A Survey on Image Denoising

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Abstract:

In Image Processing, the impulse noise reduction from images plays a very vital role. Image denoising is one such powerful methodology which is deployed to remove the noise through the manipulation of the image data to produce very high quality images. There are several such algorithms devised for denoising, each having their own merits and demerits. In this notion reviews the existing denoising algorithms and performs their comparative study.

Keywords: ***Salt and Pepper noise, Salt and Pepper noise decline, Cellular automata*, *Neighborhood Structure***

I. INTRODUCTION

The image processing[1] is an important process in every life applications. The important problem with digital image is that impulse noise. It can be introduced by data transmission errors and/or data compression.

The impulse noise can be reduced by various methods such as the median filter which is a well-known and widely used conventional method. The median filter was important filter for removing impulse, or "salt and pepper" noise, because of its good "denoising" power and computational efficiency. However, when the noise level is over 30%, this filter lost some details and edges of the original image. The basic idea behind this thesis is the estimation of the uncorrupted image from the distorted or noisy image, and is also referred to as image "denoising". There are various methods to help restore an image from noisy distortions. Selecting the appropriate method plays a major role in getting the desired image.

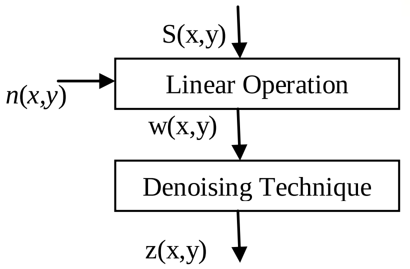

Figure 1: Denoising Concept

The "Linear operation" is the addition or multiplication of the noise $n(x,y)$ to the signal $s(x,y)$ Once the corrupted image $w(x,y)$ is obtained, it is subjected to the denoising technique to get the denoised image $z(x,y)$. The point of focus in this notion is comparing and contrasting several "denoising techniques". Noise removal or noise reduction can be done on an image by filtering. Each technique has its advantages and disadvantages.

II. KEY CONCEPTS

A. Salt and pepper Noise

Salt and pepper noise is one of the type of an impulse noise. The impulse noise caused due to errors in data transmission. The salt and pepper noise is generally caused by faulty of pixel elements in the camera sensors, faulty memory locations, in the digitization process. It has only two possible values, *a* and *b*. The corrupted pixels are set to the minimum or to the maximum value, giving the image a "salt and pepper" like appearance. For an 8-bit image, the value for pepper noise is 0 and for salt noise 255

B. Cellular Automata

CA model is composed of set of cell(each cell corresponds to image pixels), neighbourhood and local rule[2].The cellular automaton is a discrete, decentralized, self organized system which can make an ordered structure starting on a stochastic state. Thus the rules of the system are local and uniform. There are one- dimensional, two-dimensional CA models. For example, a simple two-state, one dimensional CA consists of a line of cells, each of which cell lies between the value zero or one..In Cellular Automata the computations are done in parallel mannaer. Parallelism means updating of an individual cell is performed independently of each other.

C. Neighborhood Structure

As the image is a two dimensional[4], here we use 2DCA model. In 2DCA model, there are three regular lattices namely, triangular, square, and hexagonal. In most cases, the square lattice is used and in only occasionally is the triangular or hexagonal a better choice. In our experiment, a rectangular regular grid is used to represent a digital image and each cell represents one pixel of the image. So initial configuration at u=0, is the original image. Before designing the de-noising rule based on CA, it is necessary to determine the structure of the neighbours firstly. The structure of the neighbours mainly includes von Neumann neighborhood and moore neighborhood are shown in figure (2)

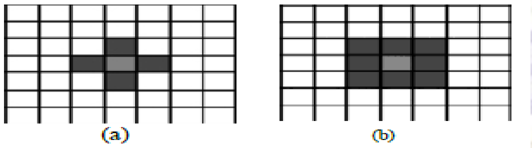

Figure.2: Structure of neighborhoods (a) Von Neumann neighborhood (b) Moore neighborhood

Von Neumann neighborhood, there are four cells, the two cells are above and below, and the other two are right and left from each cell is called vonNeumann neighborhood of this cell. The radius is 1, as only the next layer is considered. The total number of neighborhood cells including itself is 5 [10] as shown in the equation (1):

$$N(I,j) = \{ (p,q) \in L : |p-i| + |q-j| \leq 1 \} \quad (1)$$

Where, p is the number of states for the cell and q is the space of image pixels. Besides the four cells of von Neumann neighborhood, moore neighborhood also includes the four next nearest cells along the diagonal.The total number of neighbor cells including itself is 9 all as shown in the equation (2):

$$N(I,j) = \{(p,q) \in L : \max(|p-i|,|q-j|) \leq 1 \} \quad (2)$$

The state of the target cell at time t+1 depends on the states of itself and the cells in the moore neighborhood at time t, that is:

$$S_{i,j}^{t+1} = F[S_{i,j-1}^{t}, S_{i,j+1}^{t}, S_{i-1,j}^{t}, S_{i+1,j}^{t}, S_{i-1,j-1}^{t}, S_{i-1,j+1}^{t}, S_{i+1,j-1}^{t}, S_{i+1,j+1}^{t}] \quad (3)$$

To compare the central pixel with the neighborhoods we use the concept of structuring element as shown in the equation (4)

SE=Strel("square",w) (4)

creating a square structuring element whose width is w pixels. w must be a non-negative integer scalar as shown in the figure 3:

(i-1,j-1)	(i-1,j)	(i-1,j+1)
(i,j-1)	(i,j)	(i.j+1)
(i+1,j-1)	(i+1,j)	(i+1,j+1)

Figure.3: structuring element

III. COMPARATIVE STUDY

This section includes a study on some of the filtering algorithm that have included remove the impulse noise as well.

A. Non-Local Means Filter

The approach of Non Local Means (NLM) [5] filtering is based on estimating each pixel intensity from the information provided from the entire image and hence it exploits the redundancy caused due to the presence of similar patterns and features in the image. In this method, the removed gray value of each pixel is obtained by the weighted average of the gray values of all pixels in the image. The assignment of weight is proportional to the similarity between the local neighborhood of the pixel and the neighborhood corresponding to other pixels in the image. The advantage of NLM filter is to remove impulse noise but the drawback of NLM filter is a single pixel with a very unrepresentative value can significantly affect the mean value of all the pixels in its neighborhood. When the filter neighborhood bestride an edge, the filter will interrupt new values for pixels on the edge and so will blur that edge. This produces a problem if sharp edges are required in the output.

B. Standard Median Filter

The Standard Median Filter (SMF) [6] was once the most popular non linear digital filter for removing impulse noise because of its good denoising power and computational efficiency. But the main drawback of this filter is that it is effective only for low noise densities. At high level f noise, SMFs often exhibit blurring for large window size

C. Adaptive Median Filter

The Adaptive Median Filter (AMF) [7] is non linear filter. To reduce the noise by using varying the window size. To increases the size of the window until correct value of median is calculated and noise pixel is replaced with its calculated median value. Here two conditions are used, one condition is used to detect the corrupted pixels and second one is used to check the correctness of median value. If trial pixel is less than minimum value present in rest of pixel in window and if text pixel is greater than maximum value present in rest of pixel in window then center pixel then it is treated as corrupted pixel. If calculated median is corrupted then increase the window size and recalculate the median value until we get correct median value or else window size reach maximum limit.

D. Switching Median Filter

One of the branches for the improvement of median filter is based on switching approach [8]. In general, switching median filter divides its implementation into two stages; which are noise revealing stage, and noise annulment stage. During the first stage, by using some of the image characteristics such as pixel intensity, the noise discover algorithms classify the image pixels either "noise" or "noise-gratis" pixels. Then, in the second stage of the method, only "noise" pixels are processed by the filter, whereas "noise-gratis" pixels are left unchanged. This condition enables the method to preserve most of the image details. Switching median filters identifies each pixel as "corrupted" or "original", only those corrupted pixels would under go the filtering process, while other pixels remain unchanged. So SM filter can get more satisfactory results for restraining impulse noise. The disadvantage of switching median filter is Less effective in removing Gaussian or random-intensity noise. The median filter can remove noise only if the noisy pixels occupy less than one half of the neighborhood area

E. Progressive Switching Median Filter:

It is a median based filter [9], which works in two stages. In the first stage an impulse detection algorithm is used to generate a sequence of binary flag images. This binary flag image predicts the location of noise in the observed image. In the second stage noise filtering is applied progressively through several iterations. This filter is a very good filter for fixed valued impulsive noise but for random values the performance is abysmal. The advantage of using progressive switching median filter preserves the positions of boundaries in an image, making this method useful for visual examination and measurement. But the disadvantage is to removes both the noise and the fine detail since it can't tell the difference between the two.

F. Switching Bilaterl Filter

The switching bilateral filter [10] proposed by C. H. Lin et al, is a nonlinear filter which removes both Gaussian and impulse noise while preserving image details. This filter consist of two stages, in first stage to identify the type of noise then apply the filtering to the noisy pixel is a second stage.

A Modified Switching Bilateral filter, which is supported by the global trimmed mean value instead of reference median value and the weights of the bilateral filter is supported by the noise free pixels alone. But, in bilateral and switching bilateral filters weights depends on both noisy and noise gratis pixels in the window. The modified switching bilateral filtering removes the noise and enhances the fine details in an image, by means of a nonlinear combination of nearby noise free pixel and global trimmed mean value. The main advantage of Bilateral filter is easy to set up and understand and the main drawback is it is complex ,because it cannot be precomputed

TABLE SHOWING PERFORMANCE PARAMETERS

Parameter	Mean Filter	Median Filter	Bilateral Filter	Cellular Automata
Performance in High Noise Ratio	Very low	High	Moderate	Very high
Types Of Noise	Gaussian Noise	Impulse Noise	Gaussian and Salt-Pepper Noise	Impulse Noise
Computational Time	High	Low	Low	Very Low
Feature	Serial	Serial	Serial	Intrinsic Parallelism

IV. FUTURE RESEARCH DIRECTION

The application of digital image processing is considered a real time process in which process speed is important. Therefore, the parallel algorithms in image processing are much more important compared with serial algorithms. In [11], a Cellular Automata is used as a parallel method for impulse noise revealing. CA is used as a method for noise removal in digital images. Although these methods are simple because of using median to replace the value of noisy places, they are useful only when noise density is very low and they do not render a good performance when the noise density is medium or high.

One of the main problems in most noise elimination methods is the elimination of important data and details of the image such as the edges and zone texture. In addition, in conventional methods such as median filter and its variations, the image will take damage because without any information about the noisy points, the correct pixels are also changed. Considering the uncertainty and ambiguity of impulse noise in digital images, Cellular Automata can have a suitable behavior in such situations[12]

V. CONCLUSION

In this paper some of the best Noise filtering algorithms that accomplish to remove noise have been discussed. The algorithm Cellular Automata performs well when detecting the noise based on parallel manner. Most soft computing methods reduce noises effectively but lack of robustness, high costs of computation, being time-consuming, high complexity, and the need for evaluating and tuning the parameters are some problems of these methods. Cellular Automata is a simple and robust method with parallelization ability used in for image processing applications such as improving image quality.

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