Neutrosophic Statistics for Social Science

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Abstract

Social Science deals with the study of phenomena related to the social status of human beings. The importance of such sciences lies in the fact that they make it possible to know, predict, modify and improve the functioning of human societies today. Due to the great complexity of modern societies, it is virtually impossible to have accurate data or knowledge about any contemporary society. That is why neutrosophic theory is suitable for representing and modeling the data from studies on any social sciences. They may contain data that is contradictory, incomplete, inaccurate, vague, and so on. In particular, neutrosophic statistics generalizes classical statistics to interval-valued data. Since classical statistics are of great importance for the study of Social Sciences. We will emphasize the Legal Sciences in our approach

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1. Introduction

The term "social sciences" is used to refer to a wide range of academic topics that study social organizations and individuals, as well as the material and immaterial representations of these phenomena. Human sciences and humanities (terms defined by various epistemological concerns) are further examples of convergent or differentiated names, depending on the speaker's aim. Personal and organizational science are two common examples of hybridizations of these concepts. The field of study known as social science investigates where our individual and societal habits come from by looking for the underlying social laws that govern them and finding their manifestation in the complex web of human organizations and societies[1]–[4].

They are differentiated from the Sciences and the Logical Sciences in the hierarchy of scientific disciplines[5], [6].

They are concerned with human activities and behavior, which are often beyond the purview of the Natural Sciences. There are methodological challenges in the social sciences that don't exist in the biological sciences. In the realm of Natural Science, the question of what does and does not qualify

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as such is seldom debated. The distinction between what is and is not a Social Science has been the subject of much debate in the past[7]–[10].

Some areas of study are not considered social sciences even if they require critical thinking and debate[11]–[14].

While the conventional split between the Social Sciences and the Natural Sciences may be questionable in certain situations, there is little consensus on which fields should be included in each[15]–[18].

For instance, while linguistics has traditionally been classified as a branch of the social sciences, the contemporary approach to the investigation of language, which began with Noam Chomsky's functional grammar, suggests that language is not so much of the social contact but should be considered a portion of psychotherapy, or ethology. This is because the workings of languages and their dynamic properties of the conscious experience of the voices or their psychological depictions do not seem to be influenced by any external factors. Some writers argue that this means languages are something like rocks or trees, rather than the product of human desire[19]–[23].

Many writers classify the following fields as Social Sciences since they share some characteristics with them but do not need excessive rigor to be deemed part of that field[24]–[26]:

Studies in the social sciences: Studies in Economics, Psychology, Political Science, and Sociology, as well as Anthropology, History, and Human Geography.

Studies of the human mind and how it works; include linguistics and psychology.

Fields of study concerned with how human civilizations change through time; include history, demographics, and environmental science.

However, Neutrosophy explores the neutralities inherent in ambiguity and uncertainty, such as ignorance, contradiction, paradox, and imprecision. When it comes to set theory, neutrosophic sets may be thought of as a further generalization of fuzzy sets and fuzzy intuitionist sets. There are several examples of this theory being used to solve issues in the real world[27]–[31].

The application of neutrosophic scientific methodologies to the field of sociology is known as Neutrosophic Sociological (or Neutrosociology). In sociology, we have to deal with a deluge of social data, much of which is imprecise, unreliable, contradictory, hybrid, prejudiced, uninformed, redundant, useless, meaningless, confusing, unclear, etc.

Neutrosophy (a new school of philosophy), intuitionistic fuzzy set, neutrosophic logic, intuitionistic fuzzy odds and statistics, neutrosophic analysis, univalent functions measure, etc., should all play a role in this kind of investigation[32]–[34].

When the data being analyzed, or any subset thereof, is uncertain, the field of study known as Neutrosophic Statistics is called into play. One key difference between intuitionistic fuzzy statistics and conventional statistics is that in the former, all data are fixed in advance You may find some studies on Neutrosophic Stats.

If the value of indeterminacy is 0, then neutrosophic stats will be the same as classical statistics. Therefore, the neutrosophic measurement may be used to evaluate ambiguous information. Using neutrosophic statistical tools, we may decipher and order data with some degree of uncertainty such that hidden patterns can be seen[35]–[39].

Since the Fields Of social science often deal with imprecise, contradictory, inadequate, and unfamiliar data, this work aims to gather, define, and show the application of neutrosophic statistical approaches in the field[40]–[43].

We will focus on the subfield of law known as the "Legal Sciences" within the "Social Sciences," where such information abounds despite the requirement for nuanced judgments that have real-world consequences. You may find some studies on the application of Neutrosophy to the Society and Legal Sciences.

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2. Philosophy of Statistics

Some elementary notions of neutrosophic sets and neutrosophic stats are presented here.

Definition 1: Neutrosophic sets have three elements a, b, c

$$0 \leq a + b + c \leq 3$$

Where $a, b, and\ c$ refers to the true, indeterminate, and false functions.

Definition 2:

Imagine a realm of conversation,

$X. Set\ A\ on\ X\ is\ a\ Single - Valued\ Neutrosophic\ Set\ (SVNS)$

$$if\ and\ only\ if\ it\ has\ the\ form:$$

$$A = \{\langle x, uA(x), rA(x), vA(x) \rangle : x \in X\}\ (1)$$

$$In\ the\ range\ [0,1], for\ all\ x, uA\ (x), rA\ (x), and\ vA\ (x)$$

$$are\ real\ numbers, then\ 0 \leq uA\ (x) + rA\ (x) + vA\ (x) \leq 3.$$

$$Membership\ functions\ for\ truthiness, indeterminacy, and\ falseness$$

$$of\ x\ in\ A\ are\ denoted\ by\ uA\ (x), rA\ (x), and\ vA(x), respectively.$$

$$To\ keep\ things\ simple, let's\ write\ a\ Single$$

$$Valued\ Neutrosophic\ Number\ (SVNN) as\ A$$

$$= (a, b, c)\ where\ a, b, and\ c\ [0, 1]\ and\ 0 \leq a + b + c \leq 3$$

Expanding on conventional statistics, Neutrosophic Statistics allows us to work with continuous rather than discrete data.

All methods used to summarise and characterize neutrosophic numerical data fall under the umbrella term of "descriptive statistics."

You can use the procedures in Neutrosophic Causal inference Statistics to extrapolate from a neutrosophic sample onto the population from which it was drawn.

Some uncertainty is there in neutrosophic data. If the values are discrete, like in classical statistics, we might call this kind of information "discrete neutrosophic data."

Neutrosophic data is continuously collected if the values fall into one or more periods.

The foregoing is a further categorization:

Example 1: a figure in the range [we don't know precisely], 46, 53, 68, or 70; Example 2: a subjective (classification) neutrosophic data set, such as [we don't know exactly] blue or [we don't understand precisely] red, white, black, or [we don't know exactly] emerald or [we don't know exactly] yellow

All of the findings in the multivariate neutrosophic data set pertain to a single neutrosophic property.

Data in neutrosophy that includes information on many qualities is called multivariate.

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There is a distinction between the "determinate component" (d) and the "indeterminate part" (I) of a Neutrosophic Statistic Number (N).

In a Neutrosophic Frequency Distribution, subcategories, rates, and frequency distribution are all shown in an indeterminate table. When it comes to frequency, indeterminacies often arise when data is missing, inaccurate, or otherwise unknowable. The relative frequency becomes vague, partial, or undetermined as a result.

Data from a survey with a neutropenic philosophy.

When the membership of a population is unclear, or "neutrosophic," we cannot be certain if certain people are included or excluded.

From a traditional or neutrosophic population, a simple random neutrosophic sampling of size n is a group of n people where at least one of them is uncertain.

To conduct a multistage sampling neutrosophic sample, a pollster first divides the target population into strata based on a predetermined classification method and then selects samples from each stratum that are statistically representative of the whole. Neutrosophic sampling is used to cope with uncertainty.

Furthermore, interval arithmetic ideas that will be helpful to this research are described.

$$Some\ operations\ between\ the\ neutrosophic\ numbers\ N1\ =\ a1\ +\ b1I\ and$$

$$N2\ =\ a2\ +\ b2I\ a$$

$$It\ may\ be\ written\ as$$

$$N1\ +\ N2\ =\ a1\ +\ a2\ +\ (b1\ +\ b2)I\ (Addition),$$

$$and\ N1\ N2\ =\ a1\ a2\ +\ (b1\ b2)I\ (Subtraction).$$

$$I\ (Difference), N1\ N2\ =\ a1a2\ +\ (a1b2\ +\ b1a2\ +\ b1b2)I\ (Product), N1\ N2\ =\ a1 + b1I\ a2 + b2I$$
$$=\ a1 + b1I\ a2 + b2I\ =\ a1 + b1I\ a2 + b2I\ =\ a1 + b1I\ a2 + b2I$$
$$=\ a1 + b2I\ (Division).$$

$$There\ are\ also\ the\ following\ operations$$

$$between\ I1\ =\ [a1, b1]$$

$$and\ I2\ =\ [a2, b2]\ provided\ that:$$

$$It\ holds\ that\ a1\ >\ a2\ and\ b1\ >\ b2$$

$$if\ and\ only\ if\ I1\ >\ I2.$$

$$I1\ +\ I2\ =\ [a1\ +\ a2, b1\ +\ b2](Addition);$$

$$I1\ I2\ =\ [a1\ -\ b2, b1\ -\ a2]$$

$$I1\ \cdot\ I2\ =\ [min\{a1b1, a1b2, a2b1, a2b2\},$$

$$max\{a1b1, a1b2, a2b1, a2b2\}]\ (Product),$$

$$If\ II2\ then\ II1\ =$$

$$II1\left(\frac{1}{I2}\right) = \frac{a}{b}:$$

$$aI1, bI2,$$

$$with\ 0I2\ always\ (Division).$$

$$Six, I\ =\ [a, b],$$

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$$provided\ that\ a\ 0.(Square\ root).$$

$$I^n = I \cdot I \cdot \cdots \cdot I \cdot \underbrace{I}\ n\ time$$

3. Statistical philosophy in the social sciences

In this chapter, we will discuss the statistical approaches from the neutrosophic perspective that may be used in the Social Sciences. In particular, we teach correlation techniques such as Contingency Tables, Pearson's, and Spearman's correlation coefficients.
3.1. Probability Distribution Tables

A contingency table is a tool used in classical statistics for recording and analyzing the association between three or more qualitative (nominal or ordinal) variables. The number of occurrences meeting the criteria in each cell of the table is the basis for its construction. Many social science specialists, however, disagree on what this frequency is, hence it is sometimes impossible to nail down an exact figure. Because the ideas upon which certain disciplines are built might partly contradict one another, the interpretations ascribed to the situations analyzed can vary with the theory in question. However, there may be instances that cannot be classified due to a lack of information, divergent opinions amongst investigators, or any number of other factors. Therefore, it is suggested to do the computations using frequency intervals rather than numerical frequencies.
When dealing with the qualitative values that are common in the data utilized by social scientists, a contingency table becomes an invaluable tool.

Third, a neutrosophic table is one in which at minimum one cell component is an intermediate rather than a discrete number.
To begin, we should point out that the neutrosophic contingencies table is established for the first time when the spectrum of the intervals has the same limit values.
A gauge of the "strength" of the association between the observable features, the coefficient (sometimes termed quadratic dependency coefficient) upon which the dependency coefficient is based. Dependency tables in neutrosophic statistics follow the same equation as those in classical statistics, with the exception that the interval-valued variables of the quadratic contingency are used here. The equation looks like this:

$$\frac{NX^2}{n} = \frac{1}{n}\sum_{i=1}^{k}\ \sum_{j=1}^{m}\ \frac{\left(I_{ij} - \frac{I_i I_j}{n}\right)^2}{\frac{I_i I_j}{n}}$$

Where $\frac{NX^2}{n}$ n is the neutrosophic mean nonlinear contingency and Iij is the intermediate value of the cell located in the i-th row and j-th column. The sum of the columns in the i-th row is denoted by Ii, whereas the total of the rows in the j-th column is denoted by I.j. k is the number of rows in the table, and m is the total quantity of columns; n is the interval sample size.
The stronger the correlation between the variables, the higher this value is. If the two qualities (variables) are unrelated to one another, then the numerator of the fraction will equal zero and the measure will be meaningless. With a 2x2 table, the scale is normalized such that it takes on values between 0 and 1, called the range [0, 1].
NX^2 is not constrained to the interval [0, 1], and so may take on extremely high values. The contingencies coefficient NC expands the contingency coefficient C by eliminating the reliance of the contingency factor on the random sample. The formula for determining range values when N is large is as follows:

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$$NC = \sqrt{\frac{NX^2}{NX^2 + n}}$$

Where n is the number of intervals in the sample. This partition is formulated as having:

$$\frac{I_1}{I_2} = \left[\frac{a_1}{b_1}, \frac{a_2}{b_2}\right]$$

For instance, let's say that each year, on average, 35 rapes of women are recorded in City X, Ecuador. The emotional, social, economic, and familial harm done to a woman as a result of this act is very delicate. For this reason, some victims do not come forward, and the rapist has the confidence to continue his criminal behavior, making this an issue for the city's justice system. The true crime rate, according to experts, is likely 10% higher. Some women that have been attacked and have not gone to the police are known to them via references. Sometimes the lady's friends or family report the occurrence, but the woman is too embarrassed to give the prosecutor any specifics, so nothing is done.

The administration of justice is another crucial factor. Neutrosophic contingency table 1 depicts the relationship between the number of assaults that happened in city X in 2020 and the proportion of these offenses for which the perpetrator was penalized. This number includes offenses that were not reported to authorities, yet are still deemed unsolved.

Because some of the recorded offenses are still in the court process, the table takes them into account in the form of intervals. As a result, crime statistics aren't perfectly precise, yet this degree of uncertainty has been deemed necessary for reliability.

What we end up with is this: According to the data, the correlation between penalized and reported instances might range from strongly correlated to slightly correlated

Table 1: Neutrosophic contingency chart for the year 2020 in city X, showing the number of rapes that were declared vs the number that were not, and the number that were punished versus those that were not.

Annualized reports of rapes Conclusion of the Lawsuit	Reprimanded	Not Reprimanded	Sum
Posted	[20,15]	[13,16]	[33,31]
Not Posted	[0,0]	[2,6]	[2,6]
Sum	[20,15]	[15,22]	[35,37]

3.2 Correlation as measured by Pearson's chi-square

Pearson's correlation coefficient is used to quantify the linear interaction among two qualitative random variables in classical statistical analysis. Pearson's correlation does not rely on a common scale for its calculations, unlike covariance.

As a less formal definition, we might say that the Pearson coefficient is an indicator that may be used to quantify the degree of the link between two summary statistics.

The Pearson correlation coefficient, denoted by XY, is a formula that enables us to determine the degree to which two random variables, x, and y, in a population, are correlated with one another.

$$p_{xy} = \frac{\sigma xy}{\sigma x \sigma y} = \frac{E[(x - x\mu)(y - \mu y)]}{\sigma x \sigma y}$$

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$$r_{xy} = \frac{\sum \quad x_i y_{i-nxy}}{nsxny}$$

Both formulae rely on the dividing factorization's fourth-placed equation. When the input data (X, Y) or (xi, yi) are intervals rather than decision variables, the fifth and sixth equations are transformed into neutrosophic equations. Let's name the neutrosophic version of Pearson's correlation coefficient (NXY) and the adaptation of the formula to the neutrosophic frame, Nrxy. Similar to what was said in the prior paragraph, interval data is preferred over crisp data.

Example 3:

It is common practice to infer information regarding illness transmission or spread by analyzing the geographical distribution of disease occurrence. This is particularly true when looking at the geographical patterns of heteroecious rust fungus. The development of resistance or pathogenicity in plant and pathogenic populations could be better understood if the geographical scale about which hosts and infections communicate in natural systems is studied.

Disease distributions are sensitive to both the availability of hosts and the quantity of inoculum. Unlike agricultural systems, which often only feature one creature as a source of inoculum, natural systems typically have a far wider variety of species present. The leaf rust pathogen Puccinia andropogonis is widespread in the grasslands prairie (Andropogon gerardii). The macrocyclic, heteroecious rust Puccinia andropogonis has a limited telial host range but may infect a wide variety of aecial hosts. A. gerardii and Schizachyrium scoparis (small bluestem) are two of the most frequent telial hosts, whereas the aecial hosts span seven host groups and seventeen taxa (Szabo 2006). The large bluestem grass used as telial hosts is a natural warm-season grass that is valuable as fodder for both wild and domesticated animals from the Blue Ridge mountains to the North Atlantic.

Distance between the aecial host, Comandra umbellata, and the telial host, A. gerardii, was studied by Barnes et al. to determine the impact on rust severity in large bluestem. Their study aimed to answer questions like whether or not large bluestem's genetic makeup had a role in rust severity, how spatial autocorrelation analysis might be used to quantify disease accumulation on both gene clusters, and so on. They discovered that the aeciospore infection rate in large bluestem was significantly altered depending on the spatial organization of the alternative host (Comandra spp.). Big bluestem's total mycelium and rust infection were significantly impacted by the plant's overall growth characteristics, such as the number of stems generated.

Pearson correlation analysis among aecial frequency on Comandra seedlings and rust incidence on large bluestem plants is shown in R using two case studies. For each distance category between the comandra and large bluestem plants, a bar plot is generated to display the connection. The two results that may emerge from such an assessment are shown. There are four examples of each separation between the two hosts in each diagram. Table 1 shows the data to compute the correlation. We compute the correlation between aecial and rust, there is a highly correlated value of 0.56.

Table 2: Pearson Correlation Coefficient

Meters	Aecial Density	Rust Severity
1	47	10
5	50	15
10	44	25
15	40	20
20	21	10
30	87	30
40	15	20

3.3 Correlation as measured by Spearman's

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Spearman's rho (p), a measure of the relationship of two random variables, is a staple of classical statistics. To determine, the data must be sorted and then restored in the original order.

$$p = 1 - \frac{\sigma \sum \quad D^2}{N(N^2 - 1)}$$

Spearman's coefficient may be interpreted in the same way as Pearson's. Moving from negative to positive correlations, with zero signifying neither dependency nor dependence.
When (xi, yi) are intervals instead than crisp numbers, it is easy and beneficial to extend to the neutrosophic structure the notation used for contingency tables and Pearson's correlation coefficient, N. Similarly, if we change to N in Equation 8, we get Nt. Based on the idea of an order for interval values, the neutrosophic version of Spearman's correlation coefficient is a crisp value.
Next, we'll look at an example of how this coefficient may be put to use.

Example 4:

Table 3: The collection of dollar millions

number	Million dollars	Customer price
1	35	30
2	23	33
3	47	45
4	17	23
5	10	8
6	43	49
7	9	12
8	6	4
9	28	31

This data collection has a Spearman Rank Correlation of 0.9.

6. Conclusion

This study defined neutrosophic stats, provided an example, and made some suggestions for its use in the Social Sciences. Inconsistencies may be found in Social Science data often because of errors, conflicts in information and understanding sources, and a lack of impartiality in certain perspectives. That's why interval data may be required there. In this study, we provide a generalization of Pearson's and Spearman's correlation coefficients for the neutrosophic paradigm, as well as a definition and examples of their application in a contingency table. Each was shown with three examples to highlight how and why neutrosophic statistics might be useful in certain situations; the instances are based on imaginary difficulties in the field of legal studies. Our future work will suggest expanding this Neutrosophic framework to include other traditional statistical approaches, which will be useful in addressing issues in the humanities.

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