Neutrosophic Systems with Applications, Vol. 12, 2023
https://doi.org/10.61356/j.nswa.2023.110

An Exhaustive Review of Neutrosophic Logic in Addressing Image Processing Issues

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Abstract: Since the importance of images in our lives and the advancements in computer data gathering methods, anyone can collect a large number of images, but most of them cannot be processed manually. Image processing therefore becomes appealing since various types of data may be represented and processed digitally. Image processing has become the most popular processing method, employed in security camera films, healthcare images, images from remote sensors, and naturalistic image/videos because of fast computers and processors. In order to raise cognitive function and speed up decision-making, image processing is crucial to many information access systems. Since ambiguity now permeates every part of the world, including images, discussing the neutrosophic logic forms the central idea of this discussion, as it is able to handle this ambiguity. To apply the neutrosophic logic, this requires converting the image into neutrosophic reasoning. When using neutrosophic reasoning for image retrieval, average recall and precision measures improve over other approaches. As the image processing field covers several tracks such as image segmentation, noise reduction, image classification, and others. Because there are so many research articles published in this field every year, we thought it would be appropriate to introduce a survey study on this subject. As a result, this study offers a comprehensive assessment of the literature on applying neutrosophic logic to image processing problems that have surfaced during the previous five years (2019–2023).

Keywords: Neutrosophic Logic; Image Processing; Image Segmentation; Noise Reduction; Image Enhancement.

1. Introduction

The complex process of vision involves many different parts of both the brain and the eye cooperating. One of the most important senses regarding humanity's survival and adaptation has always been eyesight. The visual system is used by humans to view, gather, analyze, and comprehend visual information, as well as draw conclusions from it. The ultimate objective of the field of image processing is to automate the collection and processing of visual data. The process of converting an image into a digital format and carrying out specific operations on it in order to extract valuable information is known as image processing. We have seen a broad expansion in the number of image processing applications and methodologies throughout the years. In numerous applications including face recognition [1, 2], object identification [3, 4], medical images, and noise removal [5, 6], it is a crucial preliminary step. Image processing process includes a set of steps, which can be indicated in Figure 1. As mentioned above, the field of image processing encompasses a number of areas, including noise reduction, image clustering, and image segmentation. As a result, numerous approaches, including metaheuristics, machine learning, and deep learning, have been used to

address these issues. Recently, neutrosophic logic was added to them, because of its high ability to deal with blurring.

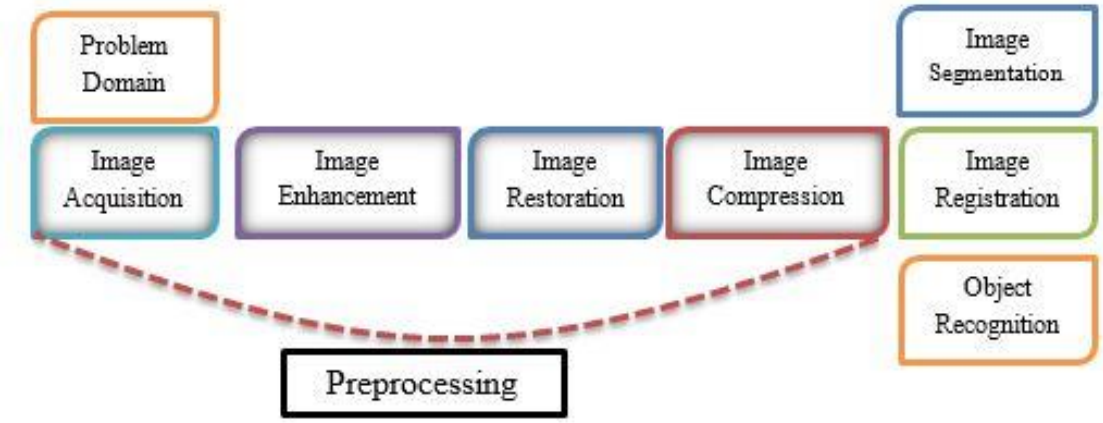

Figure 1. Phases in image processing preprocessing.

Neutrosophic set studies the nature, origins, and scope of impartialities as well as how they interact with other mental spectra. Neutrosophic sets are comparatively recent extensions of intuitionistic fuzzy sets. In Neutrosophic logic, a proposition is assigned three values, such as truth (T), indeterminacy (I), and falsity (F), to each proposition. Any set that falls between [0, 1] and has a grade of truth, indeterminacy, and falsity for each element of the cosmos is called a neutrosophic set. So, how can neutrosophic logic deal with digital images? – The digital image should be converted to a neutrosophic domain throughout a set of equations in [7], it also indicated in the following section. The conversion process from digital image to a neutrosophic image has opened the door for many researchers to solve image problems, because of its ability to handle ambiguity. Based on the previous, Neutrosophic logic has been a critical tool for image noise removal. So, Neutrosophic logic has been used and adapted by numerous scholars to solve image-related difficulties, which gave us the motivation to present a research paper that includes the publications on this era from 2019 through 2023. The primary contributions of this essay can be outlined as follows:

- Introducing a few significant difficulties with image processing that use neutrosophic logic.
- Survey the frequency of neutrosophic logic employed for image segmentation.
- Survey the frequency of neutrosophic logic employed for image classification.
- Survey the frequency of neutrosophic logic employed for image clustering.

2. Neutrosophic Logic

At the end of the nineties, Smarandache introduced neutrosophic theory for the first time [8]. Neutrosophic set is considered the generalization of fuzzy set. According to Zadeh [9], In order to account for database uncertainty, fuzzy sets were introduced. Fuzzy sets use a single-valued membership function in [0, 1] to display acceptance, rejection, and uncertainty portions. They cannot, however, each represent indeterminacy separately. Smarandache in 1998 established neutrosophic logic as a result. The membership functional values of truth, falseness, and indeterminism for every attribute are examples of single-valued neutrosophic. These three functions are independent of one another, meaning that they do not influence one another. To talk about the use of neutrosophic technology in image processing, we should discuss the fuzzy set concept. Fuzzy set concept can be discussed throughout the following. Suppose that we have a universal set U and C is a subset of$U$. Subset C contains a set of elements$u$. Each element in set C has a membership degree indicates the belonging degree to set C, and this membership degree lies between [0, 1].

Moving to neutrosophic set, we can say that, it highlights three functions: membership, non-membership, and indeterminacy. To form a neutrosophic set C in universal set U, three membership functions (truth (T_C (u) ,falseness F_C (u), indeterminacy I_C (u)) are needed for each element u in C , each membership function from these lies in range of [0,1]. The Figure 2 indicates the relationship between four sets: classical set, fuzzy set, intuitionistic fuzzy set, and neutrosophic sets.

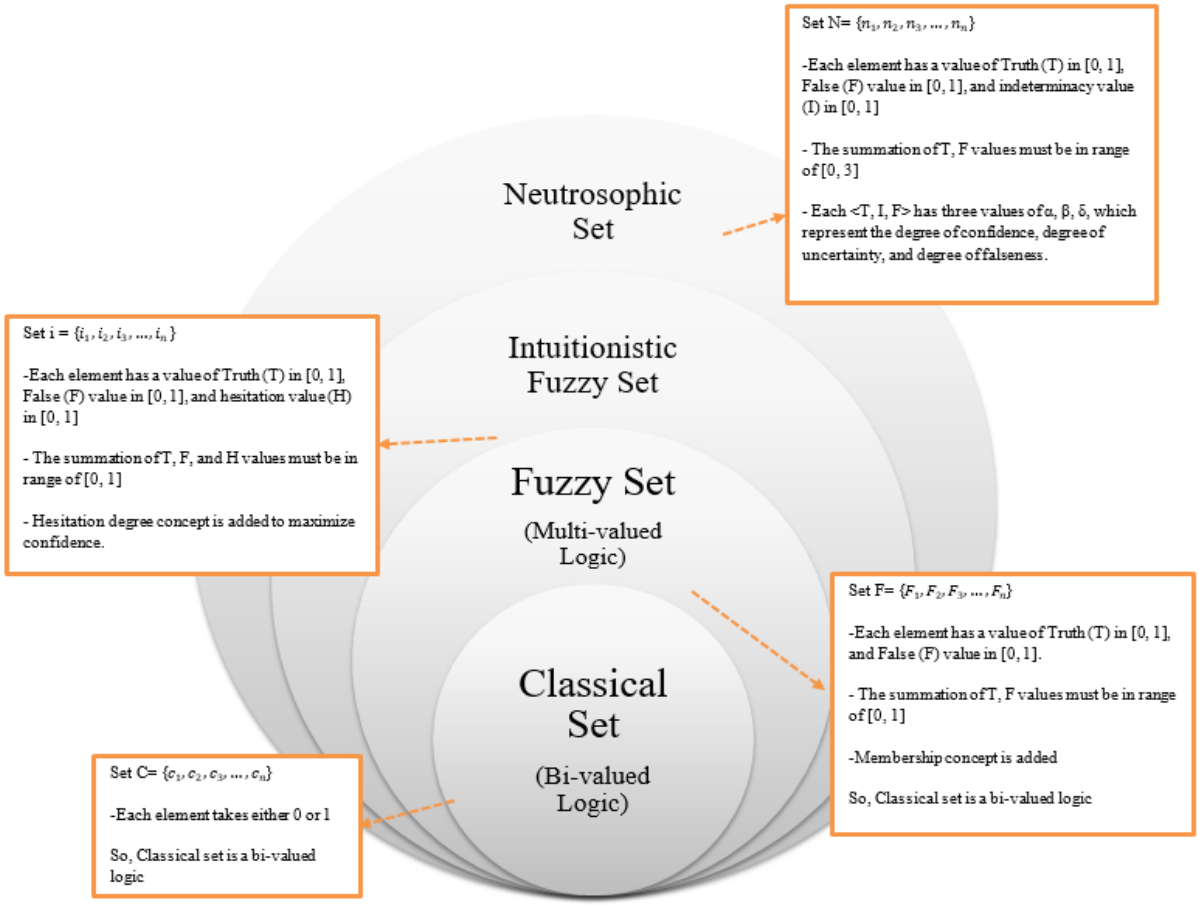

Figure 2. Generalization from classical set to neutrosophic set.

3. Image processing problems

Image processing process covers different areas such as: image segmentation, image enhancement, and image noise removal. The following subsections will cover each problem formulation and also the research trends in each topic.

3.1 Neutrosophic logic image segmentation

The well-known proverb "A picture is worth a thousand words" suggests that analyzing an image can reveal more information than analyzing written content. Image segmentation, or the division of an image into its component objects or region of interest, is the primary research field in computer vision. In general, it groups comparable parts of the image pixels together. It is a stage of pre-processing for a lot of image-based applications, such as recognition of patterns, object detection, healthcare imaging, and biometric authentication [10]. The digital image should be converted to a neutrosophic domain throughout a set of equations from 1 to 4.

Suppose that U be a discourse universe and let A be a set of bright pixels included in U. Truth (T), Indeterminacy (I), and Falseness (F) are the three subsets that define a neutrosophic image. In an image, a pixel P is identified as P(T, I, F) and is a part of A in the following manner: Where t changes

in T, i changes in I, and f changes in F, each bright pixel set has t% truth, i% undetermined(indeterminate), and f% falseness. Every component gets a value between 0 and 1. The image domain's pixel P (a, b) is converted to the domain of neutrosophic as follows: PNS (a, b) = {T (a, b), I (a, b), F (a, b)}. The probabilities associated with the white, indeterminate, and non-white sets are represented by T (a, b), I (a, b), F (a, b), can be defined as follows:

$$T(a,b) = \frac{g_{a,b} - g_{min}}{g_{max} - g_{min}}, \quad (1)$$

$$I(a,b) = 1 - \frac{h_{a,b} - h_{min}}{h_{max} - h_{min}} \quad (2)$$

$$F(a,b) = 1 - T(a,b) \quad (3)$$

$$h_{a,b} = |e(a,b)| \quad (4)$$

Where $g_{a,b}$ represents the value of the pixel and the homogeneous value of T at (a,b) is denoted by $h_{a,b}$ and is represented by the local gradient value $e(a,b)$, which is derived by applying the Sobel operation.

After converting the digital image into a neutrosophic field, researchers raced to compile many research papers in this regard, including those related to image segmentation. So, it gave us a motivation to introduce this survey paper. From 2019 to 2023, some of neutrosophic image segmentation research articles were listed in Table 1.

Table 1. An overview of some Neutrosophic logic for image segmentation.

No	Ref	Main Idea	Data	Merit	Shortcomings	De-noising method
1	[11]	This research suggests an image segmentation module with neutrosophic that is based on a set of steps: First, use min/max normalization to reduce noise. Secondly, the image non-linearities are counted using activation functions. Third, membership functions are calculated to identify various regions and create neutrosophic sets. Lastly, the neutrosophic sets and Dice's coefficients are merged to guarantee an accurate assessment of the uncertainty surrounding the missing data and its indeterminacy for the purpose of segmenting images.	- Crow images	- Less time and computing power - Efficient for segmenting and processing images. - This method can be applied to any number of images and any type of typical problem (blurred images).	- No requirement for training	- Min-Max Normalization

2	[12]	In this study, The picture is initially converted into a neutrosophic image in the suggested technique. It is suggested to use a combined FCM based on particle swarm optimization (PSO) to increase the effectiveness of global search. Ultimately, the suggested approach is utilized for the segmentation of neutrosophic images. The results of the studies demonstrate that the new method is more effective than the FCM algorithm in removing picture noise and improving the clarity of the segmentation region border.	- Lena image - rice grain image - Warship image	The algorithm has the following attributes: - An adequate mage segmentation effectiveness -A powerful global search capability. -Workable and has strong noise reduction capabilities.	- No appreciable decrease in the program's execution time	- NSS
3	[13]	This study suggests a method for segmenting images by fusing the neutrosophic set (NS) theory with a saliency map. The methodology of this study as follows: first, applying a filter to address the image's weak edges, second, after creating saliency map, gray scale and local entropy maps are created, saliency is converted to NS space. The segmentation results are obtained using threshold.	- The experiment's picture source was the MSRA10K image library	- The suggested approach may effectively suppress multiple primary noises. - Effective at handling massive amounts of picture data.	- There is a limit to objective performance.	- Ns domain + Filter
4	[14]	Two offset-based methods were presented in this research. For image segmentation, the preliminary one operates on neutrosophic offsets. For edge identification, the second is built on neutrosophic offuninorms.	- Geometric image and brain image	- Effectiveness - Noise reduction - Calculation simplification through using offset		- Neutrosophic offsets - Neutrosophic offuninorms

5	[15]	In this study, we have combined the notion of weak continuity constraints with an NS-based multiclass segmentation technique. The border information is handled by the weak continuity constraints, which aid in precisely localizing the segmentation boundaries. By taking into account the location of segment boundaries, the suggested method assists in overcoming the drawbacks of existing methods for picture segmentation in the NS domain. Without requiring any prior knowledge of the number of classes, the accurate threshold values are computed repeatedly in the proposed method by reducing the energy function.	- Synthetic images - Non-destructive testing (NDT) images - Kaggle 2018 Data Science Bowl dataset	On both synthetic and a range of natural and non-destructive testing photos, the procedure worked fairly well. The approach exhibits superior quantitative and qualitative performance. The suggested solution performs better on the extremely uncertain Kaggle nuclei photos.	- Intricately textured photos are not processed. - Slower in comparing with a non-repetitive procedure.	- The weak continuity constraints in the NS domain.
6	[16]	An innovative method based on neutrosophic logic for segmenting dental radiography images. Using neutrosophic logic, the first region of interest is chosen. Using the local binary pattern, gradient feature, entropy feature, and patch level feature, the input dental radiography image is transformed into the neutrosophic domain. Localizing the initial region of interest is aided by the application of neutrosophic reasoning. Then, to segment a more precise region of	- Panoramic Dental X-rays with Segmented Mandibles' and 'Digital Dental X-ray Database for Caries Screening.	- Elevated degree of performance	- The suggested method's dependence on image resolution is one of its main shortcomings. It cannot operate in the same manner with images of varying resolutions. It is necessary to adjust system parameters to a specific image resolution.	-NSS

		interest, a fuzzy c means method is used.				
7	[17]	This paper proposes an adaptive region growth strategy for segmenting Brest ultrasound scans based on the neutrosophic set (NSSRG). Each of the pixels in the BUS image is characterized by computing the level of homogeneity score along with similarity set score once the images are converted into the NS domain. The seed regions are created using an adaptive Otsu-based thresholding approach and morphological techniques, after which an adaptable region growing methodology is adjusted depending on the neutrosophic set for the creation of potential tumor regions. To reach the ultimate segmentation result, a deep convolutional neural network based on VGG-16 net is employed for false positive reduction.	This study uses a dataset of clinical 384 BUS pictures that were gathered using a 4-5 MHz linear probe by VIVID 7 (GE, Horten, Norway).	- For the segmentation of breast tumors on BUS pictures, it is reliable and efficient, particularly when the tumors have blurry and low contrast borders.	- Not mentioned	-NSS
8	[18]	This work enhanced the general effectiveness of skin lesion segmentation in dermoscopic images and proposed novel concepts for the NS subgroup. The suggested definition was tested using various filter mixtures, including the standard Sobel with median filter combination. Furthermore, several combinations and methods of segmentation such as GC	- Ninety dermoscopic images from the ISIC2016 skin lesion dermoscopic images were used.	- High segmentation accuracy	- High computational time.	- Neutrosophic filters.

		and k-means were investigated.				
9	[19]	Having defined their aggregate operators and procedures, this paper then utilize the linguistic neutrosophic cubic set (LNCS) for image processing. Using three membership degrees, noisy grey scale images were converted into the LNCS domain for this investigation, and aggregation procedures were then used to sum the images. The Lena image and three other test photographs have their noise clearly defined using the suggested method.	- grey-scale Lena image - images with Edge detection - images with minute object's detailing	- Uses less memory and operates more quickly than the current techniques	-Not mentioned	- Linguistic neutrosophic cubic set
10	[20]	This research aims to identify brain tumors as benign or malignant in order to create an effective automatic brain tumor segmentation system. The neutrosophic set - expert maximum fuzzy-sure entropy (NS-EMFSE) approach was used to segment brain tumors. After Alexnet extracted the segmented image features using CNN architectures, SVM and KNN classifiers were used to classify the images.	- MRI images of 80 benign and 80 malignant brain tumors	-High accuracy -The module is effective in terms of in terms of Sensitivity, Precision, Accuracy	- Not mentioned	- The neutrosophic set - expert maximum fuzzy-sure entropy (NS-EMFSE) approach
11	[21]	This research proposes a gradient-based structural similarity based spuerpixel-neutrosophic C-means clustering for color image segmentation. To obtain precise target contours, the SLIC method combines numerous morphological	-three datasets are used (EORSSD, BSDS500, and MSRC)	-This technique can efficiently and accurately segment pictures into clean and noisy ones.	-The number of super pixel must be known in advance	- gradient-based structural similarity based spuerpixel-neutrosophic C-means clustering

		reconstructions. There are fewer clusters while the target contour is kept intact. Furthermore, the NCM algorithm is enhanced by using adaptive neighborhood information, resulting in a more accurate determination of doubtful super pixels.				
13	[22]	In order to segment images, this research suggests a Neutrosophic C-means Clustering with local information and noise distance-based kernel metric (NKWNLICM). First, in order to strengthen the robustness of noise picture segmentation, fuzzy spatial information and noisy distance information are added to the NCM model. After then, the distance across pixels is calculated using the kernel function. The classification performance is additionally improved by mapping low-dimensional data into high-dimensional data. Finally, a new definition of the fuzzy factor is based on the separation between the center pixel and its surrounding pixels.	- Berkeley University image library	- improved segmentation outcomes for photos with noise	- Its segmentation performance has little advantage since the local data of the image, the spread of the noise, plus the kernel function are incorporated for image segmentation modeling.	- Local fuzzy information and noise distance
14	[23]	This work presents a novel method for handling uncertainty based on the neutrosophic set (NS) in order to segment nondestructive testing NDT image. By encoding an image as a true, false, and indeterminate subset, the NS controls the uncertainty. The two processes α − mean and β − enhancement are	- NDT images from [24]	- manage the ambiguities for the segmentation	-Not mentioned	- NS + bat algorithm

		necessary for accurate depiction of NS values. Using the bat algorithm (BA), we can determine the appropriate values of α and β based on the statistics of the image.				
15	[25]	This work presents the segmentation and location identification of brain tumor tissue features in MRIs using a newly designed (type-2 neutrosophic set) T2NS. T2NSEIF, an image segmentation technique, was proposed based on the proposed T2NS. The suggested T2NSEIF approach also included integrations of the T2NSE and image fusion principles. The suggested approach employed T2NS for the neutrosophication of MRI grey levels, and T2NSE was used to quantify the inherent uncertainties.	- A collection of 3064 T1-weighted contrast-enhanced pictures [26] is used to pick three distinct brain tumors: meningioma, glioma, and pituitary	-High performance -consumes less CPU time.	-Not mentioned	-Type Two Neutrosophic set(T2NS)
16	[27]	The residue procedure, which indicates the residual values of neutrosophic membership intensities, was used in the article. This paper will investigate a brand-new concept for picture thresholding known as RNS. Three different RNS technique kinds will be available: minimum, average, and maximal. This approach takes into consideration the principles of current thresholding methods in neutrosophic solvation. In order to give an integrated visionary route	- A fingerprint picture.	- achieves a higher mean accuracy rating.	- Not mentioned	- Residue Neutrosophic Set

		segmentation methodology, this article employs unique methodologies.				
17	[28]	The two key components of the new MR image segmentation method reported in this study were the HSV color system and the neutrosophic-entropy based clustering algorithm (NEBCA). In this study, the NEBCA was utilized to segment the MR regions, and the HSV color scheme was employed to improve the visual representation of the features inside the segmented regions.	- 30 distinct Parkinson's disease (PD) MR pictures.	- Less time in terms of CPU time -efficiently segment several MR image regions	- The proposed method is validated only with MR images of PD patients.	- Neutrosophic-entropy based clustering algorithm (NEBCA).
18	[29]	A novel fuzzy clustering technique that utilizes non-local information is presented here to enhance the image segmentation algorithm's capacity to process boundaries and its anti-noise effectiveness. To find the fuzzy subset's clustering center, the suggested method first employs the data distribution of a deterministic subset. Also, the neutrosophic fuzzy mean clustering technique incorporates the fuzzy non-local pixel correlation.	- Three types of images are used as synthetic image, medical image and natural image	-Effective image segmentation method.	- The study of the bias field in the original image between the true value and the observed value is not done.	- Fuzzy clustering approach using neutrosophic and non-local information (NLNFC).
19	[30]	This study suggested a hybrid segmentation method for automatically identifying liver tumors from abdominal CT scans that combines the watershed algorithm, fast fuzzy c-means algorithm, and neutrosophic sets.	- Over 105 patients with CT scans of their abdomens and more than 150 slices per patient are included in the dataset [31]	- Precise precision, reduced time spending, and reduced noise sensitivity. - has outstanding precision as well as efficiency on noisy and non-	- Many CT scans are not processed in order to assess performance. - This method's primary flaw is that it requires a lot of computer power and is not suitable	-NSS

				uniform pictures, reducing over-segmentation.	for real-time applications.	
20	[32]	This paper segments the dermoscopic images in the neutrosophic set (NS) domain and suggests an efficient method for dermoscopic skin lesion segmentation employing a neutrosophic set-based kernel graph cut (NKGC).	- International Skin Imaging Collaboration (ISIC) 2016 skin lesion dataset.	- best average segmentation accuracy	-Not mentioned	- Neutrosophic set-based kernel graph cut (NKGC).
21	[33]	In this article, the author suggested a novel exemplar-based image completion method that finds the best match to fill the hole by segmenting an image using neutrosophic sets and applying segmentation information along with similarity measures that take neighborhood and similarity information into account.	-Two datasets (Kaggle dataset, Dhar and Kundu (2021)	-The suggested approach performs both qualitatively and quantitatively well for photos that are corrupted.	-Noise is not considered in this research	- Noise is not take into consideration in this study
22	[34]	This study combines two potent methodologies, such as expert maximum fuzzy-sure entropy (EMFSE) and neutrosophic set (NS), to present an effective edge detection method known as neutrosophic set – expert maximum fuzzy-sure entropy (NS-EMFSE).	- MRI images with 100 different brain tumors	- Efficient segmentation tool.	- Not mentioned	- Maximum fuzzy-sure entropy (EMFSE) + neutrosophic set

3.2 Neutrosophic logic in image classification and clustering

The effectiveness of Neutrosophic set categorization can be attributed to the use of straightforward processes. To control the gain noise and indeterminacy, the NS classifier makes use of neutrosophic logic. With regard to image classification and clustering, a set of research papers were listed in Table 2.

Table 2. An overview of some neutrosophic logic for image classification / clustering.

No	Ref	Main Idea	Data	Merit	Shortcomings	Task
1	[35]	This work suggests a novel method of integrating genetic algorithms and neutrosophic logic in a rule-based classification system to diagnose COVID19 patients based on chest X-ray pictures.	1885 image were collected from three repositories -Github-COVID chest X-ray -Kaggle-COVID radiography - Radiopaedia	-The module performs well in terms of accuracy, precision, sensitivity, and specificity.	- Time complexity	Classification Medical : Chest
2	[36]	In order to control uncertainty when classifying multimodal input, this work uses neutrosophic fuzzy sets for information retrieval tasks. This work aims to identify the images using neutrosophic classification algorithms, drawing inspiration from previous methods of embedding text over images. It makes use of both image and text data. Neutrosophic Convolutional Neural Networks (NCNNs) are used to train feature representations of the generated images for classification tasks.	- Two large scale multi-modal categorization datasets	- Good classification tool	- Not mentioned	Classification Text image
3	[37]	This study solves the texture classification problem by reinterpreting the innovative neutrosophic set-based Completed Local Binary Pattern (CLBP) hybrid approaches based on the neutrosophic set and a novel feature extraction method by using neutrosophic set components. The original input image has been replaced in the suggested technique	- CURET dataset - Poly-class texture datasets - A LOT and STex datasets	-It is suitable for real-time applications. -Good classification accuracy. -The suggested approach has produced excellent classification	-The suggested method's inability to be used directly to color images due to theoretical and mathematical issues is one of its drawbacks. -Time cost	Classification Texture problem

		with the neutrosophic truth and false components of the image. As a result, there are less noise effects and a more meaningful image.		results at a reasonable computing cost.		
4	[38]	A unique, reliable, automatic, and intelligent system for COVID-19 classification utilizing chest X-rays has been proposed in this study. The suggested pipeline combines neutrosophic and machine learning methodologies in a hybrid fashion.	- A public database in Github have been built [39] - The Kaggle Chest X-ray [40]	-The module performs well in terms of The classification accuracy, precision, sensitivity, and specificity.	- The shortcoming of our suggested pipeline is that it only provides a clear-cut positive or negative COVID-19	Classification Medical : Chest
5	[41]	This study presents the Breast Cancer Classification Strategy, a novel approach to classify breast cancer utilizing Neutrosophic approaches (NTs) and machine learning approaches.	-Brest cancer images	-Performs well in terms of accuracy, precision, recall, and F-measure	-Not mentioned	Classification Medical: Breast
6	[42]	In order to determine the final mammographic micro-calcification clusters MCCs, this study used a density-based clustering approach in conjunction with a DCNN classifier to construct an automatic detection method. As the FP MCs reduction stage, the DCNN1 classifier was utilized since it is specifically trained to distinguish between individual MCs. To quicken learning, a novel adaptive NB technique based on NS theory is used.	- A publicly accessible INbreast database and Nanfang Hospital (NFH) in Guangzhou, China are the primary sources of FFDMs of solely MCs [43]	- Plays a vital part in enhancing the efficiency of the automatic identification and categorization of MCCs.	-Time consume.	Classification Medical: Breast
7	[44]	In order to categorize BUS pictures more precisely, the author offer in this research unique Neutrosophic Gaussian Mixture Models (NGMMs) that combine a Deep Neural Network (DNN), neutrosophic logic, and an enhanced Expectation Maximization (EM) algorithm.	-Two public datasets of Breast Ultrasound Images.	- Greatest classification outcomes	- Not mentioned	- Classification Medical: Breast

8	[45]	A novel CVOID-X system based on deep learning classifiers has been suggested in this study to automatically recognize or COVID-19. The COVID-19 diagnosis neural network employing Neutrosophic classifier is a model based on deep learning designed for extracting visual features during volumetric tests for COVID-19 identification. The suggested system makes it easier for people to communicate with medical facilities so that the right COVID-19 patient can be contacted promptly.	-Covid-19 evaluated dataset; for example, the images in the dataset were taken using various imaging clinics' equipment and image collection settings.	- Efficient tool that can be used to other significant areas of healthcare like hepatitis, diabetes, and cancer. - Good classification accuracy.	- Architectures that need a lot of heterogeneous devices, like those for healthcare applications, still have problems with interoperability, data processing, CPU control, memory and disc resources, and big data.	Classification Medical: Chest: COVID-19
9	[46]	This research proposes a new clustering approach using Neutrosophic Set (NS) to extract/segment the lesion/region of interest in mammography pictures. Because NS can manage indeterminate information, the images' level of uncertainty is decreased. In our study, a new method based on Shannon entropy and standard deviation is used to compute indeterminate degree.◎ Next, using the neutrosophic similarity function, an image based on neutrosophic similarity is created, which is subsequently grouped to identify lesions or tumors.	-Fifty images were used to validate the suggested strategy, and these images were obtained from Google.	-The suggested strategy is more accurate and efficient at segmenting the mammography pictures.	--Not mentioned	Clustering Medical: Breast
10	[47]	An innovative skin lesion segmentation approach, known as the optimized clustering estimation for neutrosophic graph cut algorithm (OCE-NGC), was presented in this paper.◎First, the HBCE process is optimized using the	-Dermoscopic skin lesion image dataset from the International Skin Imaging Collaboration	- The experimental findings demonstrated the recommended OCE-NGC approach's superiority.	-The unsuccessful cases that involve the use of different colors in the same lesion areas are not addressed.	Clustering Medical: Skin lesions

		genetic algorithm (GA). Next, using the neutrosophic c-means (NCM) algorithm, the skin lesion dermoscopic pictures are mapped onto the neutrosophic set (NS) domain. Lastly, during the procedure of segmentation, a cost function of the graph cut (GC) algorithm is defined in the NS domain.	(ISIC 2016) for segmentation (The training and evaluation datasets for this dataset contain 379 and 900 dermoscopic pictures, respectively).			
11	[48]	This study examines the cluster ability of the breast cancer dataset using the commonly utilized c-means clustering algorithm, as well as its improved fuzzy and neutrosophic variations. A range of measures are employed in this comparison study to objectively assess the clustering effectiveness of the breast cancer dataset. The best clustering effectiveness is obtained by the proposed neutrosophic c-means clustering with regard to of silhouette score, precision, and Rand index.	- WDBC datasets, which are breast cancer datasets. Prior data was collected from the University of Wisconsin Hospitals.	- The results of the study demonstrate the advantage of neutrosophic c-means clustering in grouping together comparable cases of breast cancer.	-A multidimensional dataset.	Clustering Medical: breast lesions
12	[49]	A novel edge detection method based on the NS scheme category has been proposed in this research. The frame of picture fusion with edge detection allowed for this to be accomplished. The indeterminate conditions and uncertainties present in the photographs can be handled by this approach. The Sobel operator and the BS function are used by the NS framework to replicate images. A new binarized image is created by integrating the subgroups and the calculated	- MR Brain images.	- The suggested strategy is more accurate and efficient	- Image de-noising are not handled	Clustering Medical: MR Brain

		thresholds after that. After the binarized picture has undergone morphological procedures, the edges of the image are obtained. Every entropy is subjected to the same method, which displays many discovered edges.				

4. Conclusions

Neutrosophic logic provides a potent tool for describing the image with imprecise information. The value of neutrosophic theory in image segmentation, image classification/clustering, and noise reduction is discussed in this work. Because the neutrosophic set can handle indeterminacy stronger than the fuzzy/non-fuzzy sets, it has been found that the outcomes obtained using the neutrosophic set are significantly better. When neutrosophic sets are used in image processing, accuracy improves because of more precise segmentation, which leads to more precise outcomes, including correctly diagnosing medical images. Some real-world applications for this include the diagnosis of skin lesions, brain tumors, breast cancer, and dental X-ray pictures, among others. Neutrosophic set produces superior results, even in photos with weak contrast and hazy borders. The work mentioned above demonstrates how more image processing applications can benefit from the use of Neutrosophic based techniques. It also aids in the resolution of issues if a membership function is imprecisely defined because human error is absent.

Acknowledgments

The author is grateful to the editorial and reviewers, as well as the correspondent author, who offered assistance in the form of advice, assessment, and checking during the study period.

Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare that there is no conflict of interest in the research.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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Received: 05 Aug 2023, **Revised:** 04 Nov 2023,
Accepted: 28 Nov 2023, **Available online:** 01 Dec 2023.