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Impulse Noise Removal Technique Based on Neural Network and Fuzzy Decisions

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Abstract— **Impulse Noise Reduction is very active research area in image processing. It is one of the important processes in the pre-processing of Digital Images. There are many techniques to remove the noise from the image and produce the clear visual of the image. Also there are several filters and image smoothing techniques available. All these available techniques have certain limitations. Recently, neural network are found to be very efficient tool for image Enhancement. In this, a two-stage noise removal technique to deal with impulse noise is proposed. In the first stage, an additive two-level neural network is applied to remove the noise cleanly and keep the uncorrupted information well. In the second stage, the fuzzy decision rules inspired by human visual system are proposed to compensate the blur of the edge and destruction caused by median filter. An neural network is proposed to enhance the sensitive regions with higher visual quality.**

***Keywords*— Impulse noise; Image enhancement; neural network; fuzzy decision rules**

I. INTRODUCTION

Images can be contaminated with different types of noise for different reasons. For example, noise can occur because of the circumstances of recording such as electronic noise in a cameras, dust in front of the lens, because of the circumstances of transmission damaged data or because of storage, copying, scanning, etc. Impulse noise e.g., salt and pepper noise and additive noise e.g. Gaussian noise are the most commonly found. Impulse noise is characterized by the fact that the pixels in an image either remain unchanged or get one of the two specific values 0 and 1; an important parameter is the noise density which expresses the fraction of the image pixels that are contaminated.

Image noise is the random variation of brightness or color information in images produced by sensors and circuitry of a scanner or digital camera. Image noise can be originated in film grain and in the unavoidable shot noise of an ideal photon detector. Faulty sensors, optical imperfectness, electronic interference, and data transmission errors may introduce noise to digital images.

According to occurrence of noise, types of noise are given as follows

(a)Salt and Pepper Noise
(b) Gaussian noise
(c) Speckle noise
(d) Periodic noise

There are various techniques present which are used as noise removal tool in image processing. But present system has some drawback to overcome that drawback; a new method is proposed to remove noise.

A new two-stage noise removal technique to deal with impulse noise is proposed here. An easily implemented NN is designed for fast and accurate noise detection such that various widespread densities of noisy pixels can be distinguished from detail edge pixels well. After suppressing the impulse noise, the image quality enhancement is applied to compensate the corrupted pixels to enhance the visual quality of the resultant images.

II. RELATED WORK

One of the most important stages in image processing applications is the noise removal. The importance of image processing is constantly growing with the ever increasing use of digital television and video systems in consumer, commercial, medical, and communication applications. Image noise removal is not only used to improve the quality but also is used as a preprocessing stage in many applications including image encoding, pattern recognition, image compression and target tracking, to name a few.

Schulte [1] proposed a fuzzy two-step filter for impulse noise reduction from color images. A novel method for suppressing impulse noise [4] from digital images is provided in this paper, in which a fuzzy detection process is followed by an iterative fuzzy filtering method [7]. The filter proposed by author is called as fuzzy two-step color filter. The fuzzy detection technique in this paper is generally based on the computation of fuzzy gradient values and on fuzzy reasoning. This step found out three different membership functions that are passed to the filtering phase. Those membership functions are used for fuzzy set impulse noise depiction. The proposed novel fuzzy technique is particularly developed for suppressing impulse noise from color images while preventing other image data and texture.

Ibrahim [3] gave a simple adaptive median filter for the removal of impulse noise from highly corrupted images. This author proposed a simple, yet efficient technique to suppress impulse noise from noise affected images. This new technique composed of two phases. The first phase is to find the impulse noise affected pixels in the image. In this phase, depends on only the intensity values, the pixels are approximately separated into two classes, which are "noise-free pixel" and "noise pixel". Then, the second phase is to remove the impulse noise from the noise affected image. In this phase, only the "noise-pixels" are processed. The "noise-free pixels" are kept as such to the output image. This technique adaptively modifies the size of the median filter depends on the number of the "noise-free pixels" in the neighborhood. For the filtering process, only "noise-free pixels" are taken into account for the detection of the median value

Sun [2] provided an impulse noise image filter using fuzzy Sets. The successful use of fuzzy set theory performance on many domains, together with the increasing requirement for processing digital images, have been the main intentions following the efforts concentrated on fuzzy sets [5, 6]. Fuzzy set hypothesis, contrasting with some other hypothesis, can offer us with knowledge-based and robust means for image processing. By calculating the fuzziness of the pixels affected degree and taking equivalent filter parameters, a novel image filter for suppressing the impulse noise is proposed here.

III. PROPOSED WORK AND OBJECTIVES

The classical noise reduction spatial filters have two main disadvantages. First, they treat all the pixels in the same way. This is not desirable, because not all the pixels will be contaminated with noise in the same way. Secondly, one should try to find an adaptive way to replace a pixel value, taking into account characteristics of the neighborhood of the pixel.

The use of NN and fuzzy technique offers a solution. Neural network is a group of elementary processes with strong interconnections. Based on the learning algorithm of error back-propagation, NN can be perfectly adapted for image enhancement. A self organizing three layered feed forward NN is employed for image enhancement.

Optimal noise removal should delete the visible noise as cleanly as possible and maintain the detail information and natural appearance to obtain a natural-looking image. In order to remove the impulse noise cleanly from input images without blurring the edge, the proposed system is divided into two stages.

1. Impulse Noise Removal
2. Image Enhancement

It is implemented in two parts as Fuzzy logic and Neural network.

The working of this process is as follows.

1. Take an input image
2. Apply neural network to check the noise present in an image
3. Apply fuzzy logic to remove the noise present
4. Generate output image.

The objective of proposed system is to implement these steps with the help of some techniques for that purpose the whole system is divided into various modules. These are arranged so that will get the desired output.

The working of these techniques can be like given diagram

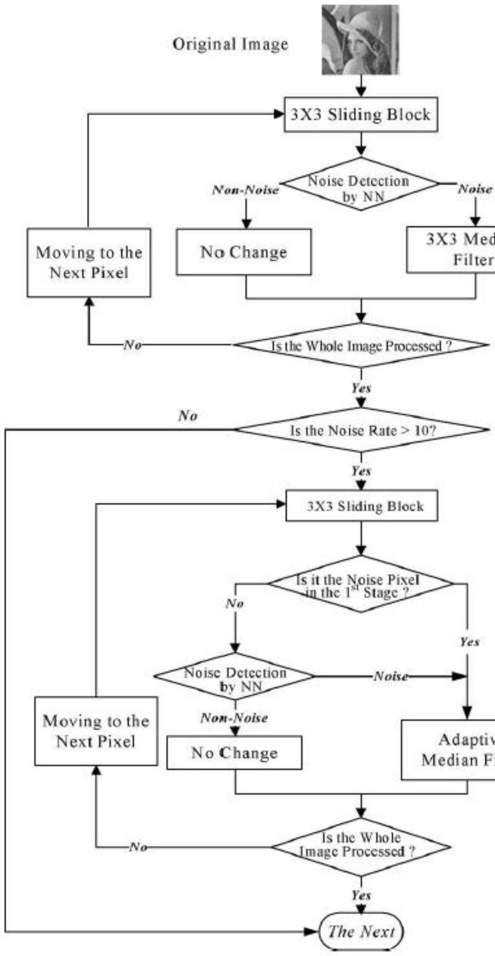

Figure 1: Procedure diagram of the two-level impulse noise removal

a) Impulse Noise Model

Impulse noise is when the pixels are randomly misfired and replaced by other values in an image. The image model containing impulse noise can be described as follows:

$$Xij = \begin{cases} Nij, & \text{with probability } p \\ Sij, & \text{with probability } 1 - p \end{cases} \quad (1)$$

where Sij denotes the noiseless image pixel and Nij denotes the noise substituting for the original pixel (OP).With the noise ratio p, only p percent of the pixels in the image are replaced and others keep noise uncorrupted. In a variety of impulse noise models for images, fixed- and random-valued impulse noises are mostly discussed. Fixed-valued impulse noise, known as the “salt-and-pepper” noise, is made up of corrupted pixels whose values are replaced with values equal to the maximum or minimum (255 or 0) of the allowable range with equal probability (p/2). The random-valued impulse noise is made up of corrupted pixels whose values are replaced by random values uniformly distributed in the range within [0, 255]. In this paper, both fixed and random-valued impulse noises are adopted as the noise model to test the system robustness.

b) NN for Noise Detection

Since the residual noise will strongly affect human perception, precise noise detection is the first important step for the noise removal. It is found that noise is more annoying in smooth and edge areas [9], [13]. Most algorithms work well on low noise density images but fail to detect noise pixels in the edge region. The decision-based algorithms for noise detection can be divided into three types. The first type is to detect whether the pixel is contaminated by noise according to the local features. The second-type decision measure considers the differences of adjacent pixel values in the rank-ordered median filtering sequence .The third-type approach, called switching schemes , first applies several types of rank-ordered filters, and then, detects the noise pixels by their relationships with the gray level of the origin pixel.

c) Median Filter

The linear processing techniques perform reasonably well on images with continuous noise, such as additive Gaussian distributed noise and they tend to provide too much soothing for impulse like noise .Nonlinear techniques often provide a better trade-off between noise smoothing and retention of fine image detail.

Lowpass spatial filtering of the smoothing method blurs edges and other sharp details. As the objective is to achieve noise reduction rather than blurring, an alternative median filter is developed by Tukey for noise suppression. That is the gray level of each pixel is replaced by the median of the gray levels in a neighborhood of that pixel, instead of by the average. In order to perform median filtering in a neighborhood of a pixel, first sort the values of the pixel neighbors, determine the median, and assign this value to the pixel.

d) Noise Removal Algorithm

After the first level, the image noise density is calculated to decide whether the second level is necessary or not by the precise detection procedure. By the experiments, it is observed that when the noise density is below 10%, only a one-level noise removal process is enough. More residual noises will occur when the noise density increases. In this case, the second-level noise removal process is essential to detect and remove the residual noises. As the local features may influence the correctness of the detection part and the median filter may still retain certain noises, the residual noise pixels are detected and removed with an adaptive median filter in the second level. If there are more than 30% noisy pixels in this image, it is identified as a highly corrupted region and the 5 × 5 median filter is applied for processing. Otherwise, the 3 × 3 median filter is used to process the noisy pixel. The proposed adaptive two level noise removal techniques is very efficient to suppress the impulse noise as well as to preserve the sharpness of edges and detail information.

e) Image Quality Enhancement

The conventional median filtering techniques have the limitation of blurring details and cause artifacts around edges. In order to compensate the edge sharpness, image quality enhancement is applied to the modified pixels. As the first stage has eliminated the visible noise, the second stage focuses the image enhancement on the edge region. For image analysis, the properties of the HVS are used to acquire the features of images. Thus, region which would worth quality enhancement is realized, since human eyes would be usually more sensitive to this region. For sensitive regions, an adaptive NN is used to enhance the visual quality to match the characteristics of human visual perception.

The procedure of Image Quality enhancement can be applied as follows

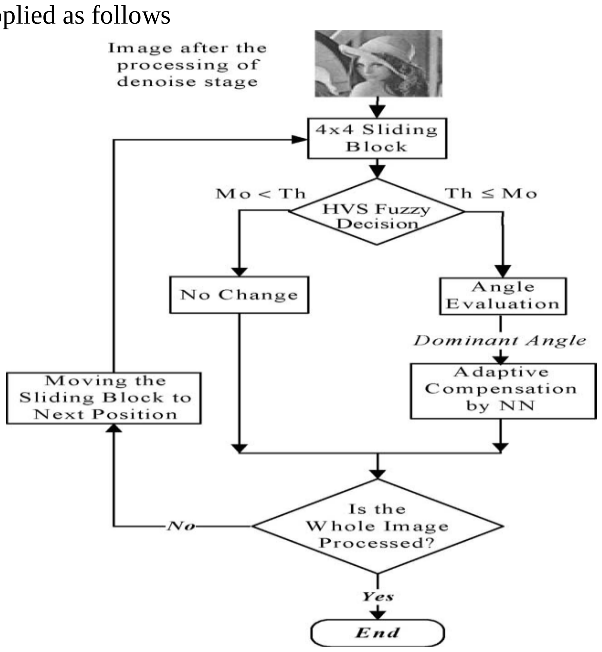

Figure 2: Procedure diagram of the image quality enhancement

HVS-Directed Image Analysis

A novel fuzzy decision system motivated by the HVS is proposed to categorize the image into human perception sensitive and nonsensitive regions. There are three input variables: Visibility Degree (VD); Structural Degree (SD); and Complexity Degree (CD),and one Output Variable (Mo) in the proposed fuzzy decision system.

f) Angle Evaluation

The fuzzy system identifies the reference pixel as sensible delineated edge and the trained adaptive neural-network model is chosen for quality enhancement according to its corresponding edge angle. The angle evaluation is performed to determine the dominant orientation of the sliding block. It firstly computes the orientation angle of each neighborhood of the original image pixel

g) NN-Based Image Compensation

The function of the proposed NN is to obtain the weights W_θ where θ represents the quantized dominant orientation of the reference pixel. Thus, the proposed NN is used to obtain eight sets of weighting matrices through training,

Each weighting matrix W_θ can be represented as

$$W_\theta(i,j) = \begin{bmatrix} w_{-1-1} & w_{-10} & w_{-11} & w_{-12} \\ w_{0-1} & w_{00} & w_{01} & w_{02} \\ w_{1-1} & w_{10} & w_{11} & w_{12} \\ w_{2-1} & w_{20} & w_{21} & w_{22} \end{bmatrix} \quad (2)$$

In order to use supervised learning algorithms to train the proposed NN, several clean image portions with dominant orientation are used as training patterns. Assuming a clean image portion is denoted as I,the noise-corrupted version of I has been processed by the proposed noise removal method in the first stage and the filtered result is denoted as I', let be the reference pixel,where O (0, 0) =I'(i, j) , and it is classified as an edge pixel with dominant orientation θ after angle evaluation. The input of the NN can be defined as IP = θ and the network output is the compensated pixel value of I' (i, j). The pixel value of I (i, j) obtained from the clean original image is used as the desired output of the NN for training

IV. APPLICATIONS

Image noise removal using neural network and fuzzy logic has many applications. Images are corrupted during transmissions, by applying noise removal algorithm, those images can be reconstructed. It is having wide area of application some of them are mentioned here.

1. Military applications for filtering out an image in the field
2. Biomedical usage to remove the noise and view a proper image
3. Aerospace filtering of image, so that the plane Captains can get a proper look in rainy seasons.

V.CONCLUSION

Here, two-stage noise removal algorithm was proposed to deal with impulse noise. In the first stage, a two level noise removal procedure with NN-based noise detection was applied to remove the noise cleanly and keep the uncorrupted information as well as possible. In the second stage, a fuzzy decision rule inspired by the HVS was proposed to classify pixels of the image into human perception sensitive and nonsensitive classes. An NN is proposed to enhance the sensitive regions to perform better visual quality. I will try that proposed method will work superior to the conventional methods in perceptual image quality, and it can provide a quite a stable performance over a wide variety of images with various noisy densities.

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