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Review of impulse noise reduction technique using fuzzy logic for image processing

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Abstract

In this paper we have represented the study and comparison of filtering algorithm for the detection and filtering of impulse noise from the gray scale images. In this paper we have discussed filters like Mean filter(MF),Median filter, Rank conditioned median filter(RCMF), Arakawa's Fuzzy Median Filter(AFMF). Mean filter is effective to reduce the Gaussian white noise but not effective to process impulse noise. Median filter is good to work on impulse noise but effective to process Gaussian noise. But fuzzy median filter is good to work on both Gaussian noise and impulse noise. We have study the filtering method to reduce the noise from the gray scale images.

1. Introduction

The images corrupted by impulse noise are often occurred in practice. This type of noise may appear in digital images because of channel decoder damages, dyeing down of signal in communication links, communication subscriber's moving, video sensor's noises and other .The impulse noise called salt and-pepper noise, causes white and black points appears in digital gray scale images, which chaotically scattered along image area. Applying of classic median filter for removal of such type of noise gives relatively good results, which could be shown in restoring of brightness drops,objects edges and local peaks in noise corrupted images. Classic median filter has a set of disadvantages.

- Signal weakening (object's counters and edges are blurred in image); affecting to non corrupted ("good") image pixels.

Different modifications of median filter have been proposed to eliminate these disadvantages of median filtering. Now the switching scheme attracts a high interest of many researches. This approach proves its efficiency for salt-and-pepper impulse noise removal from digital images. The switching scheme approach means splitting of noise removal procedure into two main stages .

1. Preliminarily detection of noise corrupted pixels of digital image.
2. Filtering of noise impulses which have been detected in first stage of processing using information about gathered image properties [1].

2. Impulse noise in gray scale images

A grayscale image represented by a two-dimensional array where a location (i, j) is a position in image and called pixel. Often the grayscale image is stored as an 8-bit integer that giving 256 possible different shades of gray going from black to white , pixels can have value in [0-255] integer interval, but some pixels in an image have not correct value and they are noise that their value's is 0 or 255. On another hand (i, j) can be include impulse noises such as pepper(255) and salt(0)[2].

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3. Fuzzy Logic

Fuzzy Logic [3] is first proposed by the American mathematician Richard in 1965. He proposes a unique logical concept to further general logical concept 0 and 1 to the range of [0, 1] in which the fuzzy set of logical values can be infinite. Then he uses the membership to describe relationship between fuzzy sets accurately. This unique concept of imitating the human brain by certain rules to reason the uncertainty of things is using to many important parts of society, especially in the fields of AI (artificial intelligence) and automatic application. Some terms are explained following:

3.1 Fuzzy Concepts

All membership functions are types of triangular encountering but the number they are variables in the different nature of the natural parameters such as body temperature is originated. The most important reasons for using fuzzy systems are:

- Excessive complexity of the real world that ultimately led to a description or approximation for a system model is fuzzy.

- Need to formulate a model for human knowledge to the legal form and lawful way Insert true the system. In this manuscript fuzzy logic used to help new way in impulse noise detection that has been produced to build the fuzzy model of the effective value can be helpful in the impulse noise detection [2].

3.2 Fuzzy Rules

With using effective value and other information that I extract from noisy image, rules of fuzzy system are defined[2] as follows:

a) if V1 is small and V2 is small then noise is Large.
b) if V1 is small and V2 is Medium then noise is Large.
c) if V1 is small and V2 is Large then noise is Large.
d) if V1 is Medium and V2 is small then noise is Large.
e) if V1 is Medium and V2 is Medium then noise is Large.
f) if V1 is Medium and V2 is Large then noise is Small.
g) if V1 is Large and V2 is small then noise is Large.
h) if V1 is Large and V2 is Medium then noise is Small
i) if V1 is Large and V2 is Large then noise is Small

3.3 Fuzzy Performance

We will use four indices[3], Execution Time, Mean Squared Error, Signal to Noise Ratio, and Signal to Noise Ratio, to evaluate the performance of the three filters above in different cases objectively.

a) **Execution Time (ET)** It does not mean that execution time of the same program is the same in any case. It is relative to the environment or the hardware and so on, such as the machine frequency. The actual values are not general, but the trend we got is general, so this is a necessary index to evaluate the performance of an algorithm.
b) **Mean Squared Error (MSE)** The definition of MSE is the equation. Sij stands for the original image and Yij present the filtered image. M and N is the width and the height of the image. MSE is smaller, the performance is better, which means the filtered image is close to the original.
c) **Signal to Noise Ratio (SNR)** Generally, the SNR is bigger, the noise is less.
d) **Peak Signal to Noise Ratio (PSNR).** We can use it to evaluate the quality of an image, the bigger PSNR, the less distortion.

4. Mean Filter

The mean filter is mainly used to reduce Gaussian white noise from the gray scale images.The nature of mean filter is linear. Let us consider an image as an M * N array which stands each point by the discrete functions f(x, y). The function of mean algorithm processed image is marked as g(x, y). We process one point at (x, y) in its n by n neighborhood area each time. Disadvantage of mean filter is that it does not work to reduce the impulse noise from the grayscale images. We can say that this kind of linear filter is commonly used in Gaussian white noise[3].

5. Median Filter

Median filter is used to remove the disadvantage of the mean filter. This filter is mainly used to reduce impulse noise from the gray scale images. The nature of this type of filter is non-linear. Let us regard an image as an M * N array with the discrete functions f(x, y). The median algorithm processed image's function is marked as g(x, y). We process one point at (x, y) in its n by n neighborhood area per time. The operator 'Med' is to choose the median value in the n by n values[2,3]. There are types of median filter as follows:

Types of Median Filters: Three important types of noise existing: impulse noise, multiplicative noise and additive noise, and available many algorithms for reduction noise of each type. Here we propose and descript a new method that detect and replace noisy pixels. Filters are

5.1 Standard median filter (SMF) that is based on order statistic and its nonlinear filter [2] but it has some problem, for example this method mistakenly destroys the edges.

5.2 Adaptive median filter (AMF) is another method for impulse noise reduction [3, 4] although these methods have been improved, but the quality of restoration image is still not satisfactory.

5.3 Weighted median filters (WMF), Center weight median filter (CWMF), Adaptive length median filter (ALMF), Alpha trimmed median filter (ATMF):Most of these algorithms provide suitable

and good results at smaller percent of noise levels and find difficulty with higher level noises.

5.4 The boundary discriminative noise detection filter (BDNDF) can be improved images that corrupted up to 90% noise [9], but this method is too time-consuming and isn't suitable for real applications.

5.5 Fuzzy logic and Median Heuristic Filter (FMHF) is better than FIDRM because work in low time and have better results in PSNR metric.

5.6 Heuristic median filter(HMF) used for noisy pixels and its neighborhood, this heuristic is similar to trim median filter but this method use from average of neighbor pixels by this concept that good replace pixel is similar to neighbor pixel, in below we introduce this heuristic in 3 step such as: we know there is some noisy pixel in a mask that are zero or 255, thus in step 1 remove all pixels that have 0 or 255 value, then we use from average of other pixels that are not noise in step 2, then in step 3 we replace all noisy pixels that we detect in fuzzy detection mechanism by average that we calculate in step 2. Figure 1 show this idea[2].

0	0	0	65	68	68	69	70	255	255

65	68	68	69	70

AVG=(65+68+68+69+70)/5=68

5.7 Rank conditioned median filter (RCM): A simple but effective impulse-detection-based filter is the rank-conditioned median (RCM) filter, in which pixels in the filtering window are ranked according to their magnitudes and ranks are given according to their positions in the sorted order. The centre pixel is considered to be corrupted if it lies outside the trimming set, which is formed by excluding the extreme values from the sorted pixels. In the conventional conditional median filters, thresholds are set to separate the input signal and the median. Recently, impulse noises removal based on fuzzy inference logic have attracted investigation.

6. Arakawa's Fuzzy Median Filter

Arakawa's fuzzy based median filter is constructed as a weighted sum of the input signal and the output of the median filter, and the weighting coefficients concerning the state of the input signal sequence are set by deriving fuzzy rules. Then, the learning process is realized by training over a reference image to obtain the optimal weight. Moreover, considering the combination of the fuzzy rules during the inference process, each membership function is proposed by approximating with a step-like function, and setting the height of each step so that the mean square error of the filter output can be the minimum for training signal data. However, the computation time is a compromise. Furthermore, if the inference process adopts another smooth nonlinear membership function, such as a Gaussian type or sigmoid functions, in approximating the membership function, the performance is frugal. Because the form of the membership function is limited to be close to these functions, and the filter is expressed as a nonlinear form of the parameters to be controlled, the performance of their training can be worse, or a local minimum can exist in some cases. According to Arakawa's proposition, median filters based on fuzzy rules [4].

7. Conclusion

This paper gives a review of filtering algorithm that are used to reduce the noise from the grayscale images. Mean filter (linear filter) is just work on to reduce Gaussian white noise but does not work to reduce the impulse noise from the grayscale images. Median filter(non- linear filter) is effective to reduce the impulse noise from the grayscale images. We have also discussed other median filters also these filters are work well with the smaller percentage of noise. Median filters are not good with the higher percentage of noise. It could effect on edges of the images. Median filters are not good to process the Gaussian noise. So we have used the rank conditioned median filter (RCMF) to remove the some disadvantage of other median filters like mean filter, standard median filter(SMF),adaptive median filter(AMF) .RCMF filter is simple and effective filter in which pixels resides in the filtering window are ranked according to their magnitudes and ranks are arranged according to their positions in sorted order. RCMF to reduce the probability of detecting a healthy pixel as an impulse and the probability of detecting a noisy pixel as healthy. But median filters are not to work with the real applications, so that we have moved from the median filter to Arakawa's fuzzy based median filter which is used from the fuzzy logic to noise detection. It is more suitable in real applications, it is soft thresh holding approach that tests in the gray scale images whether impulse noise is present in sliding window or not. If there is a impulse noise then it further clarifies whether it is impulse noise

or feature point, so that it has a ability to differentiate between impulse noise and feature point.

8. References

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