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Research Article

Uncertainty-Based Trimmed Coefficient of Variation with Application

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In this paper, the neutrosophic trimmed average, neutrosophic trimmed standard deviation, and neutrosophic trimmed coefficient of variation (NTCV) are introduced. The application of the proposed neutrosophic trimmed descriptive statistics is given with the help of measurement data. The comparisons of the proposed NTCV are compared with the existing neutrosophic coefficient of variation (NCV). From the comparisons, it is concluded that the proposed NTCV is more efficient than NCV in terms of consistency and measures of indeterminacy. Based on the study, it is recommended to apply the proposed NTCV in the industry when there is a need to make decisions on the basis of measurement data.

1. Introduction

The statistical methods and techniques are playing an important role in decision-making in all fields of social sciences, medical sciences, and industries. Among them, the average and coefficient of variation (CV) have been widely used in decision-making in the presence of more than one characteristic. The average is used to select the variable of interest which is better on average, and CV is applied to check the consistency of that characteristic. For example, industrials are interested to make the decision about the product on the basis of measurements recorded by different operators. To make the decision, a more consistent operator is selected using the CV. It is important to note that better on the average does not mean more consistent than the others. In other words, the CV tells about the variation in the data. Less the variation means better the data for the decision-making. A CV of less than 10% is considered very good and larger than 30% is not acceptable. The variation in the data can be reduced by omitting the outliers from the data. The outlier of the data can be removed from the data using the idea of the trimmed mean. In this method, a preselected percentage of the values are removed from the starting and ending of the ordered data. The use of the trimmed average is helpful to reduce the variation by removing extreme observations from the data. Wu and Zuo [1] proposed trimmed measures using the scale deviation method. Alkhazaleh and Razali [2] worked on estimation using the trimmed average. Yusof et al. [3] discussed various trimmed methods. Wang et al. [4] introduced the mean approach in medical science. Lugosi and Mendelson [5] introduced heavy-tailed distribution. More information about the application of trimmed measures can be seen in [6–10].

Uncertainty is defined as the lack of sureness about measurement, parameters, and observations. For example, measuring the water level, measuring rock joint roughness, and measuring the lifetime of a virus is done under uncertain environment. According to [11], "different sources of uncertainty may affect the quality of measurement results: environment, measurement setup, measuring instrument, appraiser, measuring object, measuring procedure, physical constants, the definition of the characteristic, software, and calculations." In case, when uncertainty is presented in the data, the fuzzy logic can be applied for the analysis of the data. The trimmed average under fuzzy logic can be applied to remove the extreme observations from the fuzzy data. The authors of [12–15] discussed the applications of trimmed average using fuzzy logic. More applications can be seen in [16, 17].

Fuzzy logic is based on membership and nonmembership values. Neutrosophic logic is a general form of logic that deals with three measures, namely, the measure of truth (membership), the measure of falsehood (nonmembership), and the measure of indeterminacy. The fuzzy logic is a special case of neutrosophic logic, see [18]. The information about the measure of indeterminacy can be obtained from the neutrosophic logic. The neutrosophic logic has been applied in a variety of fields, see [19–21]. Using the idea of neutrosophic logic, neutrosophic statistics which is the extension of classical statistics was introduced by [22]. The methods to analyze the neutrosophic data were discussed in [23, 24]. Aslam [25] introduced the neutrosophic coefficient of variation. Aslam and Bantan [26] introduced a measurement system using neutrosophic statistics. More information on dealing neutrosophic numbers can be seen in [27–29].

As mentioned earlier, the trimmed average is a useful technique to reduce the variation by removing the extreme observations from the data. In this method, a small percentage of values are removed to minimize the variation in the data. The trimmed average helps to remove the outliers from the data before calculating the traditional average. The coefficient of variation under neutrosophic statistics is known as the neutrosophic coefficient of variation (NCV) and the coefficient of variation using the trimmed average under neutrosophic statistics is known as the neutrosophic trimmed standard deviation (NTSD). The coefficient of variation using trimmed average under classical is called the trimmed coefficient of variation. Aslam [25] introduced NCV. By exploring the literature and best of our knowledge, there is no work on neutrosophic trimmed average, neutrosophic trimmed standard deviation (NTSD), and NTCV. In this paper, the introduction of average, standard deviation, and coefficient of variation using the neutrosophic statistics will be given. In addition, we will give the application of the proposed NTCV using the measurement data from the industry. It is expected that the proposed NTCV will be helpful to increase the consistency as compared to NCV. Furthermore, the proposed NTCV will be helpful to minimize the measure of indeterminacy.

2. Methodology

Let $I_N \epsilon [I_L, I_U]$ be an indeterminacy interval associated with neutrosophic random number $X_{Ni} = X_{Li} + X_{Ui} I_N \, (i = 1, 2, 3, \ldots, n_N)$ of size $n_N \epsilon [n_L, n_U]$, where X_L, n_L and X_U, n_U are the lower and upper values, respectively. The basic operations such as multiplication, division, and inverse of these neutrosophic numbers can be seen in [23, 24]. Suppose a data analyst has a neutrosophic sample $n_N \epsilon [n_L, n_U]$ and he is interested to find α% neutrosophic trimmed average (NTA). Suppose that X_L and X_U denote the lower and upper values of an indeterminate interval of measurement parts. The trimmed observation is denoted by$k_N = n_N \alpha$, where α is the percentage of values trimmed from the data. Suppose that $R_N = n_N - n_N \alpha$ shows the difference between the total observation and trimmed observations. The following process can be adopted to calculate α% neutrosophic trimmed average.

Step 1: arrange X_L and X_U observations in the ascending order

Step 2: trim $k_N \epsilon [k_L, k_U]$ observations at both ends of arranged data, where $k_N = n_N \alpha$

Step 3: compute NTA of remaining observations, $R_N = n_N - n_N \alpha$, $R_N \epsilon [R_L, R_U]$

The neutrosophic trimmed average, say $\overline{T}_L$ of values X_L, is calculated as

$$\overline{T}_L = \frac{1}{R_L} \sum_{i=k_L+1}^{n_L - k_L} X_{Li}, \tag{1}$$

where index of summation runs from the lower value of k_N to the lower value of R_N.

The neutrosophic trimmed average, say $\overline{T}_U$ of values X_U, is calculated as

$$\overline{T}_U = \frac{1}{R_U} \sum_{i=k_U+1}^{n_U - k_U} X_{Ui}, \tag{2}$$

where index of summation runs from the upper value of k_N to the upper value of R_N.

The neutrosophic trimmed average, say $\overline{X}_{Ni}$, using equations (1) and (2), is calculated by

$$\overline{X}_{Ni} = \frac{1}{R_L} \sum_{i=k_L+1}^{n_L - k_L} X_{Li} + \frac{1}{R_U} \sum_{i=k_U+1}^{n_U - k_U} X_{Ui} I_{\overline{X}N}; \; I_{\overline{X}N} \epsilon \left[I_{\overline{X}L}, I_{\overline{X}U} \right]. \tag{3}$$

The neutrosophic trimmed sum of the square of observations from $\overline{X}_{Ni}$ is calculated by

$$\sum_{i=k_U+1}^{n_U - k_U} \left(X_{Ni} - \overline{X}_{Ni} \right)^2 = \sum_{i=k_U+1}^{n_U - k_U} \begin{bmatrix} \min \begin{pmatrix} \left(X_{Li} + X_{Ui} I_L \right) \left(\overline{X}_L + \overline{X}_U I_L \right), \left(X_{Li} + X_{Ui} I_L \right) \left(\overline{X}_L + \overline{X}_U I_U \right), \\ \left(X_{Li} + X_{Ui} I_U \right) \left(\overline{X}_L + \overline{X}_U I_L \right), \left(X_{Li} + X_{Ui} I_U \right) \left(\overline{X}_L + \overline{X}_U I_U \right) \end{pmatrix} \\ \max \begin{pmatrix} \left(X_{Li} + X_{Ui} I_L \right) \left(\overline{X}_L + \overline{X}_U I_L \right), \left(X_{Li} + X_{Ui} I_L \right) \left(\overline{X}_L + \overline{X}_U I_U \right), \\ \left(X_{Li} + X_{Ui} I_U \right) \left(\overline{X}_L + \overline{X}_U I_L \right), \left(X_{Li} + X_{Ui} I_U \right) \left(\overline{X}_L + \overline{X}_U I_U \right) \end{pmatrix} \end{bmatrix}, \; I_N \epsilon [I_L, I_U], \tag{4}$$

where $\overline{X}_L = 1/n_L \sum_{i=1}^{n_L} X_{Li}$ and $\overline{X}_U = 1/n_U \sum_{i=1}^{n_U} X_{Ui}$

The neutrosophic trimmed standard deviation (NTSD), say s_{NT}, is given by

$$s_{NT} = \sqrt{\frac{1}{R_N} \sum_{i=k_N+1}^{n_N-k_N} \left(X_{Ni} - \overline{X}_{Ni}\right)^2}. \quad (5)$$

The neutrosophic trimmed coefficient of variation (NTCV) tells about the consistency and is computed by

$$CV_{NT} = \frac{s_{NT}}{\overline{X}_{Ni}} \times 100. \quad (6)$$

3. Application Using Measurement Data

Now, we present the case study from the automotive industry in Kachiran Company in Asia, see [30], for more details. The company is a manufacturing housing clutch used as automobile parts. To make a better decision about the performance of these parts, the company needs the measurements of these parts. The decision about the performance depends on the consistency of the operators. The operators working in the company have the instruction to measure the length of the parts. The measurements of these parts cannot be recorded completely; therefore, the measurement observations are neutrosophic. The measurements in mm by three operators are shown in Table 1.

From Table 1, it can be seen that the use of classical statistics may mislead the managers in decision-making. Therefore, the consistency of the operators in measuring will be discussed with the help of the proposed methods. Let α = 1% and $n_N \epsilon [10, 10]$. The application of the proposed method to find NTCV for operator 1 is stated as follows (Tables 2 and 3).

Step 1: arrange X_L and X_U observations of operator 1 in the ascending order as shown in Table 2.

Step 2: trim $k_N = 1$ observations at both ends of arranged data, where $k_N = 10 \times 0.1$. The remaining data are given in Table 3.

Step 3: compute NTA of remaining observations, $R_N = 10 - 2 = 8$.

The neutrosophic trimmed average of values X_L is calculated as

$$\overline{T}_L = \frac{1}{8} \sum_{i=2}^{8} X_{Li} = 62.12. \quad (7)$$

The neutrosophic trimmed average of values X_U is calculated as

$$\overline{T}_U = \frac{1}{8} \sum_{i=2}^{8} X_{Ui} = 62.24. \quad (8)$$

The neutrosophic trimmed average is defined by

$$\overline{X}_{Ni} = 62.12 + 62.24 I_N;\ I_N \epsilon [0, 0.0019]. \quad (9)$$

The neutrosophic trimmed sum of the square is calculated by

$$\sum_{i=2}^{8} \left(X_{Ni} - \overline{X}_{Ni}\right)^2 = [0.0264, 0.1059]. \quad (10)$$

The neutrosophic trimmed standard deviation (NTSD), say s_{NT}, is given by

$$s_{NT} = \sqrt{\frac{1}{8} \sum_{i=2}^{8} \left(X_{Ni} - \overline{X}_{Ni}\right)^2} = [0.0575, 0.1150]. \quad (11)$$

The neutrosophic trimmed coefficient of variation (NTCV) tells about the consistency and computed by

$$CV_{NT} = \frac{[0.0575, 0.1150]}{[62.12, 62.24]} \times 100 = [0.0924, 0.1851]. \quad (12)$$

The values of NTCV for other operators can be calculated in the same way as for operator 1. The neutrosophic descriptive statistics for three operators are shown in Table 4. From the first column of Table 4, it can be seen that, on average in measurement, operator 2 is better than other operators. We also note that the indeterminacy interval of operator 3 is smaller than other operators. Therefore, operator 3 is more consistent in measuring the length of housing clutch parts. Based on this study, it is concluded that the management can make the decision about the product on the basis of measurement recorded by operator 3.

4. Comparative Study

Aslam [25] introduced the neutrosophic coefficient of variation (NCV) under the neutrosophic statistics. In this section, we will discuss the advantages of the proposed NTCV with NCV. Note here that the proposed NTCV reduces to the existing NCV when no observation is trimmed from the data ($\alpha = 0\%$). To show the efficiency of the proposed NTCV over NCV, we will consider the same descriptive neutrosophic statistics of measurement data are presented in the last section. The NCV and NTCV for three operators are shown in Table 5. From column four of Table 5, it can be noted that the values of NTCV from the proposed method are smaller than the existing NCV which indicates that the proposed NTCV is more consistent in measurement as compared to NCV. For example, for the measurement data given by operator 3, the indeterminate interval is from 0.0826 to 0.1695. On the contrary, this interval from the existing NCV is from 0.1029 to 0.2045. From Table 5, it can also be noted that the use of the proposed method increases the efficiency of the values of the coefficient of variation. From this study, it is concluded that the proposed NTCV is smaller than the existing NCV. We conclude that the proposed method is helpful to increase the consistency of measurement. The neutrosophic forms of NCV and NTCV along with the measures of indeterminacy are placed in Table 6. The first values in neutrosophic form denote the determined values under classical statistics and the second

Table 1: The real example data.

Part no.	Operators		
	1	2	3
1	[62.14, 62.26]	[62.09, 62.21]	[62.09, 62.21]
2	[62.13, 62.25]	[62.13, 62.25]	[62.13, 62.25]
3	[62.05, 62.17]	[62.05, 62.17]	[62.04, 62.16]
4	[62.11, 62.23]	[62.11, 62.23]	[62.11, 62.23]
5	[62.19, 62.31]	[62.19, 62.31]	[62.19, 62.31]
6	[62.06, 62.18]	[62.06, 62.18]	[62.06, 62.18]
7	[62.07, 62.19]	[62.08, 62.20]	[62.07, 62.19]
8	[62.14, 62.26]	[62.14, 62.26]	[62.14, 62.26]
9	[62.24, 62.36]	[62.24, 62.36]	[62.23, 62.35]
10	[62.22, 62.34]	[62.22, 62.34]	[62.22, 62.34]

Table 2: Observations of operator 1.

X_L	62.05	62.06	62.07	62.11	62.13	62.14	62.14	62.19	62.22	62.24
X_U	62.17	62.18	62.19	62.23	62.25	62.26	62.26	62.31	62.34	62.36

Table 3: Trimmed observations of operator 1.

X_L	62.06	62.07	62.11	62.13	62.14	62.14	62.19	62.22
X_U	62.18	62.19	62.23	62.25	62.26	62.26	62.31	62.34

Table 4: Neutrosophic descriptive statistics.

Operators	$\overline{X}_{Ni}$	s_{NT}	CV_{NT}	Range
1	$[62.12, 62.24]$	$[0.0575, 0.1150]$	$[0.0924, 0.1851]$	0.0927
2	$[62.12, 62.26]$	$[0.0514, 0.1078]$	$[0.0826, 0.1731]$	0.0905
3	$[62.12, 62.24]$	$[0.0526, 0.1053]$	$[0.0845, 0.1695]$	0.085

Table 5: The comparison in NCV and NTCV.

Operators	NCV	Status	NTCV	Status
1	[0.1003, 0.2011]	Good	$[0.0924, 0.1851]$	Very good
2	[0.1013, 0.5628]	Not acceptable	$[0.0826, 0.1731]$	Very good
3	[0.1020, 0.2045]	Good	$[0.0845, 0.1695]$	Very good

Table 6: The comparison in NCV and NTCV.

Operators	Neutrosophic form of NCV	Neutrosophic form of NTCV
1	$0.1003 + 0.2011\ I_N, I_N \epsilon [0, 0.5012]$	$0.0924 + 0.1851 I_N, I_N \epsilon [0, 0.5]$
2	$0.1013 + 0.5628\ I_N, I_N \epsilon [0, 0.82]$	$0.0826 + 0.1731\ I_N, I_N \epsilon [0, 0.5228]$
3	$0.1020 + 0.2045\ I_N, I_N \epsilon [0, 0.5012]$	$0.0845 + 0.1695 I_N, I_N \epsilon [0, 0.5]$

part is indeterminate parts. For example, in neutrosophic form $0.0826 + 0.1731\ I_N, I_N \epsilon [0, 0.5228]$, the value 0.0826 presents the value of the coefficient of variation (CV) for classical statistics. The value $0.1731\, I_N, I_N \epsilon [0, 0.5228]$, is the indeterminate part with the measure of indeterminacy $(0.1731 - 0.0826)/0.1731 = 0.5228$. We note that the measure of indeterminacy from the existing method is given by [25] is 0.82. From this study, it is concluded that the proposed method is helpful to minimize the measure of indeterminacy. We also compared the results of the proposed study with interval statistics. The interval statistics used intervals in order to capture the data inside the intervals. Therefore, the interval statistics tells the values of NTCV from 0.0826 to 0.173 without giving any information about the measure of indeterminacy. Therefore, it is concluded that the proposed NTCV is more efficient in measure of indeterminacy than the existing CV proposed by [25] and interval statistics.

5. Concluding Remarks

In this paper, the neutrosophic trimmed average, neutrosophic trimmed standard deviation, and neutrosophic trimmed coefficient of variation (NTCV) were introduced. The application of the proposed neutrosophic trimmed descriptive statistics was given with the help of measurement data. The comparisons of the proposed NTCV are compared with the existing neutrosophic coefficient of variation (NCV). From this study, it is can be seen that the proposed NTCV is more efficient than NCV in terms of measures of indeterminacy. In addition, it can be seen that the proposed NTCV reduces the variation in the measurement data. The proposed NTCV can be applied for the decision-making in the industry when the data are obtained from the measurement having the neutrosophy. The other trimmed statistical methods under neutrosophic statistics can be considered as future research.

Data Availability

The data used to support the findings of the study are given within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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