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Survey of Image Denoising Algorithm

M. Nandhini*
PG student, Department of CSE
Bharath University , Chennai-73

Dr.T.Nalini
Professor,Department of CSE
Bharath University Chennai, India

Abstract- Image denoising is a well explored topic in the field of image processing. The removal of noise from the image is known as denoising. Image denoising is an essential step that involves the manipulation of the image data to produce a visually high quality image. Removing noise from digital image is a big challenge for researchers. Several noise removal algorithms have been proposed till date. Choice of denoising algorithm is applicant dependent and depends upon the type of noise present in the image. Every algorithm has its own assumption, advantage & limitation. This paper presents a comparative study of various image denoising algorithms.

Keywords- Image denoising, Robust outlyingness Ratio (ROR), Non-Local Mean (NLM), Noise Adaptive Fuzzy Switching Median Filter (NAFSM), Fuzzy C-Means (FCM), Adaptive Center Weighted Median Filter (ACWMF), Detail Preserving Variational Method(DPVM), impulse noise , Gaussian noise.

I. INTRODUCTION

Digital images play an important in research and technology such as geographical information systems as well as it is the most vital part in the field of medical science such as ultrasound imaging, X-ray imaging, Computer tomography and MRI. The quality of image is degraded by various noises in its acquisition and transmission. A very large portion of digital image processing includes image segmentation, object recognition, edge detection and image restoration. Image restoration is a method of removal or reduction of degradation that are incurred during the image capturing. Degradation comes from blurring as well as noise due to the electronic and photometric sources. Blurring is the form of bandwidth reduction of images caused by imperfect image formation process such as relative motion between camera and original scene or by an optical system that is out of focus. Noise is unwanted signal that interferes with the original signal and degrades the visual quality of digital image. The main sources of noise in digital images are imperfect instruments, problem with data acquisition process, interference natural phenomena, transmission and compression. There are various noise reduction algorithm used for removing noise. Most of the standard algorithms used to denoise the noisy image and perform the individual filtering process which reduces the noise level. Image denoising forms the preprocessing step in the field of photography, research, technology and medical science, where somehow image has been degraded and needs to be restored before further processing.

Image denoising is still a challenging problem for researchers as image denoising causes blurring and introduces artifacts. Various denoising algorithm are discussed in this paper.

II. SURVEY REVIEW

A. In this section, we are presenting the research work of some prominent authors in the same field and explaining a short description of various algorithms used for image denoising. Bo Xiong and Zhouping Yin **"A UNIVERSAL DENOISING FRAMEWORK WITH NEW IMPULSE DETECTOR AND NONLOCAL MEANS", 2012[1]** proposed a new detection mechanism for universal noise and a universal noise-filtering framework based on the nonlocal means (NL-means). Impulse noise detection is a critical issue when removing impulse noise and impulse/Gaussian mixed noise. The operation is carried out in two stages, i.e., detection followed by filtering. For detection, first, propose the robust outlyingness ratio (ROR) for measuring how impulse like each pixel is, and then all the pixels are divided into four clusters according to the ROR values. Second, different decision rules are used to detect the impulse noise based on the absolute deviation to the median in each cluster. In order to make the detection results more accurate and more robust, the from-coarse-to-fine strategy and the iterative framework are used. In addition, the detection procedure consists of two stages, i.e., the coarse and fine detection stages. For filtering, the NL-means are extended to the impulse noise by introducing a reference image. Then, a universal denoising framework is proposed by combining the new detection mechanism with the NL-means (ROR-NLM). Finally, extensive simulation results show that the proposed noise detector is superior to most existing detectors, and the ROR-NLM produces excellent results and outperforms most existing filters for different noise models. Unlike most of the other impulse noise filters, the ROR-NLM also achieves high peak signal-to-noise ratio and great image quality by efficiently removing impulse/Gaussian mixed noise.

B. P.Krishnapriya, S. Sanjeeve kumar **"A NOVEL APPROACH TO NOISE REDUCTION FOR IMPULSE AND GAUSSIAN NOISE", 2013[2]** 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.

C. James C. Bezdek, Robert Ehrlich, William full **"FCM: THE FUZZY C-MEANS CLUSTERING ALGORITHM", 1983[3]** proposed a method of clustering which allows one piece of data to belong to two or more clusters. This method was developed by Dunn in 1973 and improved by Bezdek in 1981 and it is frequently used in pattern recognition. With fuzzy *c*-means, the centroid of a cluster is computed as being the mean of all points weighted by their degree of belonging to the cluster. By iteratively updating the cluster centers and the membership grades for each data point, FCM iteratively moves the cluster centers to the "right" location within a data set. Performance depends on initial centroids.

D. M. Atiquzzaman **"COARSE TO FINE SEARCH TECHNIQUE TO DETECT CIRCLES IN IMAGES",1999[4]** Detection of patterns in images is an important high-level task in automated manufacturing using machine vision. Straight lines, circles and ellipses are considered to be the basic building blocks of a large number of patterns occurring in real-world images. Real-world images frequently contain noise and occlusions resulting in discontinuous patterns in noisy images.

The aim of coarse-to fine search technique is to reduce the storage and computing time in detecting circles in an image. The accuracy and the rate of convergence of the parameters at different iterations of the algorithm are presented. The results demonstrate that the coarse-to-fine search strategy is very suitable for detecting circles in real-time environments having time constraints.

E. T.W. Liao, Aivars K. Celmins, Robert J. Hammell **"FUZZY C-MEANS VARIANT FOR THE GENERATION OF FUZZY TERM SET",2003[5]** proposed a FCM variant differs from the original in two areas, the first modification ensures the two end terms take the maximum and minimum domain values as the centers. The second modification prevents the generation of non-convex fuzzy terms that often occurs with the original algorithm. The exponential weight used in the algorithm is found to greatly affect the shape of the membership function. A generalized shaped function with a tunable parameter along with its complement is developed to all term sets generated by the FCM variant using various m values.

F. Shuqun Zhang **"A NEW IMPULSE DETECTOR FOR SWITCHING MEDIAN FILTERS", 2002[6]** proposed a technique for switching median filters is presented, which is based on the minimum absolute value of four convolutions obtained using one-dimensional Laplacian operators. The impulse detection is usually based on the following two assumptions: 1) a noise-free image consists of locally smoothly varying areas separated by edges and 2) a noise pixel takes a gray value substantially larger or smaller than those of its neighbors. Extensive simulations show that the switching median filter provides better performance than many of the existing switching median filters with comparable computational complexity. In particular, the switching median filter is directed toward improved line preservation.

G. LUO Wenbin **"A NEW EFFICIENT IMPULSE DETECTION ALGORITHM FOR THE REMOVAL OF IMPULSE NOISE", 2005[7]** proposed to remove impulse noise from corrupted images while preserving image details. The impulse detection algorithm is combined with median filtering to achieve noise removal. The main advantage of this paper is that it can detect the impulse noise with high accuracy while reducing the probability of detecting images details as impulse. Also, it can be applied iteratively improve the quality of restored images. It is efficient and low in complexity. Furthermore, it requires no previous training. Extensive experimental results show that the impulse detection approach significantly outperforms many well- known techniques.

H. Remya Soman, Jency Thomas **"A NOVEL APPROACH FOR MIXED NOISE REMOVAL USING ROR STATISTICS COMBINED WITH ACWMF AND DPVM", 2014[8]** proposed a mixed noise removal framework using Robust Outlyingness ratio (ROR) statistics combined with adaptive center weighted median and detail preserving variational approach is discussed. The pixels are classified into different clusters based on the ROR statistics, which measures how impulse like each pixel is .To make the results more accurate, each cluster undergoes coarse and fine stage of noise detection and removal, which make use of ACWMF for noise detection and DPVM for restoration of noise candidates. Final stage of filtering is done by means of Non Local Means filter. Extensive simulations show that the proposed scheme consistently works well in suppressing both impulse and Gaussian noise with different noise ratios.

I. Roman Garnett, Timothy Huegerich, Charles Chui, and Wenjie He **"A UNIVERSAL NOISE REMOVAL ALGORITHM WITH AN IMPULSE DETECTOR", 2005[9]** proposed a local image statistic for identifying noise pixels in images corrupted with impulse noise of random values. The statistical values quantify how different in intensity the particular pixels are from their most similar neighbors. We continue to demonstrate how this statistic may be incorporated into a filter designed to remove additive Gaussian noise. The result is a new filter capable of reducing both Gaussian and impulse noises from noisy images effectively, which performs remarkably well, both in terms of quantitative measures of signal restoration and qualitative judgments of image quality. Universal noise removal approach is extended to automatically remove any mix of Gaussian and impulse noise.

J. Antoni Buades, Bartomeu Coll, Jean-Michel Morel **"A NON-LOCAL ALGORITHM FOR IMAGE DENOISING", 2005[10]** proposed a new measure, the method noise, to evaluate and compare the performance of digital image denoising methods. It first compute and analyze this method noise for a wide class of denoising algorithms, namely the local smoothing filters. Second a new algorithm is proposed the non local means (NL-means), based on a non local averaging of all pixels in the image.

III. COMPARISON OF DIFFERENT ALGORITHM:

Comparison of observations given in all references is discussed here.

Table1. Comparative Study of Various algorithm

Sl.no	Author and year	Techniques / Algorithm	Advantage	Limitation
1	Bo Xiong and Zhouping Yin 2012	ROR-NLM	ROR-NLM achieves high peak signal-to-noise ratio and great image quality by efficiently removing impulse/Gaussian mixed noise.	The detection method is done using the pixels one by one. This pattern gets good result but efficiency is low.
2	P.Krishnapriya 2013	ROR-NAFSM-FCM-NLM	The ROR-NAFSM-FCM-NLM 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.	---
3	James C 1983	FCM	This method is frequently used in pattern recognition. It includes three norms Euclidean, Diagonal, Mahalonobis an adjustable weighting factor that essentially control sensitivity to noise.	By iteratively updating the cluster centers and the membership grades for each data point, FCM iteratively moves the cluster centers only to the "right" location within a data set. Performance depends only on initial centroids.
4	M.Atiquzzamn 1999	Coarse to Fine search	The coarse-to-fine search strategy is very suitable for detecting circles in real-time environments.	It has time constraints.
5	T.W. Liao 2003	Fuzzy c- mean variant	The generalize pie-shaped function with an adjustable parameter, z, was proposed to fit all fuzzy terms generated by the FCM variant when various exponential weight values were used.	The data size reduces, the term centers move and there might not be sufficient number of data points to define the desired number of terms. Gaussian functions do not fit well because of the inherent lower overlap than the (d,m) pairs generated by the fuzzy c-mean variant algorithm.
6	Shuqun Zhang 2002	Switching median filter	It provides better performance than many of the existing switching median filters with comparable computational complexity. In particular, the switching median filter is directed toward improved line preservation.	The pattern recognition is based on line. It does not depends on circles and ellipses.
7	LUO Wenbin 2005	Impulse Detection	It can detect the impulse noise with high accuracy while reducing the probability of detecting images details as impulse. Also, it is applied iteratively to improve the quality of restored images. It is efficient.	It is low in complexity.
8	Remya Soman 2014	ROR-ACWMF-DPVM	It is consistently works well in suppressing both impulse and Gaussian noise with different noise ratios.	The detection method is done using the pixels one by one. This pattern gets good result but efficiency is low
9	Roman Garnett 2005	Universal Noise removal with an impulse detection	t is capable of reducing both Gaussian and impulse noises from noisy images effectively, which performs remarkably well, both in terms of quantitative measures of signal restoration and qualitative judgments of image quality. Universal noise removal approach is extended to automatically remove any mix of Gaussian and impulse noise.	---
10	Antoni Buades 2005	Non – Local Algorithm	NL-means filter is applied to remove Gaussian noise.	The numerical Measurement in non local algorithm is the most objective one, since it does not rely on any visual interpretation. However, this error is not computable in a real problem and a small mean square error does not assure a high visual quality.

IV. CONCLUSION

In this paper, we have discussed various denoising algorithms and their performance metrics are compared with individually. The nonlocal means with adaptability shows very good results in image denoising. Though the applications are different, the various denoising schemes perform within their limit. There must be a technique which can be applied globally for all types of noisy images irrespective of the applications. The future research gives the scope for such denoising algorithm which also helps in preserving the necessary sharp details of the image.

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