. Furthermore Adeleke Adegbami [18] has concluded that effect of underemployment causes same level of anxiety as unemployment itself. The workers who are underemployed are not provided with the opportunities to utilize their educational qualification, experience and skills that they possess. They assume that their ability and capability are not up to the mark with the work they are assigned to. Therefore these workers experience lower job satisfaction and get frustrated. This can be referred to as disguised unemployment. Further Kimberly Amadeo a U.S. Economy expert [21] has studied underemployment and its effects on poverty and found that underemployment leads to higher levels of poverty. Hence underemployment has indeterminate relationship with crime which is being shown in NCM but not in FCM. Now we include indeterminacy in Figure 1. Dotted lines represent indeterminate relation between the nodes.

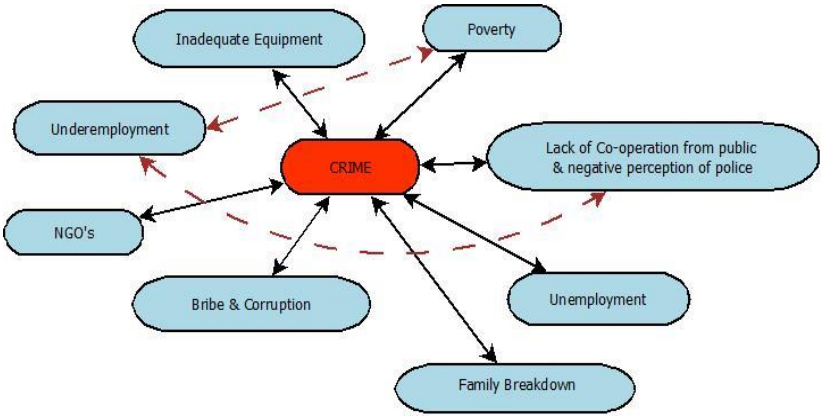

Figure: 4 Factors effecting crime and indeterminate relations

Now we reformulate previous logic of FCM used in analyzing the situation into NCM in Figure 5.

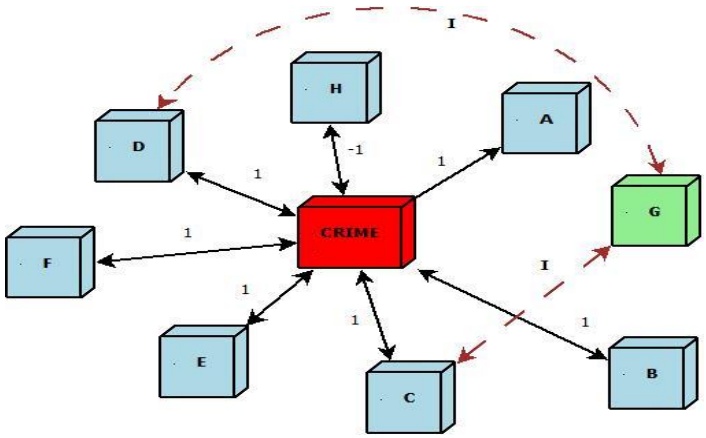

Figure: 5 An instance of NCM model

Neutrosophic Cognitive Maps not only represent the existence or non-existence of relationship among concepts but also represent indeterminate relations among the concepts as shown above. Further we represent Neutrosophic Augmented Matrix N (E) in Figure 6.

$$N(E)=\begin{pmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 0 & -1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & I & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & I & I & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Figure: 6 Related connection matrix to the graph in Figure 5.

Earlier we have studied effect of X_1 on E. Now we will try to find what effect does $X_1=(1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$ has on N (E). After resultant vector is updated and thresholded we have the following.

$X_1 N(E) = (0\ 1\ 1\ 1\ 1\ 1\ 0\ -1\ 1) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1) = X_2$

$X_2 N(E) = (6\ 1\ 1\ 1\ 1\ 1\ I\ -1\ 1) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ I\ 0\ 1) = X_3$

$X_3 N(E) = (6\ 1\ 1+I\ 1+I\ 1\ I\ 1\ -1\ 1) \rightarrow (1\ 1\ 1\ 1\ 1\ 1\ I\ 0\ 1) = X_3$

The symbol '$\rightarrow$' represents the thresholded and updated resultant vector. This shows that crime has affect or is affected by lack of co-operation from public & negative perception of police, poverty, unemployment, family breakdown, bribing & corruption and the factor underemployment is indeterminate to crime. However results obtained using FCM show as if there is no effect of underemployment on crime. Hence NCMs are better than FCMs in analyzing situation in Situation Analysis.

5 Interpretations of the Results Obtained Using FCM and NCM

Work done in Situation Analysis earlier was based on FCMs. FCMs do not consider indeterminate relations. Since in situation analysis there is uncertainty of sense i.e. data driven (bottom-up perspective) together with uncertainty in finality i.e. goal driven (top-down perspective) which comes as a challenge to the agent. It is a limitation in FCMs modeling that only assigns weightage to known concepts and unconcern about indeterminate relationships between concepts; thereby our views are sometimes biased and skewed. Further with NCMs we include indeterminacy in FCMs. Now experts face Neutrosophic questions like "Is there any relationship among concepts?" or "Are you not in a state to determine any relation among concepts?" and so on. In this way they get familiar with the idea of indeterminacy. The problem formulated by FCM is considered and we reformulate questionnaire in different format so that the experts are allowed to answer like "the relationship among certain concepts is indeterminable or not known". On the grounds of expert's opinion together with the notion of indeterminacy a model is obtained which is referred to as Neutrosophic model. The result obtained is mentioned in the table below:

Table 1: Results obtained from FCM and NCM

Effect of X_1 on E using FCM	Effect of X_1 on N(E) using NCM
$(1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1)$	$(1\ 1\ 1\ 1\ 1\ 1\ I\ 0\ 1)$

Earlier when problem was formulated using FCM we got resultant vector as $(1\ 1\ 1\ 1\ 1\ 1\ 0\ 0\ 1)$ where A was ON state which shows that crime in ON state affects or is affected by lack of co-operation from public & negative perception of police, poverty, unemployment, family breakdown, bribing and corruption, but underemployment, Inadequate equipment, Non-Governmental Organization (NGOs) are absent in this plot. The sate Vector leads to a fixed point. But in real life underemployment has effect on crime. We have employed Neutrosophic Cognitive Maps (NCMs) in place of Fuzzy Cognitive Maps (FCMs) to represent the real life situation in Situation Analysis. When indeterminacy is included and Neutrosophic Adjacency Matrix is formulated, we again studied the effect of factors on crime. This time the resultant vector is $(1\ 1\ 1\ 1\ 1\ 1\ I\ 0\ 1)$. This clearly shows that crime is affected by lack of co-operation from public & negative perception of police, poverty, unemployment, family breakdown, bribing and corruption, but underemployment is indeterminate to crime. In FCMs, the values assigned to edges of graph are the results of knowledge and experience possessed by the expert. These values are functions of engineering judgments and common sense. Moreover in FCM structure the parameters are tunable. Now as FCMs are replaced by NCMs, we allow the experts to make statement of indeterminacy among concepts. If FCM is employed, these edges do not get any value except a '0' but in case of NCM, certainly they do have a weight 'I'; an element of indeterminacy.

6 Proposed Solution versus Previous Solution

The work done earlier in the field of Situation Analysis has not included the indeterminacy which could occur in modeling the situation. In parameter analysis of educational model only factors which have effect or no effect are considered. The experts are put forward with questions like "this factor affects another or not?" the expert responds with positive, negative or absence of impacts, but indeterminacy of impacts is not taken into consideration. In Failure Mode Effect Analysis nothing about the uncertainty of system design is mentioned. In contrast uncertainty in system design is of much importance since changes In Design of the system under consideration will have corresponding changes in the modes of failure of the system. In Information Processing Model Fuzzy Cognitive Maps (FCMs) are used for acquisition of causal knowledge and guide the reasoning process. Indeterminate relations are not considered. Taking indeterminacy into account; improves the evaluation and hence valid inferences are drawn. Now further modeling the situation using Neutrosophic Cognitive Maps (NCMs) allow us to model indeterminacy. In this model experts face Neutrosophic questions like "is there any relation among concepts" or "are you not in a state to determine any relation among concepts and so on". These questions led to the introduction of indeterminacy to the experts. The problem formulated by FCM is considered and we reformulate questionnaire in different format so that the experts are allowed to answers like "the relationship among certain concepts is indeterminable or not known". On the grounds of opinion of the expert together with the notion of indeterminacy, we have obtained the Neutrosophic model.

7 Conclusion

One of the great scientists Albert Einstein [22] quoted, "**So far as the laws of mathematics refer to reality, they are not certain. And so far as they are certain, they do not refer to reality**". Earlier used FCM technique does not take into account indeterminacy. When unsupervised data is analyzed we are not in a position to say anything for certain. At some point of time we come across the indeterminacy of facts when analyzing the unsupervised data. The only powerful tool that aids in understanding and applying the concept of indeterminacy is the notion of Neutrosophy. This paper discusses NCM technique and a comparison with FCM is presented. The presented Neutrosophic Cognitive Map approach in analyzing the situation has led to the inclusion of indeterminacy in Situation Analysis and gives a better understanding of how indeterminacy plays a vital role in this field. By exploring various concepts and relationships among them, NCM is designed and corresponding Neutrosophic

Adjacency Matrix is formulated. Through examining the Adjacency matrix a valid inference can be drawn. Future work in this regard might be exploring the structure of NCM and corresponding adjacency matrix, applying learning algorithms to refine structure and carrying out simulation where Situation Analysis is needed to validate the output.

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