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A NOVEL APPROACH TO NOISE REDUCTION FOR IMPULSE AND GAUSSIAN NOISE

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Abstract

An efficient noise reduction approach is proposed by combining Robust Outlyingness Ratio (ROR) which measures how impulse like each pixel is, with noise adaptive fuzzy switching median filter (NAFSM) and fuzzy c-means (FCM) segmentation. Based on the ROR values all the pixels are divided into four levels. Then in the coarse and fine stage introduce the NAFSM filter that optimizes the performance by using fuzzy, median and processing pixel. For further optimization the FCM separates the remaining noisy and noise less pixels for the detection and removal of salt and pepper impulse noise. Finally the NL-means filter is applied to remove Gaussian noise and produce the high quality images. The experimental result shows the proposed denoising framework outperforms most existing filters and achieves high PSNR values.

***Keywords*--** **salt and pepper impulse noise; ROR; noise adaptive fuzzy switching medianfilter; fuzzy c-means; fuzzy; NL-Means.**

I. INTRODUCTION

Image Processing is a technique that enhances the raw images received from cameras placed on satellites or pictures taken in normal day-to-day life for many applications. Images taken by digital cameras could be affected by noise due to random variations of pixel elements in the camera sensors. Noise represents unwanted information which destroys image quality. The most common types of noise models used are: salt and pepper impulse noise, random valued impulse noise and Gaussian noise. In the salt and pepper impulse noise the pixels are corrupted by minimum or maximum value.

$$Y = \begin{cases} 0 \text{ or } 255 & withprobabilityp \\ x & withprobability\ 1-p \end{cases}$$

Where 'y' is the noisy pixel and 'x' is the original value. For random valued impulse noise, the noise can take the value between minimum and maximum values.

$$y = \begin{cases} n & withprobabilityp \\ x & withprobability\ 1-p \end{cases}$$

Where 'y' represents noisy pixel, n is the noise value and x is the original value.

In Gaussian noise each and every pixel of the image gets affected. Image denoising is the method of removing unwanted noise from the corrupted images. Several filtersare used for denoising the images. The main goal of the filtering process is to remove noise while preserving edges and image detail information.

These filters work well, but when the noise level is above 30% it removes some image details and retains some impulse noise. In this paper, we propose a denoising method ROR-NAFSM-FCM filter that effectively detects and removes the high density salt and pepper impulse noise from corrupted images. To improve the performance of noise reduction process we have used the fuzzy reasoning scheme which proved to be an optimal, detail preserving method. It achieves a high PSNR value and able to reduce the noise above 80%.

II. RELATED WORK

In general image denoising provides the quality images by increasing the PSNR values. The ROR NL-means Filter [1] separates the noisy pixels into various levels. Then using the median filter, it replaces the noisy pixels. It removes both impulse and Gaussian noise. The non-local means algorithm [2] was based on the non-local weighted average of all the pixels in the image. The weight value depends on the similarity between each pair of pixels in the neighbourhood window. The directional weighted median filter [3] restores the images corrupted by random valued impulse noise with lower level. In this filter the detector is based on the difference between the current pixel and its neighbours in four main directions. Then apply weighted median filter. Tristate median filter [4] for image denoising proposed a tristate decision. The detection stage involves the output of both standard median filter and center weighted median filter to show whether the pixel is corrupted or not, by comparing them with the output of those filters.

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Adaptive median filter[5] proposed two new algorithms: rank order based adaptive median filter(RAMF) and impulse size based adaptive median filter(SAMF).For preserving the image details these filters have variable window size in the removal of impulse noise. RAMF perform two level tests. First it tests the presence of impulses in the median filter. In second stage it tests the center pixel alone. SAMF detects the size of impulse and then adjusting the window length of the median filter. Switching median filter [6] uses switching scheme followed by progressive methods. The impulse detection algorithm is applied before filtering in a progressive manner. Edge preserving filter [7] proposed a detection mechanism as rank order logarithmic difference for identifying most of the noisy pixels in the corrupted images. Noise adaptive fuzzy switching median filter [8] proposed detection based on the median value. Then in the filtering stage fuzzy reasoning is applied to the extracted local information. Fuzzy c-means segmentation [9] proposed a membership function in the image pixels. It calculates the centre pixel in the function and then separates the noisy and noiseless pixels for optimization.

III. PROPOSED SYSTEM

Image denoising involves the processing of image data to produce a visually high quality image. In this paper we proposed the denoising framework which involves ROR, NAFSM filter, FCM segmentation and NL-means filter.

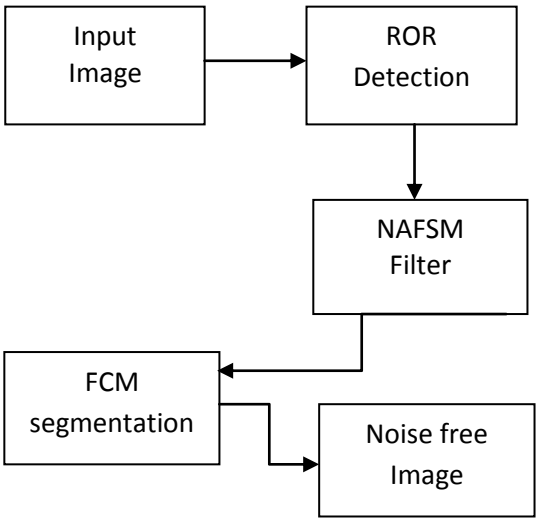

Fig 1. Overall block diagram of denoising framework

Fig1. represents the overall block diagram of the denoising frame work which is elaborately discussed below.

Figure1 represents the overall block diagram of the denoising frame work which are elaborately discussed below. After the ROR detection the undetected pixels in the first stage of detection are given to the second stage of detection. The noise adaptive fuzzy switching median filter is used as the first stage of filtering where only the noisy pixels are replaced by the optimized value of median and fuzzy reasoning. The second stage of filtering is done by the Fuzzy c-Means segmentation.

IV. ROR DETECTION MECHANISM

When an image is corrupted by salt and pepper impulse noise or random valued impulse noise, the detection of impulse noise is far difficult. The intensity of the noisy pixel will be distinct from its nearest surrounding pixels. The new detection mechanism helps in the detection of such impulse noise. It initially computes the robust outlyingnessratio (ROR) for each and every pixel in the image. ROR measures how much each pixel gets affected by impulse noise.

For computing the ROR of a particular pixel, construct a 5*5 window around that pixel. Calculate the difference between the neighbouring pixels and median value in the window. Then the median absolute deviation (MAD) is found out. ROR value of a pixel is calculated as follows;

$$MAD(y) = med(y-m).$$
$$MADN(y) = MAD(y)/0.6457$$
$$ROR\ (y_i) = (y_i-m)/MADN(y).$$

Where ‘m’ is the median value and ‘y’ is the Neighbouring pixels in the window. Based on the ROR values of each pixel classify all the pixels in the images into four different levels. In each cluster different decision rules are applied to detect the impulse noise based on the absolute deviation. The four levels are the most like level ROR>3, second like level 2<ROR<=3, third like level 1<ROR<=2 and the fourth like level is 0<ROR<=1.

V. NOISE ADAPTIVE SWITCHING MEDIAN FILTER

For making the detection results more accurate and robust, from coarse to fine strategy is used. In these stages different pregiven thresholds are compared with the absolute difference in each level. The steps followed in coarse and fine stages are as follows:

(i) Choose different thresholds.
(ii) Calculate ROR of the current pixel and absolute difference D(i,j) between the current pixel and the median of its local window.
(iii) Compare the difference with the pregiven thresholds.

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NAFSM filter applies fuzzy reasoning to the extracted local information D (i, j).

$$F(i,j) = \begin{cases} 0 & : \quad D(i,j) < T1 \\ \frac{D(i,j)-T1}{T2-T1} & : T1 < D(i.j) < T2 \\ 1 & : \quad D(i,j) \geq T2 \end{cases}$$

Then the restoration term is,

$$Y(i,j)=[1-F(i,j)].X(i,j)+F(i,j).M(i,j).$$

It is an iterative process. Thus NAFSM filter detects and removes the salt and pepper noise effectively.

VI. Fuzzy C-Means Segmentation (FCM)

For further optimization process, FCM segments the noisy and noiseless pixels into individual levels. The FCM clustering method allows an element of the data to belong to a cluster with a degree of membership. FCM is the most prominent algorithm. Initially it receives the sample set of pixels and forms the cluster. Then find out the cluster center and distance matrix. From the distance matrix make the partition matrix and reconstructs the image. Fuzzy c-means objective function is:

$$J = \sum_{j=1}^{C} \sum_{i=1}^{n} (u_{ij})^m \left\| x_i^{(j)} - c_j \right\|^2$$

Steps to follow in FCM Clustering algorithm is:

(i) Consider set of pixels to be clustered.
(ii) Assume no of clusters C.
(iii) Initialize the membership matrix 'U'.
(iv) Calculate the cluster centres.
(v) Calculate the distance measures''.
(vi) Update the fuzzy membership matrix U based on'd'.
(vii) Continue from step (5) until the change in U is less than a given tolerance.

FCM segmentation separates the noisy and noiseless pixels and filters out the noise values in images.

VII. NL-Means Filter

The most similar pixels to a given pixel have no reason to be close to it. Several existing algorithms scan the vast portion of the image which includes all pixels that are restored. So, NL-means filter computes the weighted average of all the pixels in the image. The weight is based on the similarity between the pixels. Denoised value of a pixel is determined by the pixels with the similar neibourhoods.

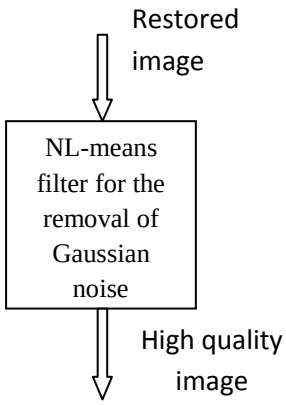

Fig 2. Reduction of Gaussian Noise

The **Fig 2.**shows the filter mainly concentrates on the removal of Gaussian noise in images. This filter removes the blurriness' of the image. The denoised pixel z (i) of the image is computed as

$$z(i) = \sum_{j \in I} w(i,j)s(j) / \sum_{j \in I} w(i,j)$$

Where weight w(i,j) represents the amount of similarity between the neighbourhoods of each pair of pixels. It is calculated as,

$$w(i,j) = \exp\left(\frac{\left\| a_i - b_j \right\|^2}{h^2} \right)$$

Where

h- Decay parameter of the weights,

$a_i$and b_j - neighbourhood pixels.

Image self-similarity eliminates the Gaussian noise so that it removes the blurriness of the images.

VIII. Expected Results

The expected results are estimated between different noise ratios and different PSNR values.The PSNR value of an image is computed as

$$PSNR = 10log_{10} \frac{(R)^2}{MSE}$$

$$MSE = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (X(i,j) - U(i,j))^2}{m \times n}$$

Where

R-Maximum fluctuation.By default 255.

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X-Original Image

U-Restore Image

m-No of rows

n-No of columns

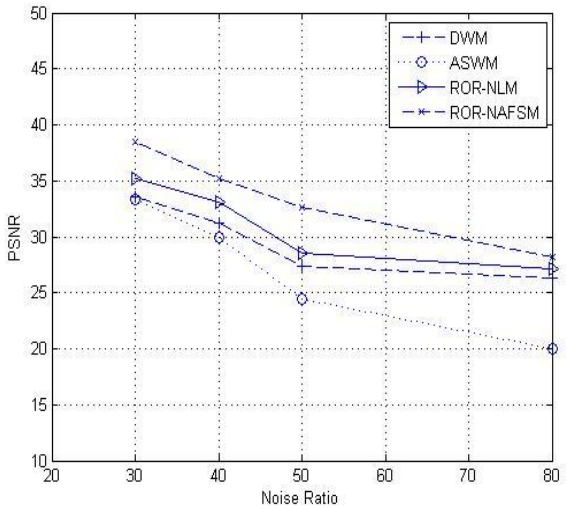

Fig.3 Graph for PSNR(dB)versus Noise Ratio(%)

Fig 3.shows the graph of average PSNR value using lena image plotted against different noise percentage.the proposed ROR-NAFSM filter outperforms other existing Filters by having the highest PSNR values.

IX. CONCLUSION

In this paper, the ROR detection and NAFSM-FCM filter effectively suppresses the high density salt and pepper impulse noise presented in the images.

In addition the NL-means filter smoothens the image by removing the Gaussian noise. The proposed filter able to preserve the image details and edges even at the higher noise levels and achieve high PSNR values. It is able to yield good filtering results with efficient processing time.

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