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## Neutrosophy Logic and its Classification: An Overview

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**Abstract:** Over the past few years, neutrosophy has gained an exponential growth and has attracted a good number of researchers especially those who focus on soft computing based uncertainty computation. This paper presents the various techniques in neutrosophy. The various techniques are discussed lucidly which help a naïve researcher in this field to understand the on-going researches and establish a strong base. We have summarized the previous work carried out in the field of neutrosophic logic, set, measure, and also classification techniques in neutrosophy and the relevant research work has been discussed. Further, various applications in the field of neutrosophy are elaborated. The major contributions of the existing research in neutrosophy is reviewed and presented from different perspectives. The development of newer algorithms for solving the problems of neutrosophy will provide impetus to the existing research in this field.

**Keywords:** Neutrosophy, indeterminacy, neutrosophic logic

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### 1. Introduction

Neutrosophy, having emerged as a generalization to fuzzy logic is being used in the research area in a number of fields like logics, set theory and others. Florentin Smarandache, in 1980, introduced this new field of philosophy which deals with the uncertainties and indeterminacy in the data. He defines neutrosophy as the science which deals with neutralities. This field takes into consideration the dawn, kind and scope of such neutralities and how they interact with various ideational spectra. The fundamentals of the study of the logic of neutrosophy, probability in neutrosophy, sets in neutrosophy and the statistics is given by neutrosophy. Various researchers have incorporated the idea of Neutrosophic Logic (NL), Neutrosophic Cognitive Maps (NCM) and other technologies in areas such as Information system application, IT, Decision Support System Application, Physics, Healthcare, Social Sciences etc. In 2019, F. Smarandache, introduced the concept of Neutrosociology[1], which is the amalgamation of sociology and neutrosophic methods. In [3], an improved method using clustering using k-means was incorporated for performing image segmentation using neutrosophic logic. In [4], the authors presented a way of correcting the uncertainties that arise in discursive analysis by applying Neutrosophy Theory in relation with sentiment analysis. In [5], the authors gave a framework to see how mental models could be analyzed using neutrosophic logic. In [6], [9], [10], [11], [15], [16] and [17], Neutrosophy was used to deal with the uncertainties and indeterminacy in situation analysis. In [25], the evaluation of the smart disaster response systems in times of ambiguity has been done using a framework. The

degrees of contradiction in the evaluation criteria have been addressed with the help of plithogenic set theory which checks the uncertainty environment. In [26], to tackle time scheduling in projects, a framework has been given to minimize the cost of projects in environments which are ambiguous. Neutrosophic theory has been used to consider the dynamic features of all parameters. In [29], a resource levelling model to minimize the costs of daily resource fluctuations is given, using neutrosophic set, with the aim of tackling the issues of uncertainty in the problems of the real world. In [30], the authors have given a framework for professional selection by making use of neutrosophic multi-criteria decision making, in an attempt to check the vagueness and ambiguity in the selection process. In [31], a case study of Thailand's sugar industry has been done to validate the model proposed, using the plithogenic decision making perspective for evaluating supply chain sustainability. In this paper, we have reviewed the neutrosophic technologies that have been incorporated in various researches all over the world. The figure 1 depicts the workflow.

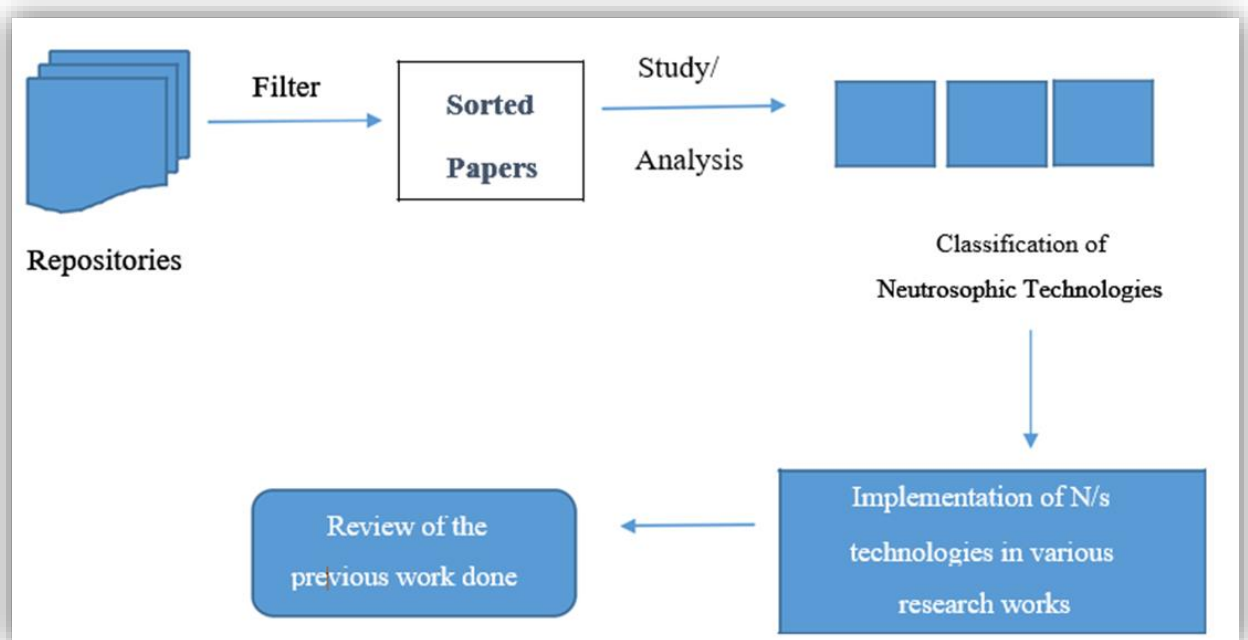


Figure 1. Block diagram for the process of the research carried out in the manuscript

## 2. Background Study

Florentin Smarandache [2019] in his book, Introduction to Neutrosophic Sociology (Neutrosociology) discussed Sociological Forecasting, Neutrosophic Social norms and situations which cannot be solved in the classical way. He discussed neutrosophic Grand Theories to find abstract ideas about concrete facts in large social groups. He has also discussed Neutrosophic Big Data, IoT and Neutrosophic Microsociology in this book. [1]

Aasim Zafar, Mohd Anas Wajid [2019] used the concept of neutrosophy to study the reasons of criminal behavior in Nigeria. They found that out of various factor taken by the researchers, some were excluded because they were found to be indeterminate. To show how such factors did actually contribute to the criminal behavior, they modelled the situation mathematically using FCM's and NCM's, where the former stands for Fuzzy cognitive Maps and the latter stands for Neutrosophic

Cognitive Maps. They further conclude how NCM is more effective than FCM in dealing with uncertainties and indeterminacy in situation analysis. They further concluded that if the indeterminate factors were taken, it could improve the efficiency and accuracy of the mathematical models using the concept of Neutrosophic Cognitive Maps. [6]

V Christiano, F Smarandache [2019] reviewed the seven applications of Neutrosophic Logic. They have used logical analysis based on Neutrosophic Logic. They further suggest that NL theory could be applied in Psychology pertaining to different cultures, forming theories in the field of economics, resolution of conflicts, philosophy of science and other fields like applied mathematics, economics and physics. [7]

Nancy El-Hefenawy, et al. [2016] reviewed the application of Neutrosophic Sets. They suggest that there exist a number of application in fields such as in decision making systems, IT, various information systems. This paper presented some important areas of neutrosophic sets, logic in neutrosophy, neutrosophy related measures and a neutrosophic set of a single value (SVNS). They further suggest that these could produce a new algorithm for tackling any neutrosophic problem. These can help also to solve any fuzzy problem using neutrosophic algorithm. [8]

S Pramanik, S Chackrabarti [2013], studied the issues which were faced by the construction workers in West Bengal and used the technique- neutrosophic cognitive maps in order to find the solutions for it. They discussed the major problems faced by the workers and based on the opinions of the experts and after considering the indeterminacy factor, they formulated the NCM. [9]

Anne-Laure Joussetme, et al. [2003], proposed a discussion on how uncertainty plays a role in situation analysis. They gave an overall understanding of the principal typologies of uncertainty which were found in the literature of the recent times. They discuss that besides richness and ambiguity of the language which is natural is the reason for varied uncertainty conceptions, it is also a result of the not-so-simple physical nature of the information. They further define some concepts to better understand uncertainty and the benefits that are sought. [10]

Vasanth K, W. B.; Smarandache, Florentin [2004], used NCM to study and analyze the social aspects of laborers who had migrated from different place and were suffering from HIV/AIDS in the rural areas of Tamil Nadu. They made use of the Relational Maps in neutrosophy (NRM) and defined some new neutrosophic tools which they adopted in the study and analysis of this issue. They further gave a sketch of some sixty laborers who were infected with HIV/AIDS. [11]

K Pérez-Teruel, M Leyva-Vázquez [2014], gave a structure with the help of which they analyzed the mental models and did their elicitation using neutrosophic logic. To show the applicability of the project, they showed an illustrative example. They discuss a framework for the processing of indeterminacy and uncertainty in mental models. [12]

Mustafa Mamat et al. [2012], used an approach based on fuzzy linear programming for the planning of a balanced diet. They discussed the causes of disease-related lifestyle and eating disorders which are critical issues in the world. They calculated the nutrient amount in food to be taken by the Fuzzy Linear Programming Approach and considered it to estimate the nutritional requirements for an individual on a daily basis. They further suggest that this planning could help in preventing the eating disorders and certain disease-related lifestyle. [13].

Igor Bagány and Márta Takács [2017] discussed the correlations in a number of factors involved in education system in a way that the functionality could be modelled. They do so to examine the education system in an effective manner. They further employed the fuzzy cognitive map (FCM)

technology, because it helps in determination of qualitative description of the given parameters and relationships [14].

S No.	Author and Year	Primary Contribution	References
1.	Florentin Smarandache (2019)	<ul style="list-style-type: none"> <li>⊙ Sociological Forecasting, Neutrosophic Social norms</li> <li>Neutrosophic Grand Theories</li> <li>⊙ Neutrosophic Big Data, IoT and Neutrosophic Microsociology.</li> </ul>	[1]
2.	Victor Christiano and F Smarandache (2019)	<ul style="list-style-type: none"> <li>Applications of neutrosophy in :</li> <li>⊙ Psychology with respect to cultures</li> <li>⊙ Forming theories in economics</li> <li>Resolving conflicts.</li> </ul>	[7]
3.	Nancy El-Hefenawy et al. (2016)	<ul style="list-style-type: none"> <li>⊙ Decision support system, IT, information system</li> <li>⊙ Some important notions pertaining to Neutrosophy.</li> </ul>	[8]
4.	Aasim Zafar and Mohd Anas Wajid (2019)	<ul style="list-style-type: none"> <li>⊙ NCM to model the criminal behavior in Nigeria.</li> <li>⊙ Indeterminate factors, if considered improve the accuracy and efficiency of the model.</li> </ul>	[6]
5.	Surapati Pramanik and Sourendranath Chackrabarti (2013)	<ul style="list-style-type: none"> <li>⊙ NCM for the issues related to laborers in West Bengal.</li> </ul>	[9]
6.	Anne-Laure Joussetme (2003)	<ul style="list-style-type: none"> <li>⊙ Role of uncertainty in situation analysis</li> </ul>	[10]
7.	Vasanth K, W. B. and Smarandache, F (2004)	<ul style="list-style-type: none"> <li>⊙ Analyzing the social aspects, using NCM, of those laborers who had migrated and suffer from HIV-AIDS.</li> </ul>	[11]
8.	KPTeruel and ML Vázquez (2014)	<ul style="list-style-type: none"> <li>⊙ A framework for the analysis of mental models based on NL (neutrosophic logic).</li> </ul>	[12]
9.	M Mamat et al. (2012)	<ul style="list-style-type: none"> <li>⊙ An approach incorporating FLP for a balanced diet planning.</li> </ul>	[13]
10.	Igor Bagány and Márta Takács (2017)	<ul style="list-style-type: none"> <li>⊙ FCM for finding correlations in a number of factors involved in education system in a way that the functionality could be modelled.</li> </ul>	[14]
11.	Shuqi Xue et al. (2014)	<ul style="list-style-type: none"> <li>⊙ The information processing model which focuses on the behavior of the human brain, with respect to cognition.</li> </ul>	[15]
12.	Dr.M.Albert William et al. (2013)	<ul style="list-style-type: none"> <li>⊙ NCM for analyzing the risk factors for Breast Cancer</li> </ul>	[16]
13.	K Mondal and S Pramanik	<ul style="list-style-type: none"> <li>⊙ NCM for analyzing the issues faced by Hijra community in West Bengal.</li> </ul>	[17]

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		<ul style="list-style-type: none"> <li>• Smart disaster response systems in uncertainty environments</li> <li>• Plithogenic Decision Making approach (Supply Chain Sustainability) [25], [26],</li> <li>• Bipolar Neutrosophic Multi-Criteria Decision Making Framework (Professional Selection) [29], [30], [31].</li> <li>• Neutrosophic Set for assessing uncertainty of linear time-cost tradeoffs</li> <li>• Resource levelling model based on neutrosophic set</li> </ul>	
14.	Abdel-Basset et al. (2020)		

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Shuqi Xue et al. [2014], described the information processing model which is based on the behavior of the human brain, with respect to cognition. They proposed that the two methods of modelling a situation cognitively are representing and reasoning about situation analysis with the help of Ontology and the use of FCM, in order to formulate a Situation analysis framework. The presented approach of FCM is for a systematic analysis of the Situation Analysis theory; it provides an understanding of how the working of its elements. [15]

Dr.M.Albert William et al. [2013] analyzed the risk factors for breast cancer using NCMs. Based on the expert's opinion, they had chosen certain factors as the main nodes for obtaining a neutrosophic directed graph. They had analyzed the risk factors and their solutions and discussed how certain factors are crucial for the development of the disease [16]. However few softcomputing approaches have been used in [27, 28] K Mondal and S Pramanik [2014] have studied the situation of the hijra community in West Bengal and addressed their issues using NCMs. On the basis of the experts' opinion as well as the idea of indeterminacy, they have formulated the NCM [17].

### 3. Classification of Neutrosophic Techniques:

Various researchers have studied the concept of neutrosophy and applied various techniques to address different problems of indeterminacy. Some techniques are given below:

- a) Neutrosophic Cognitive Maps
- b) Neutrosophic Logic
- c) Neutrosophic Set
- d) Neutrosophic Measure
- e) Single Valued Neutrosophic Set

#### 3.1. Neutrosophic Cognitive Maps (NCM):

Florentin Smarandache introduced the idea of NCM. They are considered to be an addendum of the Fuzzy Cognitive Maps with the difference being in the fact that, the values of indeterminacy are included. Various real life situations contain the factor of indeterminacy which cannot be modeled using existing methods. To show how indeterminacy affects the situation under consideration, NCMs have proven to be an important tool.

Definition:

It is a directed graph which has concepts (as in, any policy/event) and causalities where the former is for nodes and the latter is for the edges. It is a representation of a relationship between concepts. A simple NCM can be defined as those which have edge weights or causalities from the set  $\{-1, 0, 1, I\}$ .

Let the two nodes of the NCM be denoted by  $A_i$  and  $A_j$ . The effect of one node on the other is represented with the help of a directed edge from  $A_i$  to  $A_j$ , which is called connections. The weightage is assigned to each edge with a number in the set  $\{-1, 1, 0, I\}$ . We assume that  $e_{ij}$  is the weight assigned to the directed edge  $A_i A_j$ ,  $e_{ij}$  belongs to  $\{-1, 0, 1, I\}$ . The following table II shows the value of  $e_{ij}$  and the effect it has on the corresponding edges:

Table II: Value of  $e_{ij}$  and its effect on corresponding edges

Value of $e_{ij}$	Effect of $A_i$ on $A_j$
$e_{ij}=0$	No effect.
$e_{ij}=1$	Increase (or decrease) in $A_i$ causes increase (or decrease) in $A_j$ .
$e_{ij}=-1$	Increase (or decrease) in $A_i$ causes decrease (or increase) in $A_j$ .
$e_{ij}=I$	The effect of $A_i$ on $A_j$ is indeterminate.

Many researchers have incorporated the concept of NCMs in their work. NCMs are an effective way to deal with uncertainties and indeterminacy in Situation Analysis. They have shown how indeterminate factors if taken into consideration could enhance the efficiency and accuracy of the mathematical models using the concept of Neutrosophic Cognitive Maps.

Dr. M. Albert William et al. (2013) have analyzed the risk factors of Breast Cancer and their solutions with the help of Neutrosophic cognitive maps (NCMs). They have taken some twelve factors as the main nodes for their study. With the help of corresponding adjacency matrix related to the neutrosophic directed graph, they model the situation with the help of certain mathematical calculations.

Dr A. Kalaichelvi and L. Gomathy (2011) have analyzed the issues that the girl students had to face who got married while studying, with the help of Neutrosophic Cognitive Maps (NCM's). they collected the data from some hundred students in different courses in various colleges in Tamil Nadu, India. They identified certain factors on the basis of the generated opinions by those who were considered. In this way, they assessed what the effect of one factor would be on the other.

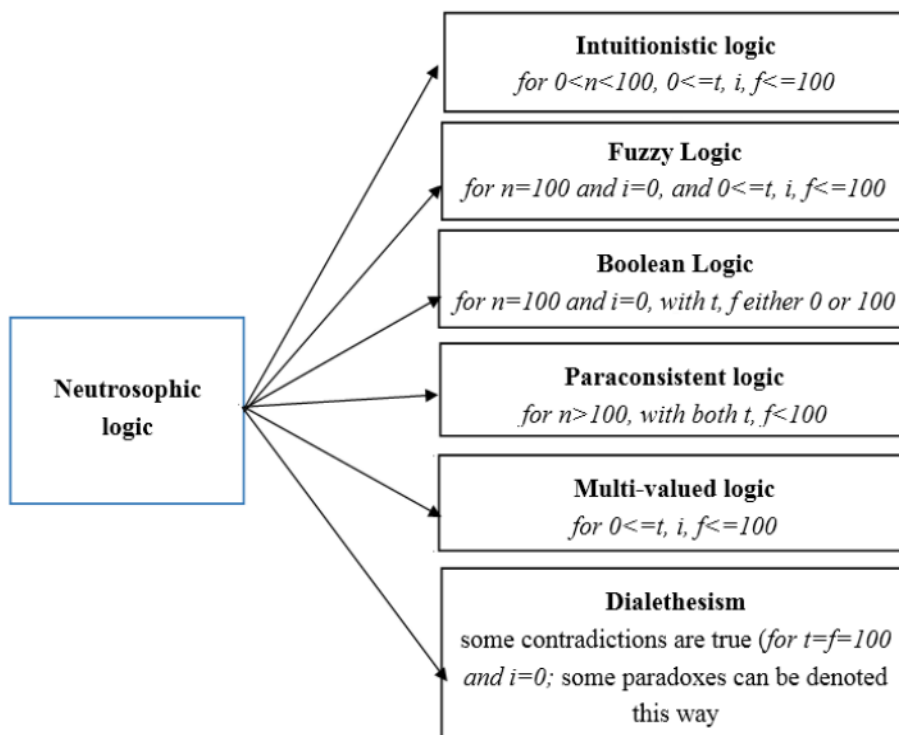
Surapati Pramanik et al. studied the issues faced by the laborers in the construction industry in West Bengal on the basis of NCM's. They identified some major problems and on the basis of the opinion of the expert and the factor of indeterminacy, they formulated the NCM. Then, they studied how the state vectors would affect the two matrices i.e; the connection matrix and neutrosophic adjacency matrix.

Aasim Zafar and M Anas Wajid studied the various factors which led to criminal behavior in Nigeria. They analyzed the situation of crime there and found out that the prominent researchers who had been monitoring the situation there cited certain causes like family breakdown,

corruption, poverty etc as the reasons for criminal behavior. However, they do not take into account factors like inadequate equipment, NGOs, underemployment because these are considered to be indeterminate factors. They used NCMs to show that these indeterminate factors were actually related to the crime in Nigeria. They further conclude that the accuracy and efficiency of mathematical models can be enhanced using NCMs if indeterminate factors are taken into consideration.

### 3.2. Neutrosophic Logic (NL):

It is also called Smarandache logic. The fuzzy logic is generalized on the basis of Neutrosophy and it gives rise to something called Neutrosophic logic. It says that a proposition could take three values: true (t), false (f) and indeterminate (I) and each of these are the values from the range of [T, I, F]. There is an introduction of a certain idea of 'indeterminacy' because of the parameters which are not expected and therefore, concealed in some statements. NL is the analysis of the partition in a triad. It includes the membership degrees of truthfulness T, falsity F and indeterminacy I. Figure 2 illustrates the following.



**Figure 2.** Neutrosophic logic and its relationship with intuitionistic logic

Florentin Smarandache in 2003 has written a paper to give an understanding of the Neutrosophic Logic (NL). He has also pointed out the differences between the Intuitionistic Fuzzy set and the neutrosophic set. [20]

Karina Pérez-Teruel and Maikel Leyva-Vázquez have analyzed the mental models and did their elicitation using NL. To show the applicability of the project, they showed an illustrative example. They discuss a model for the understanding the effect of indeterminacy and uncertainty in such models. [5]



Florentin Smarandache and Luige Vlădăreanu in 2011, have introduced the concept of NL and set operators. They have described the dynamics of a robot mathematically and how neutrosophic science is applicable to robotics [8].

### **3.3. Neutrosophic Set (NS):**

Neutrosophic set is defined as the area of neutrosophy that is associated with the study of the dawn, scope and type of neutralities, and how they interact with various analytical spectra. [8]

Smarandache defined neutrosophic set as: Let the space of points be denoted by  $(Y)$ . Let the general element in  $(Y)$  be denoted by  $(y)$ . A NS  $(B)$  in  $(Y)$  has three membership functions (MF): truth MF  $-T B(y)$ , an indeterminacy MF-  $I B(y)$  and a falsity MF-  $F B(y)$ . The functions  $T B(y)$ ,  $I B(y)$ , and  $F B(y)$  are real subsets of  $[0-, 1+]$  (they could be real standard or nonstandard).

That is:

$$T_B(y): Y \rightarrow [0-, 1+], I_B(y): Y \rightarrow [0-, 1+] \text{ and } F_B(y): Y \rightarrow [0-, 1+]$$

There is no limiting condition on the sum of  $T B(y)$ ,  $I B(y)$  and  $F B(y)$ , so  $0- \leq \sup T B(y) + \sup I B(y) + \sup F B(y) \leq 3+$ .

Neutrosophic Sets have been used in various research works. Some examples are: F. Smarandache, in [7] wrote about the Schrödinger's Cat Theory. He said that at one moment, the photon's quantum state could be in more than one place. It meant that one particular element might or might not belong to a set or a place at one time. It also refers to the fact that an element (a quantum state) has a possibility of belonging to two contrasting sets (or places) at one time.

In [26], to tackle time scheduling in projects, a framework has been given to minimize the cost of projects in environments which are ambiguous. Neutrosophic set theory has been used to consider the dynamic features of all parameters.

In K. Atanassov, *Fuzzy Sets and Systems* (2005), neutrosophic sets could also be used to relate an image with information that is not certain, using a new tool; the information could have been applied to some technique wherein the processing of images takes place. The examples are in the field of image segmentation, thresholding and removing the noise. Neutrosophic sets find their real life example in terms of philosophical application. They could also be used to calculate the truth-value in some theories of philosophy of Zen doctrine.

### **3.4. Neutrosophic Measure (NM):**

The classical measure is generalized for such a case where the space has some factor of uncertainty or indeterminacy. The imprecise probabilities and the classical ones are generalized with the help of neutrosophic probability. There are a number of rules of the classical probability that are defined in the way that they are in unison with those of neutrosophy [8].

Let an item be defined as  $\langle B \rangle$ .  $\langle B \rangle$  could be any thought, feature, hypothesis, concept etc. Let  $\langle \text{anti } B \rangle$  be the inverse of  $\langle B \rangle$ ; while  $\langle \text{neut } B \rangle$  be none of the two:  $\langle B \rangle$  and  $\langle \text{anti } B \rangle$ , having some sense of neutrality (or indeterminacy) in relation to  $\langle B \rangle$ . For example, if  $\langle B \rangle = \text{rain}$ , then  $\langle \text{anti } B \rangle = \text{no rain}$ , while  $\langle \text{neut } B \rangle = \text{no idea}$ . Let  $\langle B \rangle$  represent the truth value of a notion, then  $\langle \text{anti } B \rangle$  represents its falsehood, while  $\langle \text{neut } B \rangle$  represents its degree of indeterminacy.

If  $\langle B \rangle = \text{it will rain tomorrow}$ ,  $\langle \text{anti } B \rangle = \text{it will not rain tomorrow}$ , while  $\langle \text{neut } B \rangle = \text{not knowing if it will rain or not/cloudy/humid day}$ . We think of the measure to be null  $\{m(\text{anti } B) = 0\}$  when the case does not prevail. When  $\langle \text{neut } B \rangle$  does not prevail, the measure is written as null  $\{m(\text{neut } B) = 0\}$  [8].

### 3.5. Single Valued Neutrosophic Sets (SVNS) :

It is the instance of a NS which gives an additional possibility for the representation of uncertainty or indeterminacy, imprecision, incompleteness or inconsistency in some details which is present in the real world. The use of information that is not determinate and consistent could be suitably used in applications which include scientific and engineering domains. [9][10]

Let  $X$  define the space of points (objects). Let the collective elements in  $X$  be denoted by  $x$  (Wang et al., 2010). A Single Valued Neutrosophic Set,  $A$  in  $X$  is described by three membership functions (MF): truth MF  $T_A(x)$ , falsity MF  $F_A(x)$  and an indeterminacy MF  $I_A(x)$ .

For every point  $x$  in  $X$ , the three MF's:  $T_A(x)$ ,  $I_A(x)$ ,  $F_A(x)$  belong to the interval  $[0, 1]$ .

SVNS, when continuous is written mathematically as [9,10]:

$$A = \int_X \frac{\langle T_A(x), I_A(x), F_A(x) \rangle}{x}, \quad x \in X.$$

SVNS, when discrete is written mathematically as:

$$A = \sum_{i=1}^n \frac{\langle T_A(x_i), I_A(x_i), F_A(x_i) \rangle}{x_i}, \quad x_i \in X.$$

Jun Ye, in [25], has presented the correlation and correlation coefficient of SVNSs, based on the extension of the connection of intuitionistic fuzzy sets (IFS's). Further, the use of correlation coefficient or similarity measure in cosine (both weighted) is suggested for the decision-making method. The options are evaluated on the basis of the criteria with the help of the membership degrees of truth, falsehood and indeterminacy under the SVNS environment.

M Abdel-Basset et al. in their paper, have analyzed the role of SVNS's and rough sets in smart city. They have proposed a framework for dealing with information that is incomplete and imperfect with the help of theories of SVNS and rough set. This combination of these two sets will take into account

all aspects of uncertainty, imprecision of data and information and make lives of the citizens of the smart cities better with the introduction of services and decisions. They have focused mainly on making a framework of all kinds of imperfection that could possibly happen in smart cities [24].

#### 4. Application Areas of Neutrosophy:

1. Cultural Psychology
2. Socio-economic theorizing
3. Information System Application
4. Decision Support Systems
5. IT Application
6. Healthcare and related areas
7. Situation Analysis
8. Sociological Forecasting
9. Supply chain Sustainability
10. Project Management

- In cultural psychology, NL theory can be used to reconcile the issues in socio-economic theorizing (collectivism vs individualism).

- In socio-economic theorizing, the conflicts arising out of human tensions could be reconciled, as in the conflicts between the two different perspectives i.e.; fermions and bosons, capitalism and socialism.

- In the deep problem of philosophy of science, NL theory can be implemented wherein it suggests that whenever there are two sides which oppose each other, a choice is always there to find the part that is neutral, so that the two opposite sides could be reconciled.

- In the field of cosmology, the NL analyses the underlying cause of changes of neutralities and opposites. It concludes that there is a possibility that there had been some start, in addition to some lasting background also, which they could be the 'primordial fluid'.

- In American football game, an attempt to score a goal involves an infinite sort of events that could happen. So, there is a possibility that NL could be expanded some states which could be more than three.

- In gravitation, this perspective could help find a middle-course between the two kinds of forces (pull and push), by keeping in view the fact that both the forces are in action. [11]

So, many fields of science are being improved with the help of the theory of neutrosophic logic. This theory is applicable in different research areas as well- in applied mathematics, social sciences, economics, and physics.

#### More Applications:

- In Information System Application (Neutrosophic Database, Analysis of the social

networks, systems which deal with e-learning, in finding the middle course in the information of financial markets).

- In Information Technology Application (Neutrosophic Security, NCM's for Situation Analysis, In Robotics).
- Decision Support System (in markets related to finances, management of risks, expert systems related to neutrosophy, linguistic variables in neutrosophy).

In short, it has applications in any field related to science or even human-centered, where inconsistency, incompleteness, indeterminacy is present. In general terms, where  $\langle \text{neut } A \rangle$  (i.e; sense of neutrality in relation to item  $\langle A \rangle$ ) occurs [11].

### 5. Conclusion and Future work:

Neutrosophy is an important field of research nowadays as it deals with uncertainties which cannot be taken into consideration using conventional modeling methods. There is indeterminacy in almost all aspects of this world; neutrosophy is doing its bit to make sense of the unknown. This paper presents a review of the technologies used in neutrosophy and the researches which have incorporated these concepts as well. Various applications of neutrosophy in many fields such as information system, information technology, decision support system and others are given. The future work holds the potential to develop newer algorithms for solving any problem of neutrosophy, which can also help in solving any fuzzy problems. The algorithms in the multi-criteria decision making problems which are based on neutrosophic theory are being used to solve practical applications in other areas such as medical diagnosis, financial market information, robotics, security, information fusion system, expert system and bioinformatics.

**Conflicts of Interest:** "The authors declare no conflict of interest."

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