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Filtering Noise on two dimensional image Using Fuzzy Logic Technique

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1 . Abstract

This paper presents one simple and novel technique for removal of impulse noise from corrupted image data. The algorithm involves impulse detection followed by spatial filtering of the corrupted pixels. In this method the presence of impulse noise is detected by a simpler method called a fuzzy logic based technique (FLT). However, the filtering idea is to recover the healthy pixel by the help of neighboring pixels. Sometimes the loss of edges or presence of noise makes the image noisy or blurred in appearance. This fuzzy logic filter is presented through 5 stages. (1)A sliding moving window is constructed to check every pixel of the whole image.(2)Two conditional rule are applied according to the averaging value of the neighboring pixels. (3)some membership functions are generated to improve the intensity of pixel value so that it can be distinguishable.(4) A simpler function is developed for better reorganization and removal of noisy data. (5)The resulted matrix appears with suppression of less no of noise. It is shown that FLT is a preferred method of rejecting impulse noise both in terms of computational complexity and lower residual NSR(noise to signal ratio).

2. Introduction

An image acquired by optical or electronic means is usually degraded in the form of sensor noise, blur due to camera misfocus, relative object camera-motion and random atmospheric turbulence. In digital signal processing the filtering of such noises is one of the most important task. This is achieved by linear filtering technique. However, in many situations such as the presence of sharp edges and impulse noise, the performance of linear filter is poor. To overcome these loopholes , nonlinear method of filtering has been proposed. The most popular non-linear filter is the median filter. It is computationally efficient, but yields blurred and distorted outputs. Subsequently, a fast real time algorithm has been reported for median filtering of signal and images. In this method noise filtering based on their local mean and variance for both the additive and multiplicative cases has been suggested. Recently, it has been shown that the use of local statistics works better for removal of additive white and multiplicative noise . However, it is not suitable for the removal of impulse noise as it employs optimal linear approximations. Another effective algorithm of noise filtering which does not require image modeling for both the additive and multiplicative noise cases has recently been reported . Some statistical properties of median filter are analyzed and it is shown that the median filter can remove impulsive and gaussian white noise.

This filtering scheme is based on replacing the central pixel value by the general mean of all pixels inside a sliding window. As the probability of noise corruption increases, its performance decreases while that of the median filter remains constant. Besides, if both positive and negative types of impulses are present, the performance of generalized mean filter is unsatisfactory. This filter is also not suitable for simultaneous removal of impulsive and non-impulsive noises. Its performance in presence of signal dependant noise is satisfactory. A novel class of non-linear filter for image processing known as order statistics filter has been reported. This filter is used for reduction of white noise, signal-dependent noise, and impulse noise. Another filter known as signal adaptive median filter has been developed which performs better than other non-linear adaptive filters for different .kinds of noises. The adaptive averaging filter proposed in performs 'poorly' in the presence of impulsive noise and does not remove noise close to the edges. The filtering scheme proposed in cannot suppress the impulsive noise sufficiently, but can preserve the edge better than the mean filter. It is claimed that decision based order statistics filters can reduce both impulsive and non-impulsive noise and can also enhance blurred edges better than many other order statistics filter. A fuzzy operator has been presented in for enhancement of blurred and noisy images. A new approach to spatial adaptive image restoration, which employs minimum additional computational load compared to the direct techniques have been proposed. The use of wavelet coefficient presents a new method for adaptive restoration and yields very good edge preservation in the restored results. A novel algorithm for removing impulse noise from images is presented, in which the nature of filtering operation is conditioned on a state variable. The key of the algorithm is a classifier that indicates in the probability of impulse corruption by operating on the rank ordered differences within a sliding window. This technique significantly outperforms a number of well known techniques in presence of impulsive Gaussian and mixed type of noise. A reliable and efficient computational algorithm for restoring blurred and noisy images has been proposed . By using inverse filtering technique blurred images can be restored. In a recent publication Malladi and Seth Ian have proposed an unified approach for noise removal, image enhancement, and shape recovery. This approach relics on the level of set formulation of curves and surface motion, which leads to a class of PDE-hascd algorithm. Enhancement of medical images can be successfully achieved by this technique. Several adaptive least mean square (LMS) filters have been recently proposed for noise suppression from images. This algorithim is computationally efficient In a recent paper an adaptive order statistics noise filter is proposed for gamma corrupted image sequence. This technique estimates the weights of an adaptive order statistics estimator that adapts to the probability density function of the noise. This approach is quite successful in handling the signal dependent noise. Impulse noise can also removed using higher order statistics. But this method involves corruption of higher order statistics, which is computationally expensive Filtering of impulse noise is also performed using artificial neural network (ANN). It is reported that a single layer neural network accurately detects the impulse noise of varying amplitudes . However, the multi-layer ANN involves large number of' connecting weights, bias weights, and output non-linearity. This increases the training time and the computational complexity. The technique involves two steps:

- Detection of impulse noise
- Spatial filtering of noise of corrupted pixels

In Section 11, we present the details of the techniques employed for impulse detection and filtering operation. Section III describes the simulation. study of the proposed algorithms, which are applied to different images. Section IV deals with comparative performance obtained from the simulation results experimented under different noise conditions. Section V presents the concluding remarks.

3. Techniques Employed

Consider an original image Y corrupted by the impulse noise n_i . The resultant distorted image X, may be written as:

$$X_i = Y_i + n_i ;$$

The impulse noise n_i has been added with a probability P. Since P is less than 1, it is useful to filter only those pixels which are corrupted by noise.

This approach reduces the blurring of the signal. The first step in this approach is to detect the presence of an impulse at a pixel position. To achieve this, we consider a sliding window of small size and propose an algorithm to test whether the center pixel of the test window is corrupted or not. If the test pixel is found corrupted, then we replace it by suitable filtering otherwise, we slide the test window to test the next center pixel. The process is repeated until the entire image is covered .

3.1 Fuzzy Logic Based Technique:

In this method, the detection of the presence of an impulse is based oil fuzzy logic. It is assumed that the image does not contain any sharp rise or fall in gayness at any of the pixel positions. The fuzzy detector is described below.

3.1.1 Noise Detection Process

Step 1: Consider a 3 x 3 test window x_T containing noisy pixels constructed from the corrupted image X ; as-

$$x_T = \begin{pmatrix} x_{1,1} & x_{1,2} & x_{1,3} \\ x_{2,1} & x_{2,2} & x_{2,3} \\ x_{3,1} & x_{3,2} & x_{3,3} \end{pmatrix}$$

3.1.2 Pass the X_T through a mathematical manipulator (MM) and compute A s

i=1,...,4 defined as:

$$\Delta I = (X_{1,1} + X_{3,3})/2 - X_{2,2}$$
$$\Delta 2 = (X_{3,1} + X_{1,3})/2 - X_{2,2}$$
$$\Delta 3 = (X_{2,1} + X_{2,3})/2 - X_{2.2}$$
$$\Delta 4 = (X_{1,2} + X_{3,2})/2 - X_{2,2}$$

3.1.3 Pass all A is through two membership functions, $\mu_1(.)$ and $\mu_2(.)$ characterized us

$$\mu_1(x) = \begin{cases} 0 & x<a \\ (x-a)/(b-a) & a < x < b \\ 1 & x>b \end{cases}$$

$$\mu_2(x) = \begin{cases} 0 & x>-a \\ (x+a)/(a-b) & -b<x<-a \\ 1 & x<-b \end{cases}$$

These two membership functions are graphically tested and Let's denote $\mu i(\Delta j)$ by μ_{ij}.

3.1.4 The rule for the impulse detection in a pixel is

- If either Δl or $\Delta 2$ or $\Delta 3$ or $\Delta 4$ is very large then the test pixel $x_{2,2}$ is corrupted.
- If either Δl or $\Delta 2$ or $\Delta 3$ or $\Delta 4$ is very low then the test pixel x_{22} is corrupted.

Using the above two rules, the output O of the impulse detector may be written as

$$O= \max\{\max(\mu 1j), \max(\mu 2j)); \quad \text{where } j=1..4$$

As O is in non-binary form, it is passed through a hard limiter (H) defined above to give a discrete yes or no decision.

$$H(O)= \begin{cases} 1, & x>t \\ 0 & \text{otherwise, where t-threshold value} \end{cases}$$

Computation of Eq^n. takes more time while computing a number of comparison operations. To reduce this time, the Eqn.may be approximated to a simpler form as given below:

$$O = \sum\sum \mu_{i,j} \quad ;$$

O is then passed through the hard limiter defined in Eqn below to get the value of d, the desired decision regarding the presence of an impulse i.e.

$$d = H(O) \quad ;$$

If the value of d is 1 then impulse noise is present in the test pixel and filtering process is revoked. The scheme of the proposed impulse detector can be depicted through a diagram.

3.1.2 Noise Filtering Process:

Compute a term $g=(x_{1,1}+x_{2,2}+x_{3,3})/3$

The moving window $x_{i,j}$ is then shifted by one row / one column until all pixels of the corrupted image is covered. The impulse detection and filtering process is carried out for all the windows. The complete fuzzy logic based filtering scheme can be shown through the proposed impulse detector.

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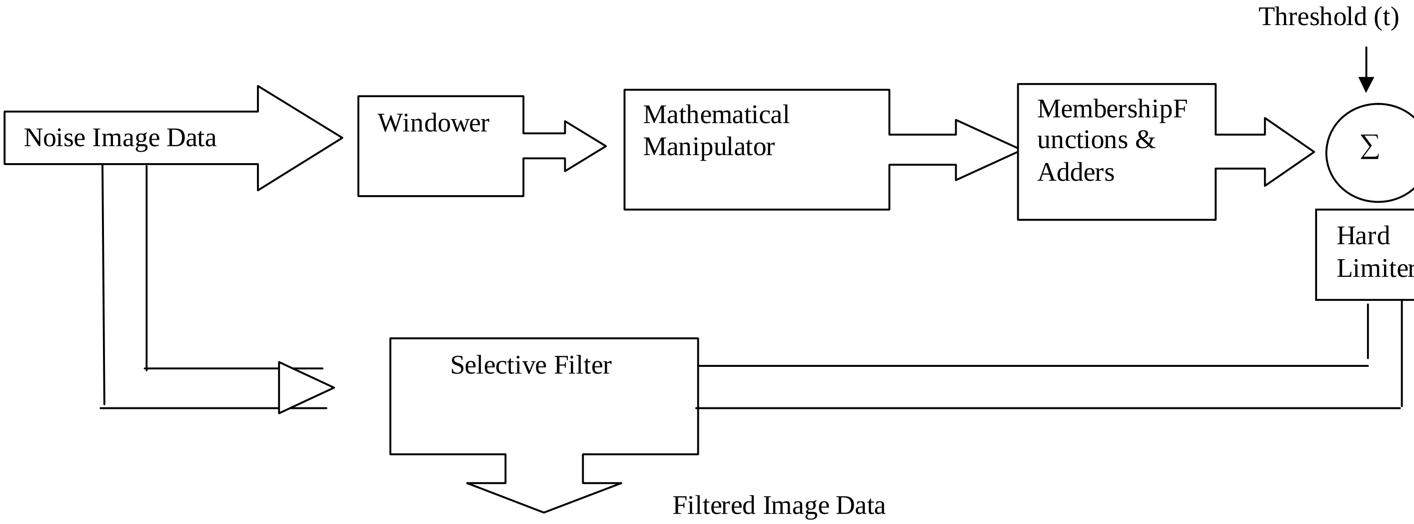

Fig 4 Fuzzy Logic Based Filtering Scheme

4.Simulation

To validate the efficiency of the proposed schemes, simulation study was carried out.
Two standard images Clown and Lenna were selected for simulation. At first, thesetwo images were converted into their normalised form, so that the the grav scale value of each pixel lies between 0 and 1 Each of these images was then distorted with impulse noise with its strength varying between 0,3 to 0.7. Probability of corruption was set between 5 to 30 percent. As the range of normalised pixel values was different for different images, the threshold values selected were different in each case. Both impulse detection and spatial filtering were carried out on the corrupted images using both double derivative and fuzzy

logic based techniques. The noise to signal ratio (NSR) in dB was estimated using conventional formula. The residual NSR associated with the restored image was used as the index of efficiency of a particular method. The noise strength in each case was varied and the corresponding NSR in dB in the restored image was computed through the simulation using both the methods. The comparative performance has been made in the next section.

5.Conclusion

The following represents the results of both Clown and Lenna images for a15 percent noise case. In each case, the original image, its corrupted version, the restored image obtained by DDT (Double Derivative method)and FLT (Fuzzy Logic Method) are shown. It may be observed that the restored Clown image exhibits a close similarity with its original image. Further, the restored image obtained from FLT is more closer to the original image compared to the image restored by DDT. The same findings are also observed in case of Lenna image. In the second part of the simulation, the percentage of noise is varied between 5 to 30 percent and in each case the residual NSR in dB is obtained by using both DDT(Double Derivative technique) and FLT(Fuzzy Logic Technique). The comparative performance of NSR present in restored images is shown in Fig.6. In general, it is observed that for both the images, the FLT outperforms the DDT in terms of residual NSR in dB, Further, to compare the computational complexity involved in both the methods, total number of operations per window is computed . In general, if the size of image is M x N pixels, the DDT requires (M-2) x (N-2) M x N windows to be processed both for impulse detection and spatial filtering for the entire image. Similarly, the FLT involves processing of (M-1) x (N-1) M x N windows. As the total number windows to be processed are of the same order in both DDT and FLT, a performance ratio E is defined as.

E = Total operations in DDT [Total operations in PUT =0.67/0.49= 1.36

Hence, it is observed that FLT is computationally efficient about 36 percent than DDT.
This paper proposes novel and efficient techniques of removing impulse noise contaminated with 2-D image, Both the methods involve two steps: impulse detection and spatial filtering. The simulation study has been performed on two standard images. Comparative performance study between two techniques has been made in terms of residual NSR and computational complexity. It is observed that FLT yields lower NSR in restored image compared to the DDT, which indicate that the first method possesses better noise filtering capability. Further,it is shown that the FLT involves less number of" I computations as compared to the DDT. Thus, it is concluded that the FLT is a preferred method of filtering the impulse noise from the iina c data both in terms of filtering potentiality and computational complexity.

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