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Mixed Gaussian and Impulsive Noise removal using Morphological Contrast detector

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Abstract: Major stage in digital image processing is image denoising. In this paper, gray scale image denoising is presented using mathematical morphology. In this proposed method Gaussian noise and salt pepper noise is added for original image. To denoise noisy image, basic operations of morphology like dilation, erosion, opening, and closing are used. With this basic operation disk structuring element is imposed on noisy image to improve the quality of the image. Top-hat transform is also used to denoise noisy image with same structuring element. Assessment parameters like mean square error and peak signal to noise ratio indicates that, proposed work yields better results when compared to other filters.

Keywords: Morphology and top-hat transfrom

I. INTRODUCTION

A common problem in image processing is the detection and reduction of noise in digital images. As a result, several methods have been proposed. In [1], grey-level images are cleaned using top-hats [2] and smoothed images. Smoothed images are obtained from alternated filters [3]. In [4, 5], a distance criterion to detect noise given by the top-hat transformation is applied, followed by an open–close sequence to remove noise. In [6], a distance criterion in terms of the open–close and close–open filters is presented, and noisy pixels are replaced by those obtained from and adaptive switching median filter. In [7], the Laplacian and gradient masks are used to estimate noise. In [8], the authors present a method to extract the relationship between image intensity and noise variance. In [9–11], different techniques to detect noise are provided. In [12, 13], noisy pixels are replaced by the mean value of the neighbouring pixels. Methods based on wavelet transformations can be found in [14–16]. A filter working similar to a median filter to suppress noise is presented in [17]. A technique based on fuzzy logic is proposed in [18]. The list of references is far from complete, given the intensive research on this topic. In several of the above mentioned papers, the common steps followed to detect noise are: (i) establish a criterion based on a certain threshold, which most often is an empirical value and (ii) create a noise map. Subsequently, noise is replaced by pixels obtained from a specific transformation. Currently, the requirements fulfilled to suppress noise in an image are not clearly defined. In [19], the conditions necessary to eliminate noise are: (i) perceptually flat regions must be as smooth as possible, (ii) contours must be preserved, (iii) texture detail must be maintained and (iv) global contrast must remain unchanged.

These points are in conflict, because when noise is removed, global contrast is affected given that noise is replaced by pixels obtained from a smoothed image. Furthermore, edges are also modified notwithstanding whether the smoothed image was filtered by an adaptive transformation. Owing to this situation, in this paper we are going to consider only two aspects that must be fulfilled when denoising an image: (a) modifying image contours as little as possible and (b) the resulting cleaned images must have an improvement in the contrast. The mathematical expressions introduced throughout the paper make use of the following transformations: top-hat by reconstruction [20], internal gradient [21], toggle mappings [22] and the opening by reconstruction [23]. These will be presented in Section 2. The ideas to detect noise were inspired by the proposal in [24], which is briefly presented in Section 2.5. In [24], two interesting things are proposed: (i) a formalisation to detect a threshold P to identify noise and (ii) noise detection is carried out by means of a contrast measure. The contributions introduced in this paper will be for grey-level images. The contrast measure provided in [24]is replaced by a new one in terms of a top-hat by C reconstruction transform, also called numerical residue [25]. The new contrast measure involves the image background obtained from a close–open by reconstruction transformation. This proposal gives rise to a toggle mapping to attenuate noise. The toggle mapping uses as primitives the original and the morphological open–close by reconstruction images, which do not create new contours. However, given that the critical point P represents the mean value defined in [24], this idea is extended to a global parameter for determining when a pixel is noise. The proximity criterion in the toggle mapping is modified and a new one is introduced in Section 3.2 in terms of the top-hat by reconstruction transformation. In Section 3.3, noisy pixels take values in accordance with a rank filter [26] to produce enhanced images with different contrast. In Section 3.4, the mean filter is approximated by morphological transformations, and the toggle mappings proposed so far can be rewritten as purely morphological transformations. In Section 3.5, the top-hat criterion is replaced by the internal gradient operator, and the primitive denoted as ‘a’ is utilized. The ‘a’ filter is given in terms of the open–close and close–open by reconstruction transformations. This filter shows a regular performance when compared to the median

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filter. According to the experiments, two transformations introduced in this paper yield a better performance with respect to the method proposed in [24] to detect noise.

Digital images are inevitably affected by noise, thus detection and reduction of noise from such noisy image is a challenging task to be carried out in order to retain its quality. This project work mainly concentrates on the presence of two noises in gray image that is Gaussian and Impulsive noise. These noises should be removed in such a way that information of image should be preserved. The concept of morphology is used which is a technique of image processing based on shapes. The value of each pixel in the output image is based on comparision of the corresponding pixel with its neighbors. The basic morphological operations to be used in our work are Erosion, Dilation, Opening, and Closing. Erosion operator takes two pieces of data as inputs first being the one which has to be eroded and the second is structuring element. Here, every object pixel is changed into background pixel. Dilation adds pixels to the boundaries of objects in an image. In dilation, every background pixel that is touching an object pixel is changed into an object pixel. Opening is done by performing erosion first followed by erosion using same structuring element. It is similar to erosion but less destructive. Closing is done by performing dilation followed by erosion.

II. Proposed Work

This flow shows frame work of the proposed work. In this frame work the noise is will detected by using morphological opening and closing. Using toggle mapping two sets of pixels are grouped. Noise elimination will be done using top hat transform.

Mathematical morphology, or morphology for short, is a branch of image processing that is particularly useful for analyzing shapes in images. Pre-processing includes transformation of RGB spot to gray scale spot for the further operations to be performed to segment the spot. There are two basic operations in mathematical morphology namely dilation and erosion. In this proposed model erosion is used, because internal boundary can be found out using erosion process. Morphological operators can filter out structures that deviate too much from the expected shape and size of a spot. Given sets I (x,y) and P (structuring element), the erosion of I by P, where I is preprocessed spot and P is structuring element, written IΘ P, is defined as: IΘ P= {w: BW Є I}. In other words the erosion of I by P consists of all points W=(x, y) for which BW is in I. To perform erosion move P over I and find all places if it will fit and for each such place mark down the corresponding (0, 0) point of P. The set of all such points will form the erosion. Erosion "shrinks" or "thins" objects in a gray scale image. The manner and extent of shrinking is controlled by a structuring element (P). Structuring element is still the key factor of morphology operations. Applying different structuring elements leads to diverse results of analyzing and processing of geometric characteristic. Therefore, structuring element determines the effect and performance of morphological transformation. Besides bigger size of structuring element will lead to rapid growth of time consumption because structuring element determines not only the data-distribution form but also the amount of data for use. As a result, self-adaptability and decomposability of structuring element should be the key point in the future research. Internal boundary can be defined as: = (I(x, y)-(IΘ P)).Where I(x, y) is preprocessed image, IΘ P eroded image. x number of rows and y is number of columns. Another useful operator opening is used to remove grains having area below a given value from the image. Mathematically it is defined as, I □ P = (IΘ P) □ P. Opening consists of erosion followed by dilation. Opening tends to smooth an image, to break narrow joins and to remove thin protrusions. Dilation is an operation that "grows" or "thickens: objects in a gray scale image. The specific manner and extent of thickening is controlled by a shape referred through structuring element (P).Suppose I and P are sets of pixels. Then the dilation of I by P denoted I □ P is defined as: I □ P = Ụ Im , m Є P. This means that for every point m Є P, translate A by those coordinates and then take the union of all these translations. The operations of erosion, dilation, opening, closing and hit-or-miss can extract many types of information about a binary image. Openings can be used to remove small objects, protrusions from objects, and thin connections between objects, while closing eliminates small holes, smoothes concaves and fills gaps in the contour. Opening and closing operations can be alternately applied as bilateral filter to eliminate noise and restore images. Hit-or-miss transformation is a basic tool for shape detection and object recognition.

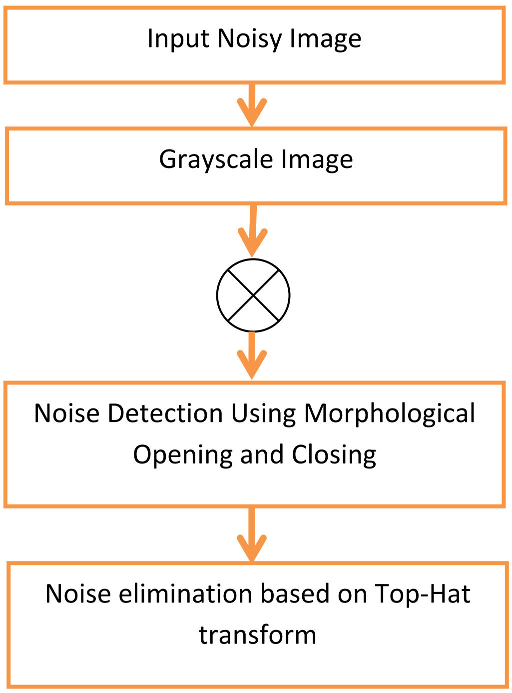

Fig 1. Flowchart

III. RESULTS

Mean Square Error (MSE) and Peak Signal to Noise Ratio are the two metrics used to assess the quality of the image. Mean Square Error can be defined as difference between cumulative squared error of enhanced image and original image. If the MSE value is lower means that lesser error in the image. Mathematically MSE can be defined as

$$MSE = \frac{1}{N \times M} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} [X(i,j) - Y(i,j)]^2 \qquad (17)$$

Where M N are rows and columns of the image, X(i,j) is enhanced image and Y(i,j) is original image. The peak Signal-to-Noise Ratio (PSNR) is defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. In the context the signal refers original image, and the noise is the error introduced during image acquisition. Usually PSNR is expressed in terms of the logarithmic decibel scale. To measure of quality of reconstructed images.(e.g., for enhanced image) PSNR parameter is used.

PSNR in DB can be defined as

$$PSNR=10\log_{10}[L^2/MSE]$$

L reflects the range of values that a pixel can take. For an 8 bit image value of L will be 2^8 -1 which is equal to 255. Higher the peak signal to noise ratio value, higher is the quality of the image and lower the mean squared value higher is the image quality.

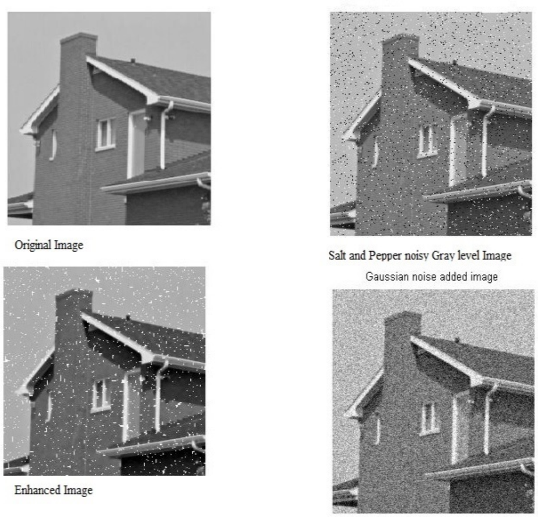

Fig 2. Results

IV. CONCLUSION

In this project work, noise reduction using mathematical morphology is implemented. For this work, basic operations of morphology like dilation, erosion, opening, and closing have used to denoise the Gaussian noise added image as well as to denoise the salt and pepper noise added image. From the experimental results it has been observed that the proposed method provides better results when compared with Gaussian low pass filter. This work can be extended for different noise types and with different structuring elements for morphological operations.

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