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A NOVEL DENOISING TECHNIQUE BASED ON MORPHOLOGICAL METHODS

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Abstract: The removal of impulse noise often brings about blurring which results in edges being distorted and poor quality. Therefore the necessity to preserve the edges and fine details during filtering is the challenge faced by researchers today. This paper proposes a Morphological approach for detecting and removing salt and pepper noise, Gaussian noise and Speckle noise. The noise detection is based on erosion and dilation. The results show that this method is good for noise reduction especially in high level noisy images.

Key words: Gaussian noise, Morphology, Salt-and-pepper noise, Speckle noise.

INTRODUCTION

Digital images are often corrupted by impulse noise also known as salt and pepper noise due to channel transmission errors or introduced during the signal acquisition stage. The goal of impulse noise removal is however achieved by means of filters[1]. The most commonly used filters are average filters, order statistic filters, weiner filters etc.

The linear filters has poor performance in the presence of noise that is not additive. if a signal with sharp edges is corrupted by high frequency noise, however, in some noisy image data. The linear filters designed to remove the noise also smooth out signal edges. In addition, impulse noise can not be reduced sufficiently by linear filters. As already known, signals are not linear in nature. Generally, when the filters are not linear, they show better performance than when they are linear in the removal of impulse noise from the image. The salt and pepper & random valued impulse noise occurs when the picture elements in the camera sensors do not function well or error in the memory location or during digitization process. a non linear scheme called median filtering with success in this situation. Order-statistic filters are nonlinear spatial filters whose response is based on ordering (ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of a centre pixel with the value determined by the ranking result. the best known filter in this category is the median filter, which , as its name implies, replaces the value of a pixel by the median of the intensity values in the neighbourhood of that pixel(the original value of the pixel is included in the computation of the median). Median filters are particularly effective in the presence of impulse noise, also called salt-and-pepper noise because of its appearance as white and black dots superimposed on an image. This paper lays emphasis on various techniques and methods of how to mitigate the noise [2]

Noise may appear in images during data acquisition such as scanning [3]-[6]. The noise should be removed prior to performing image analysis processes. The difficulty in removing noise from binary image is due to the fact that image data as well as the noise share the same small set of values (either 0 or 1) which complicate the process of detecting and removing the noise. Many algorithms have been developed to remove noise in document images with different performance in removing noise and retaining fine details of the image. Most of the methods easily remove isolated pixels while leaving some noise. In this paper many algorithms will be studied.

Mathematical morphology is a well-founded non-linear theory of image processing [3]- [4]. Its geometry-oriented nature provides an efficient framework to analyze object shape characteristics such as size and connectivity, which are not easily accessed by linear approaches. Morphological operations take into consideration the geometrical shape of the image objects to be analyzed. The initial form of mathematical morphology is applied to binary images and usually referred to as standard mathematical morphology in the literature in order to be discriminated by its later extensions such as the gray scale and the soft mathematical morphology. Mathematical morphology is theoretically founded on set theory. It contributes a wide range of operators to image processing, based on a few simple mathematical concepts. The operators are particularly useful for the analysis of binary images, boundary detection, noise removal, image enhancement and image segmentation. The advantages of morphological approaches over linear approaches are direct geometric interpretation, simplicity and efficiency in hardware implementation.

The hardware complexity of implementing morphological operations depends on the size of the structuring elements. The complexity increases even exponentially in some cases. The known hardware implementations of morphological operations are capable of processing structuring elements only up to 3×3 pixels. If higher order structuring elements are needed, they are decomposed into smaller elements. One decomposition strategy is, for example, to present the structuring element as successive dilation of smaller structuring elements. This is known as the “chain rule for dilation”. But all structuring elements cannot be decomposed.

Morphological Processing and Transforms

An image is a function of two, real (coordinate) variables $a\ (x, y)$ or two, discrete variables $a\ [m, n]$. An alternative definition of an image can be based on the notion that an image consists of a set (or collection) of either continuous or discrete coordinates. In a sense the set corresponds to the points or pixels that belong to the objects in the image. For

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the moment the present paper will consider the pixel values to be binary.

The basic morphological operations [7], namely erosion, dilation, opening, closing etc. are used for detecting, modifying, manipulating the features present in the image based on their shapes. The shape and the size of SE play crucial roles in such type of processing and are therefore chosen according to the need and purpose of the associated application. In the following, we introduce some basic MM operators of gray-scale images. In the two-dimensional Euclidean space $Z^{2,}$ Let D(i, j) denote a gray-scale two dimensional image, E denote SE.

Dilation of a gray-scale image D (i, j) by a gray-scale SE E(x, y) is denoted by

$$(D \oplus E) = \{ z \mid (\hat{E})z \cap D \neq \emptyset \} \quad (1)$$

Erosion of a gray-scale image D(i, j) by a gray-scale SE E(x, y) is denoted by

$$(D \ominus E) = \{z \mid (E)z < D\} \quad (2)$$

Opening and closing of gray-scale image D(i, j) by gray-scale SE E(x, y) are denoted respectively by

$$D \bigcirc E = (D \ominus E) \oplus E \quad (3)$$

$$D \bullet E = (D \oplus E) \ominus E \quad (4)$$

Erosion basically decreases the gray-scale value of an image by applying shrinking transformation while dilation increases the gray scale value of the image by applying expanding transformation. Both of them are sensitive to the image border whose gray-scale value changes. Erosion filters the inner image while dilation filters the outer image. Opening is erosion followed by dilation and closing is dilation followed by erosion. Opening generally smoothes the contour of an image, breaks narrow gaps. As opposed to opening, closing tends to fuse narrow breaks, eliminates small holes, and fills gaps in the contours. Therefore, morphological operation is used to detect image border, and at the same time, denoise the image.

The dilation and closing operations will expand the processed image while erosion and opening operations shrink it keeping the processed image similar to the original image.

TYPES OF NOISE

Salt & Pepper Noise

Salt and Pepper noise is also called impulse noise, shot noise or binary noise. This degradation can be caused by sharp, sudden disturbances in the image signal, its appearance is randomly scattered white or black(or both) pixels over the image.

Gaussian Noise

Gaussian noise is an idealized form of white noise, which is caused by random fluctuations in the signal. We can observe white noise by watching a television which is slightly mistuned to a particular channel. Gaussian noise is white noise which is normally distributed.

Speckle Noise

Gaussian noise can be modeled by random values added to an image; where as speckle noise (or more simple just speckle) can be modeled by random values multiplied by pixel values, hence it is also called multiplicative noise. Speckle noise is a major problem in some radar applications.

The main challenge in research is to removal of impulsive noise as well as preserving the image details. Some schemes utilize detection of impulsive noise followed by filtering where as others filter without detection of noise. In the filtering without detection, a window mask is moved across the observed image. The mask is usually of size (2N +1)2 , where N is a positive integer. Generally the centre element is the pixel of interest. When the mask is moved starting from the left-top corner of the image to the right-bottom corner, it performs some arithmetical operations without discriminating any pixel. The disadvantage of this process is that it filters all the pixels irrespective of corruption. Detection followed by filtering involves two steps. In first step it identifies noisy pixels and in second step it filters those pixels. Here also a mask is moved across the image and some arithmetical operations are carried out to detect the noisy pixels. Then filtering operation is performed only on those pixels which are found to be noisy in the previous step, keeping the non-noisy intact. These filters, generally, consists of two steps. Detection of noisy pixels is followed by filtering. Filtering mechanism is applied only to the noisy pixels. Removal of the random-valued impulse noise is done by two stages: detection of noisy pixel and replacement of that pixel. Median filter is used as a backbone for removal of impulse noise. Many filters with an impulse detector are proposed to remove impulse noise.

METHODOLOGY FOR PROPOSED WORK

In the proposed method, closing then followed by opening is performed using an appropriate Structuring Element (SE) on the image to be processed. Again closing operation is performed on the resultant image. This removes the noise from the image and hence is used to pre-process the image. The choosing of structuring element is a key factor in morphological image processing. The size and shape of the structuring element decide the final results of and de-noising the images.

Removing Speckle noise by using proposed method:

Fig 1: Original image of Telugu alphabets

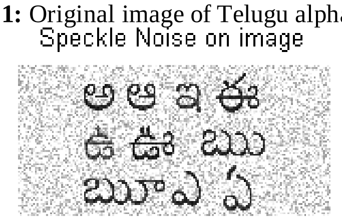

Fig 2: Image with Speckle noise

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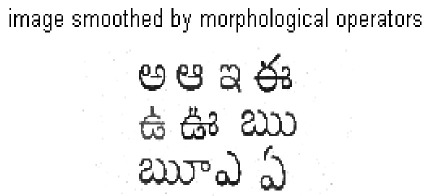

Fig 3: Image smoothed by proposed method

Removing Gaussian Noise by using Proposed method:

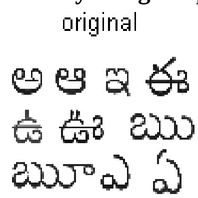

Fig 4: Original image of Telugu alphabets

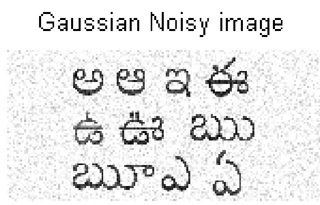

Fig 5: Gaussian Noise on image

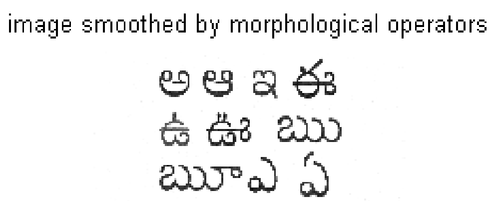

Fig 6: Image smoothed by proposed method

Removing Salt and Pepper Noise by using Proposed method:

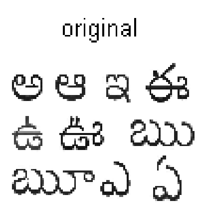

Fig 7: Original image of Telugu alphabets

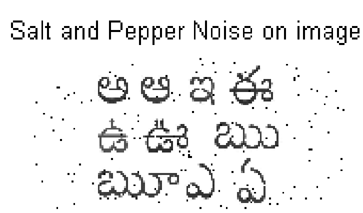

Fig 8: Image with Salt & Pepper Noise

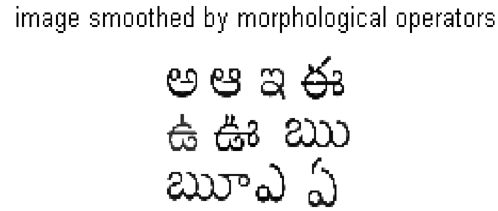

Fig 9: Image smoothed by proposed method

PERFORMANCE MEASURES

Mean Squared Error (MSE) and Peak Signal to Noise Ratio (PSNR)

In statistics, the mean squared error or MSE of an estimator is one of many ways to quantify the amount by which an estimator differs from the true value of the quantity being estimated. Here it is just used to calculate the difference between a original image with a restored image. Given that original image *Y* of size (*M* □*N*) pixels and as reconstructed image *Y*ˆ , the MSE(dB) is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

PSNR analysis uses a standard mathematical model to measure an objective difference between two images. It estimates the quality of a reconstructed image with respect to an original image. Reconstructed images with higher PSNR are judged better [6].

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

RESULTS and ANALYSIS

The proposed algorithm for removal of noise is compared with order statistic and average filters. The Peak Signal to Noise Ratio (PSNR) is more for the proposed algorithm than the other algorithms and Mean Square Error (MSE) is less for the proposed algorithm than the other algorithms as shown in Table1.

Table 1: Comparison of PSNR and MSE values for different filters

Salt &pepper noise						
Image	**Proposed Method**		**Average filter**		**Order statistic filter**	
	PSNR	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**

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Telugu alphabets	36.84	3.66	36.43	3.912	29.78	8.262
English alphabets	30.41	7.68	27.14	11.19	16.68	37.42
Numbers	30.30	7.78	27.31	10.98	16.69	37.15
Gaussian Noise						
Image	**Proposed Method**		**Average filter**		**Order statistic filter**	
	PSNR	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**
Telugu alphabets	41.13	2.02	41.08	2.07	31.98	6.41
English alphabets	35.00	4.529	31.181	7.038	18.46	30.44
Numbers	36.57	3.781	30.892	7.276	18.61	29.90
Speckle Noise						
Image	**Proposed Method**		**Average filter**		**Order statistic filter**	
	PSNR	**MSE**	**PSNR**	**MSE**	**PSNR**	**MSE**
Telugu alphabets	29.84	8.208	29.088	9.367	26.64	11.87
English alphabets	24.78	14.70	23.883	15.95	16.04	40.22
Numbers	26.56	11.98	26.072	12.77	16.73	37.14

The error functions reflect the fact between the original image and the noise free image. Table 1 shows the error rates of noise free images with original image using proposed method, order statistic filter and average filter algorithm respectively.

It is evident that the error rate of the present method is reduced when compared with other two algorithms. One more interesting point is that the error rate of the proposed method is less than the other two methods for all images by using error functions. The PSNR is high for the proposed method for all images. It indicates that it has high signal to noise ratio. The MSE is low for proposed method for all images, compared with other two algorithms.

The graphical representation of the comparison of PSNR values of existing methods with the proposed method which is given in Table 1 is shown in Fig.10 to Fig 15. From the graph it is clear that the proposed method for noise removal give good Peak Signal-to-Noise Ratio (PSNR) and less Mean Square Error (MSE) than the existing algorithms.

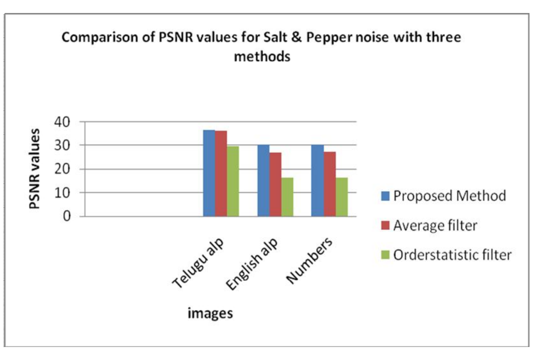

Fig 10: Comparison of PSNR values for Salt & Pepper Noise

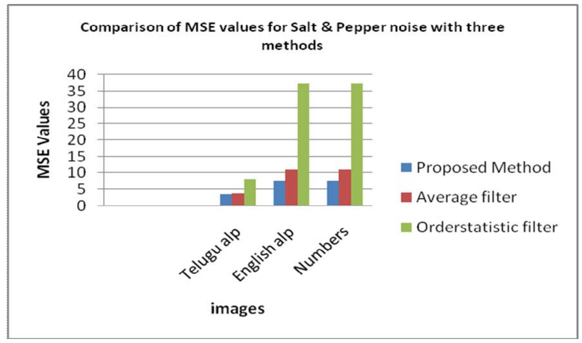

Fig 11: Comparison of MSE values for Salt & Pepper Noise

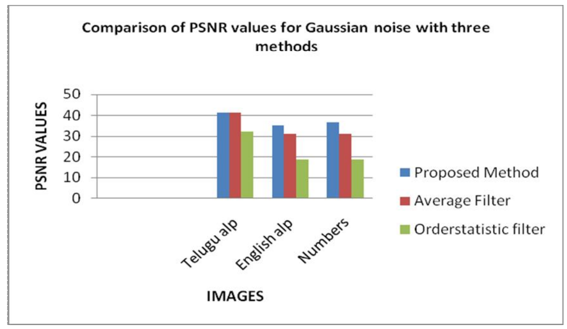

Fig 12: Comparison of PSNR values for Gaussian Noise

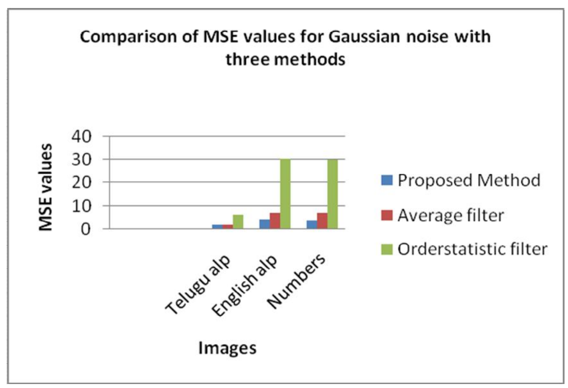

Fig 13: Comparison of MSE values for Gaussian Noise

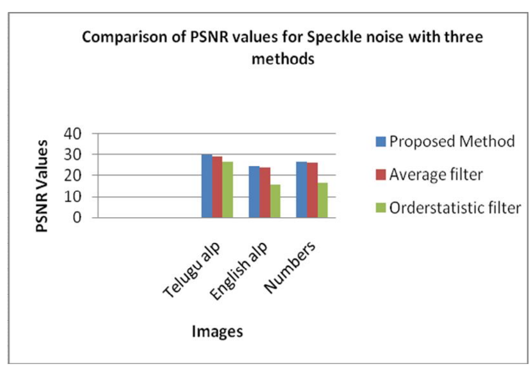

Fig 14: Comparison of PSNR values for Speckle Noise

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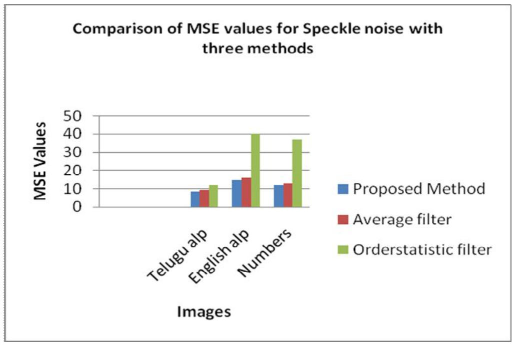
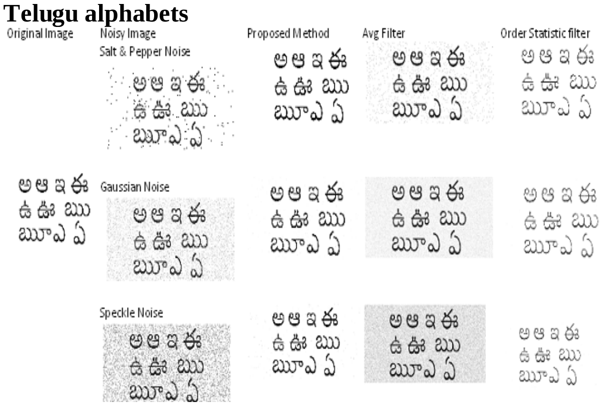


Fig 15: Comparison of MSE values for Speckle Noise

Experimental Results for Different Images

Telugu alphabets



English alphabets

CONCLUSION

In this paper, we propose a method for removal of salt and pepper noise, Gaussian Noise, and Speckle Noise of image using morphological methods. The proposed method gives better performance in comparison with Average Filter and Order statistic filter. The experimental results using error functions on different images show that the proposed method produces more clarity-based representation than the other two approaches.

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