Neutrosophic Approach to Grayscale Images Domain

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Abstract. In this paper, we propose a new technique for the enhancing images. It will work on removing the noise contained in the image as well as improving its contrast based on three different enhancing transforms, we commence by embedding the image into a neutrosophic domain; where the image will be mapped in three different levels, a level of trueness, a level of falseness and a level of indeterminacy. Hence, we act separately on each level using the enhancement transforms. Finally, we introduce a new analysis in the field of analysis and processing of images using the neutrosophic crisp set theory via Mat lab program where has been obtained three images, which helps in a new analysis to improve and retrieve images.

Keywords: Image analysis, Image Enhancement, Image processing, Neutrosophic Crisp Set, Gaussian Distribution, Logarithmic Transform, Neutrosophic Crisp Mathematical Morphology

1. Introduction

As a discipline, neutrosophic is an active and growing area of image processing and analysis. Mathematically, a gray scale image is represented by an $m \times n$ array $I_m = [g(i,j)]_{m \times n}$ with entities $g(i,j)$ corresponding to the intensity of the pixel located at (i,j). Presently applications require different kinds of images as sources of information for interpretation and analysis. Whenever an image is converted from one form to another (such as digitizing, scanning, transmitting, storing, etc.) some form of declination occurs at the output. Hence, the output image has to undergo a process called image enhancement which consists of a collection of techniques that seek to improve the visual appearance of an image [12]. Image enhancement is a process which mainly used to improve the quality of images, removing noise from the images.It has important role in many fields like high definition TV (HDTV), X-rayprocessing, motion detection, remote sensing and in studying medical images [8]. The fundamental concepts of neutrosophic set, introduced by Smarandache in [22, 23] and many applications, introduced by Salama et al. in [14-21],[27, 28] provides a natural foundation for treating mathematically the neutrosophic phenomena which exist pervasively in our real world and for building new branches of neutrosophic mathematics, as an extension of the concept of the fuzzy set theory introduced by Zadeh [25].

2. Preliminaries

we recall some definitions for essential concepts of neutrosophic sets and its operations, which were introduced by Smarandache in [22, 23] and many applications by Salama et al. in [14-21].

2.1. Image Enhancement

Recent applications are in need of different kinds of images as a source of information for interpretation and analysis. Whenever an image is transformed from one structure to another, such as: digitizing, scanning, and transmitting, some kind of distortion might occur to the output image. Hence, a process called image enhancement must be done. The process of an image enhancement contains a collection of techniques with the aim of providing a better visual appearance of the image; it is to improve the image quality so that the resultant image is better than the original image for a specific application. In other words, to convert the image to an appropriate form for analysis by either a human eye or a machine. Currently, the image enhancement research covers wide topics such as: algorithms based on the human visual system [6], histograms with hue-preservation [9], JPEG-based enhancement for the visually impaired [24], and histogram modification techniques [5]. Additive noise, Gaussian noise, Impulse noise and Poisson noise represent several types of noises that corrupt the image, to remove any of such there are various filters available. For instance: Gaussian filter, Median filter, High pass filter and Low pass filter; each of these can be used to remove the image noise and, hence, enhance the image. The applications of image enhancement are in every field where images are needed to be understood and analyzed, as in medical image analysis, and analysis of images from satellites. Generally, the enhancement techniques can be categorized into two main groups, which are the Spatial Domain Methods and the Frequency Domain Methods [26].

2.2. Spatial Domain for Image Enhancement

The spatial domain is the normal image space, which is a direct handling of image pixels [2]. It is the manipulation or the change of image representations. Moreover, spatial domain is used in several applications as smoothing, sharpening and filtering images .Spatial domain techniques such as the logarithmic transforms[7], power law transforms[11], and histogram equalization[13], are basically to perform on the direct manipulation of the image pixels. In practice, spatial techniques are useful for directly changing the gray level intensities of individual pixels and consequently the contrast of the entire image. Usually, the spatial domain techniques enhance the whole image uniformly, which in various cases produces undesirable results and do not make it possible to efficiently enhance edges or other required information.

2.3 Frequency Domain for Image Enhancement

While in the spatial domain an image is treated as it is, and the value of the pixels of the image changes with respect to the scene, in the frequency domain we are dealing with the rate at which the values of the pixel are changing in the spatial domain. In all the methods applied, a Fourier transform of the image is firstly computed so that the image is transferred into the frequency domain. Hence, any operation used for the purpose of image enhancement will be performed on the Fourier transform of the image. Afterward an Inverse Fourier transform is performed to obtain the resultant image. The main objective of all the enhancement operations is to modify the image contrast, brightness or the grey levels distribution. Therefore, the value of the pixels of the output image will be changed according to the transformation applied on the input values. In image processing and image analysis, the image transform is a mathematical tool which is used for detecting the rough or unclear area in the image and fix it. The image transformation allows us to move from frequency domain to time domain to perform the desired task in an easy manner. Various types of image transforms are available such as Fourier Transform [1], Walsh Transform [10], Hadamard Transform, Stant Transform, and Wavelet Transform [4]. The image transformation to neutrosophic
domain in [3]

3. Hesitancy Degrees with Neutrosophic Image Domain

Salama et al. in [27, 28] presented the texture features for images embedded in the neutrosophic domain with Hesitancy degree.

Definition 3.1 [15,27,28]:

Let $A = \{(\mu_A(x), v_A(x), \gamma_A(x)), x\epsilon X\}$ on $X = \{x_1, x_2, x_3, \ldots\ldots, x_n\}$. Then for a Neutrosophic set $A = \{(\mu_A(x), v_A(x), \gamma_A(x)), x\epsilon X\}$ in X, We call $\pi_A(x) = 3 - \mu_A(x) - v_A(x) - \gamma_a(x)$, the Neutrosophic index of x in A, It is a hesitancy degree of x to A it is obvious that $0 \le \pi_A(x) \le 3$.

In this section we are transforming the image I_m into a neutrosophic domain using four functions: T, I, F and π . A pixel $P(i, j)$ in the image is described by a forth ($T(i, j)$; $I(i, j)$; $F(i, j)$; $\pi(i, j)$). Where $T(i, j)$ is the membership degree of the pixel in the white set, and $F(i, j)$ is its membership degree in the non-white (black) set; while $I(i, j)$ is how much it is neither white nor black; k and $\pi(i, j)$ is hesitancy degree. The values of $T(i, j)$, $I(i, j)$, $F(i, j)$ and $\pi(i, j)$ are defined as follows:

$$T(i,j) = \bar{g}(i,j) - \bar{g}_{\min} \Big/ \bar{g}_{\max} - \bar{g}_{\min}, \quad I(i,j) = 1 - \delta(i,j) - \delta_{\min} \Big/ \delta_{\max} - \delta_{\min},$$

$$F(i,j) = 1 - T(i,j),$$

$\pi(i,j) = 3-(T(i,j)+I(i,j)+F(i,j))$, where $\bar{g}(i,j)$ is the local mean intensity in some neighborhood w of the pixel, $\bar{g}(i,j) = \frac{1}{w\times w}\sum_{u=i-w/2}^{u=i+w/2}\sum_{v=j-w/2}^{v=j+w/2} g(u,v)$, $\delta(i,j)$ is the homogeneity value computed by the absolute value of difference between the intensity and its local mean value $\delta(i,j) = abs(g(i,j)-\bar{g}(i,j))$.

4. A Neutrosophic Image Enhancement Filter

Consider an Image G in the neutrosophic domain with four functions (T, I, F, π) describing the three levels of trueness, indeterminacy and falseness with hesitancy degree as previously explained in 2. The filter we propose to enhance G is two fold. In one hand it aims to remove the noise from the image, in the other hand it improves the image contrast. To do so, we will work on each level separately.

Firstly, in the indeterminacy level, we will force the stability of this blur area around the mean using the Gaussian distribution. A general form of the Gaussian distribution is $\phi\left(\frac{t-\mu}{\sigma}\right)$, where σ is the standard deviation and μ is the mean value. Secondly, in the falseness level, a logarithmic transform is applied to enhance the details in ; 2 the dark areas while considering the brighter ones. Its general form is, c log (1 + t), where t is assumed to be non-negative; $t \geq 0$, and c is a scaling parameter.

Thirdly, a power-law transform is working over the shattered areas in the trueness level. The power law transformations include the n^{th} power and the n^{th} root transformation, these transformations are also known as gamma transformation and can be given by the general expression, cr^{γ} . Variation in the value of γ varies the enhancement of the images. Finally, we have got the output image, $\bar{G}$ of the enhancement process with the triple $(\bar{T}, \bar{I}, \bar{F}, \bar{\pi})$ where

$$\bar{T}(i,j) = CT^{\gamma}(i,j),$$

$$\bar{I}(i,j) = \frac{1}{\sigma\sqrt{2\pi}}\exp\left(\frac{(I(i,j)-\mu)^2}{2\sigma^2}\right), (2)$$

$$\bar{F}(i,j) = C\ln(1+F(i,j)),$$

$$\bar{\pi} = 3-(\bar{T}(i,j)+\bar{I}(i,j)+\bar{F}(i,j))$$

5. A Neutrosophic Crisp Operators for Grayscale Image

5.1. Grayscale Image via Neutrosophic Crisp Domain.

In this section, we introduce a new analysis in the field of analysis and processing of images using the neutrosophic crisp set theory due to Salama et al. in [14,17] via Matlab program where has been obtained three images representing, which helps in a new analysis to improve and retrieve images

A grayscale image in a 2D Cartesian domain

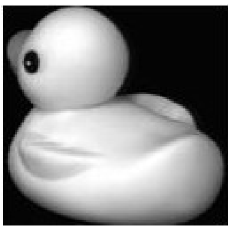

Fig. 1: a) Grayscale image

The following figure shows a grayscale image in a neutrosophic crisp components.

Fig. 1: b) Neutrosophic Crisp Components $\langle A_1, A_2, A_3 \rangle$ respectively

At this point, we have noticed that there exist some crisp sets which having the neutrosophic triple structure and are not classified in either categories of the neutrosophic crisp sets' classification. In this case, the three components of those sets may overlap. In this section, we deduced a new triple structured set; where the three components are disjoint.

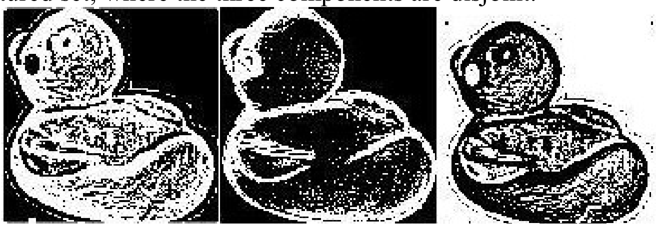

Fig. 2: b) Neutrosophic Crisp Components $\langle A_1, A_2, A_3 \rangle$ respectively

The following figure shows a grayscale image in star neutrosophic crisp components.

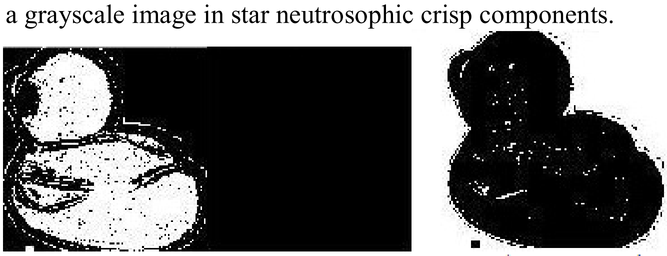

Fig. 3 b) Star Neutrosophic Crisp Components $\langle A_1, A_2, A_3 \rangle$ respectively

Definition 5.1

For any triple structured crisp set A, of the form $A = \langle A_1, A_2, A_3 \rangle$;the retract neutrosophic crisp set A^{r} is the structure $A^{r} = \langle A_1{}^{r}, A_2{}^{r}, A_3{}^{r} \rangle$,where $A_1{}^{r} = A_1 \cap co(A_2 \cup A_3)$, $A_2{}^{r} = A_2 \cap co(A_1 \cup A_3)$ and $A_3{}^{r} = A_3 \cap co(A_1 \cup A_2)$. Furthermore, the three components $A_1{}^{r}$, $A_2{}^{r}$ and $A_3{}^{r}$ are disjoint and $A_i^{r} \subseteq A_i \ \forall i = 1,2,3$.

The following figure shows a grayscale image in a neutrosophic retract crisp components.

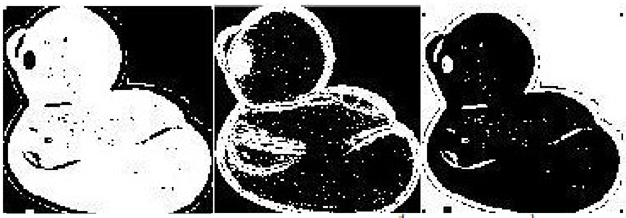

Fig.4: b) Neutrosophic Retract Components $\langle A_1, A_2, A_3 \rangle$ respectively

5.2. A Grayscale Image & Neutrosophic Crisp Operators

Salama et al. [17] extended the definitions of some morphological filters using the neutrosophic crisp sets concept. The idea behind the new introduced operators and filters is to act on the image in the neutrosophic crisp domain instead of the spatial domain.

The following figure shows a grayscale image in a neutrosophic crisp Dilation components.

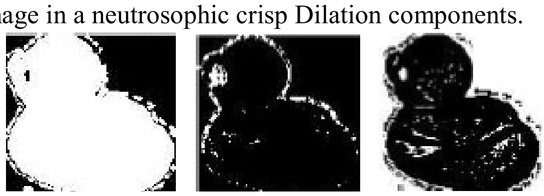

Fig.5: Neutrosophic Crisp Dilation components in type 1 $\langle A_1, A_2, A_3 \rangle$ respectively

Fig.6: Neutrosophic Crisp Dilation components in type 2 $\langle A_1, A_2, A_3 \rangle$ respectively

The following figure shows a grayscale image in a neutrosophic crisp **Erosion** components.

Fig.7: Neutrosophic Crisp Erosion components in type 1 $\langle A_1, A_2, A_3 \rangle$ respectively

Fig.8: Neutrosophic Crisp Erosion components in type2 $\langle A_1, A_2, A_3 \rangle$ respectively

The following figure shows a grayscale image in a neutrosophic crisp **Opening** components.

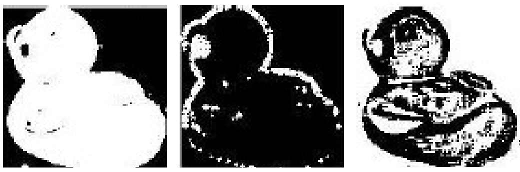

Fig.9: Neutrosophic Crisp opening components in type1 $\langle A_1, A_2, A_3 \rangle$ respectively

Fig.10: Neutrosophic Crisp opening components in type2 $\langle A_1, A_2, A_3 \rangle$ respectively

The following figure shows a grayscale image in a neutrosophic crisp **Closing** components.

Fig.11: Neutrosophic Crisp closing components in type1 $\left\langle A^1, A^2, A^3 \right\rangle$ *respectively*

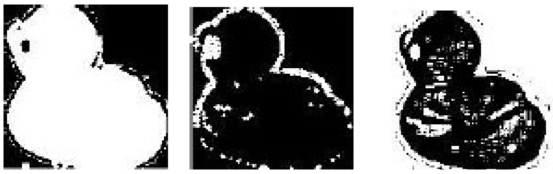

Fig.12: *Neutrosophic Crisp closing components in type2* $\left\langle A^1, A^2, A^3 \right\rangle$ *respectively*

Conclusion

As a discipline, neutrosophic is an active and growing area of image processing and analysis. In this work, we introduce a neutrosophic technique for the image processing, analysis and enhancement. The two fold proposed technique aims to remove the noise from the image, as well as improving the image contrast. To commence, we construct the embedding of the image in the neutrosophic domain; in which the image is mapped into three different levels, describing the levels of trueness, falseness and indeterminacy. Using the Power-law, Logarithmic and Gaussian transforms, the proposed a technique acts on each level of the image separately. Our plan next is to experiment our technique on different types of images, such as medical images.

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