Digital Color Image De-Noising Techniques-A Review

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Abstract*- Digital Color Image de-noising is simple and most appealing area among all the digital image processing techniques and is defined as the process of manipulating an image so as to highlight certain feature of interest. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide better input for other automated image processing techniques. During last decades, a number of methods have been proposed by researchers for de-noising of digital color images. However, enhancement of image quality is still a major concern and daunting to meet the expectations of users. In this paper, we review the work done on de-noising of digital color images and propose an improvised method for image enhancement.*

Keywords- De-noising, Image Enhancement, Random Impulse Noise.

I. INTRODUCTION

Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video and the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Unfortunately, there is no general theory for determining what good image enhancement is when it comes to human perception. If it looks good, it is good! However, when image enhancement techniques are used as pre-processing tools for other image processing techniques, then quantitative measures can determine which techniques are most appropriate.

II. ENHANCEMENT IN SPATIAL DOMAIN

Spatial Domain refers to image plane itself, and approaches in the category are based on direct manipulation of pixels in the image. The spatial domain processes are denoted by the expression

$$G(x, y) = T [(f(x, y)] \qquad (1)$$

Where f(x, y) is the input image, g(x, y) is the output (processed) image, and T is an operator on f defined over a specified neighborhood about point (x, y). In addition, T can operate on a set of images, such as performing the addition of a sequence images for noise reduction. The principal approach for defining spatial neighborhoods about a point (x, y) is to use a square or rectangular region center d at (x, y). The center of the region is moved from pixel to pixel starting say, at the top left corner and as it moves it encompasses different neighborhoods. Operator T is applied at each location (x,y) to yield the output, g, at that location. Only the pixels in the neighborhood centered at (x, y) are used in computing the value of gat (x, y). Enhancement can be done in three different ways.

2.1 Gray Scale Transformation

In this method the values of pixels before and after processing are denoted by r and s. These values are related by the expression of the form s = T(r) where T is the transformation that maps a pixel value r into a pixel value s. There are three basic types of functions used frequently for image enhancement that are image negative transformation, log transformation and power law transformation.

(i) Image Negatives

This is the most basic and simple operation in digital image processing is to compute the negative of an image. The negative transformation for images with gray levels in the range [0, L-1] is given by

$$s = L - 1 - r \qquad (2)$$

Reversing the intensity levels of an image in this manner produces the equivalent of a photographic negative. This type of processing is particularly suited for enhancing white or gray detail embedded in dark regions of an image, especially when the black areas are dominant in size.

(ii) Logarithmic Transformation

Logarithmic and contrast-stretching transformations are basic tools for dynamic range manipulation. Logarithm transformations are implemented using the expression

$$g = c\times\log(1 + r) \qquad (3)$$

Where c is a constant and r is floating point.

(iii) Power Law Transformation

- Power law transformation has the basic form $s = cr^{\gamma}$ Where c and γ are positive constants
- The transformation is entirely controlled by γ
- The transformation is similar to the log transformation but it is easier to be tuned.

III. LITERATURE SURVEY

A number of research papers have been proposed for digital color image enhancement and are as appended below:

"Perceptually Motivated Automatic Color Contrast Enhancement", Choudhury et al. [1] in 2009 addresses the problem of contrast enhancement for color images. Their method to enhance images was inspired from the Retinex theory and tries to mimic human color perception. This method helps in achieving color constancy and also results in color contrast enhancement. They express the intensity as a product of illumination and reflectance and estimate these separately. Enhancement is then applied to the illuminant component only. Non-local means filter was used to estimate the illuminant and then the enhancement of the illumination is performed automatically without any manual intervention and multiplied back by the reflectance to obtain enhancement.

"Image Contrast Enhancement by Contour let Transform ,Nezhadarya et al. [2] in 2006 propose a new method for image contrast enhancement, based on a 2D directional non-separable transform known as contour let transform. Conventional 2D wavelet transform was separable and thus cannot sparsely represent non separable structures of the image, such as directional curves. The directionality feature of contour let transform makes it a good choice for representation of curves and edges in the image. In that work a new enhancement function was proposed to enhance the edges by contour let transform.

"Image contrast enhancement based on intensity- pair distribution" Cheng et al. [3] in 2005 proposed a new approach for contrast enhancement based on the use of a so called intensity pair distribution. This distribution possesses both local information and global information of the image content. By analyzing the content of intensity-pair distribution, a set of expansion forces are generated for contrast enhancement while another set of anti-expansion forces are generated to suppress image noise. To avoid over enhancement and preserve the natural look of the processed images, a magnitude mapping function was also proposed. Experimental results show that the proposed algorithm does provide a flexible and reliable way for advantages of global approaches, such as HE, and local approaches, such as AHE. The implementation of this approach was simple and the performance of enhancement was quite promising.

"Human Visual System-Based Image Enhancement and Logarithmic Contrast Measure", Panetta et al. [4] in 2008 introduces two novel image enhancement algorithms: edge-preserving contrast enhancement, which is able to better preserve edge details while enhancing contrast in images with varying illumination, and a novel multi-histogram equalization method which utilizes the HVS to segment the image, allowing a fast and efficient correction of non-uniform illumination. They then extend this HVS-based multi-histogram equalization approach to create a general enhancement method that can utilize any combination of enhancement algorithms for an improved performance. Additionally, they propose new quantitative measures of image enhancement, called the logarithmic Michelson contrast measure (AME) and the logarithmic AME by entropy.

"A New Contrast Enhancement Technique by Adaptively Increasing the Value of Histogram", Lei et al. [5] in 2009 proposes a simple contrast enhancement scheme named AIVHE. It provides a convenient and effective mechanism to control the rate of contrast enhancement by means of an adaptive parameter, $\alpha(k)$, and a user defined value, β. AIVHE offers a gradually increment by the mean brightness of the image to modify the original PDF.

"Image interpolation using constrained adaptive contrast enhancement techniques" Philips et al. [6] in 2005 presented a method for interpolating images that also preserves sharp edge information. They concentrate on tackling blurred edges by mapping level curves of the image. Level curves are spatial curves with constant intensity. The mapping of these intensities can be seen as a local contrast enhancement problem ;therefore, they use contrast enhancement techniques coupled with additional constraints for the interpolation problem. A great advantage of this approach was that the shape of the level set contours were preserved and no explicit edge detection was needed there.

"Particle Swarm Optimization for Gray-Scale Image Noise Cancellation",Te-Jen et al. [7] in (2008) presented a method that the control the analog cellular neural network systems via particle swarm optimization (PSO). Based on PSO, this approach designs the templates of a cellular neural network and diminishes the noise interference in polluted images.

"A Histogram Modification Framework and Its Application for Image Contrast Enhancement", Arici et al. [8] in 2009 presented a general framework based on histogram equalization for image contrast enhancement. In this framework, contrast enhancement was posed as an optimization problem that minimizes a cost function. HE is an effective technique for contrast enhancement. However, conventional HE usually results in excessive contrast enhancement, which in turn gives the processed image an unnatural look and creates visual artifacts. They introduce specifically designed penalty terms with which the level of contrast enhancement can be adjusted; noise robustness, white/black stretching and mean-brightness preservation may easily be incorporated into the optimization.

"Contrast Enhancement by Automatic and Parameter-Free Piecewise Linear Transformation for Color Images", Chun et al. [9] in 2008 proposes an automatic and parameter-free contrast enhancement algorithm for color images. This method includes following steps: First, RGB color space is transformed to HSV color space. Second, image content analysis is used to analyze the image illumination distribution. Third, the original image is enhanced by piecewise linear based enhancement method. Finally, the enhancement image is transformed back to RGB color space. This novel enhancement is automatic and parameter-free.

"Non-linear Algorithm for Contrast Enhancement for Image Using Wavelet Neural Network", Jianmao et al. [10] in 2006 proposed a kind of contrast enhancement algorithm for image by employing IBT and WNN. IBT was used to enhance the contrast of an image. Nonlinear transform parameters are searched by simulated annealing algorithm (SA) so as to obtain optimal gray transform parameters. In order to calculate IBT in the whole image, a kind of WNN was proposed to approximate the IBT. Experimental results show that the new algorithm was able to adaptively enhance the global contrast for the original image well.

"An Adaptive Image Enhancement Based on the Vector Closed Operations", Hu et al. [11] in 2007 presented an adaptive image enhancement algorithm which was based on the vector closed operations, on the basis of the characteristic that grey level values arising from noise are normally weakly correlated and those arising from features are strongly correlated, the proposed algorithm distinguishes the features from noise in each scale using correlation values, and then they were adaptively processed independently and thus adaptively enhance more features and suppress more noise.

"Sonar Image Enhancement Based on Particle Swarm Optimization", Tiedong et al. [12] in 2008 proposed an adaptive local enhancement algorithm in which the evaluation function is defined by edge numbers, edge intensity and the entropy. Due to the high complexity of the algorithm proposed, the particle swarm optimization algorithm is used to search the optimal parameters for the best enhancement.

"A Generalized and Automatic Image Contrast Enhancement Using Gray Level Grouping",Chen et al. [13] in 2006 describes a new automatic method for contrast enhancement. The basic procedure was to first group the histogram components of a low contrast image into the proper number of bins according to a selected criterion, then redistribute these bins uniformly over the gray scale, and finally ungroup the previously grouped gray levels. Accordingly, this new technique was named GLG. GLG not only produces results superior to conventional contrast enhancement techniques, but is also fully automatic in most circumstances, and is applicable to a broad variety of images.

"Gray-level grouping: an automatic method for optimized image contrast enhancement - part II: the variations" Chen et al. [14] in 2006 introduces an extension of the basic GLG algorithm, SGLG, which groups the histogram components in different segments of the gray scale using different criteria and, hence, is able to enhance different parts of the histogram to various extents. This paper also introduces two new pre-processing methods to eliminate background noise in noisy low-contrast images so that such images can be properly enhanced by the SGLG technique. The extension of SGLG to color images was also discussed. SGLG and its variations extend the capability of the basic GLG to a larger variety of low contrast images, and can fulfill special application requirements. SGLG and its variations not only produce results superior to conventional contrast enhancement techniques, but were also fully automatic under most circumstances, and are applicable to a broad variety of images. Adaptive Center-Weighted Median Filter (ACWM) [15]. It devises a novel adaptive operator, which forms estimates based on the differences between the current pixel and the outputs of center-weighted median (CWM) filters with varied center weights. It employs the switching scheme based on the impulse detection mechanisms. It utilizes the center-weighted median filter that have varied center weights to define a more general operator, which realizes the impulse detection by using the differences defined between the out-puts of CWM filters and the current pixel of concern. The ultimate output is switched between the median and the current pixel itself.

Multi-State Median Filter (MSM) [16]: It proposes a generalized framework of median based switching schemes, called multi-state median (MSM) filter. By using simple thresholding logic, the out-put of the MSM filter is adaptively switched among those of a group of center weighted median (CWM) filters that have different center weights. The MSM filter is equivalent to an adaptive CWM filter with a space varying center weight which is dependent on local signal statistics.

Tri-State Median Filter (TSM) [17]: It is proposed for preserving image details while effectively suppressing impulse noise. It incorporates the standard median(SM) filter and the center weighted median (CWM) filter into a noise detection framework to determine whether a pixel is corrupted, before applying filtering unconditionally. Noise detection is realized by an impulse detector, which takes the outputs from the SM and CWM filters and compares them with the origin or center pixel value in order to make a tri-state decision. The switching logic is controlled by a threshold. The threshold affects the performance of impulse detection. An attractive merit of the TSM filter is that it provides an adaptive decision to detect local noise simply based on the outputs of these filters.

Advanced Impulse Detection Based on Pixel-Wise MAD (PWMAD) [18]: It is a robust estimator of variance, MAD (median of the absolute deviations from the median), is modified and used to efficiently separate noisy pixels from the image details. The algorithm is free of varying parameters, requires no previous training or optimization, and successfully removes all type of impulse noise. The pixel-wise MAD concept is straightforward and low in complexity. The median of the absolute deviations from the median-MAD is used to estimate the presence of image details, thus providing their efficient separation from noisy image pixels. An iterative pixel-wise modification of MAD (PWMAD) provides reliable removal of arbitrarily distributed impulse noise.

Signal-Dependent Rank Order Mean (SDROM) Filter [19]: It is a new framework for removing impulse noise from images, in which the nature of the filtering operation is conditioned on a state variable defined as the output of a classifier that operates on the differences between the input pixel and the remaining rank-ordered pixels in a sliding window. First, a simple two-state approach is described in which the algorithm switches between the output of an identity filter and a rank-ordered mean (ROM) filter. The technique achieves an excellent tradeoff between noise suppression and detail preservation with lit-tle increase in computational complexity over the simple median filter. For a small additional cost in memory, this simple strategy is easily generalized into a multistate approach using weighted combinations of the identity and ROM filter in which the weighting coefficients can be optimized using image training data. Moreover, the method can effectively restore images corrupted with Gaussian noise and mixed Gaussian and impulse noise.

Directional Weighted Median Filter (DWM) [20]: Another method for removal of random-valued impulse noise is directional weighted median filter (DWM). This filter uses a new impulse detector, which is based on the differences between the current pixel and its neighbours aligned with four main directions. After impulse detection, it does not simply replace noisy pixels identified by outputs of median filter but continue to use the information of the four directions to weight the pixels in the window in order to preserve the details as removing noise. First it considers a 5X5 window. Now it considers the four directions: horizontal, vertical and two diagonal. Each direction there is 5 pixel points. It then calculates the weighted difference in each direction and takes the minimum of them. The minimum value is compared with a threshold value and if it is greater than the threshold value then it is a noisy pixel otherwise not. In filtering phase, it calculates the standard deviation in four directions. Because the standard deviation describes how tightly all the values are clustered around the mean in the set of pixels shows that the four pixels aligned with this direction are the closest to each other. Therefore, the center value should also be close to them. Now it calculates the weighted median, giving extra weight on that direction in which direction standard deviation is small and replaces the noisy pixel with this median value. It is an iterative method. This method repeats 8 to 10 times. It gives the good performance when noise level is high too.

IV. IMAGE DE-NOISING TECHNIQUES

Image de-noising also called enhancement techniques can be divided into subcategories as shown in fig.1:

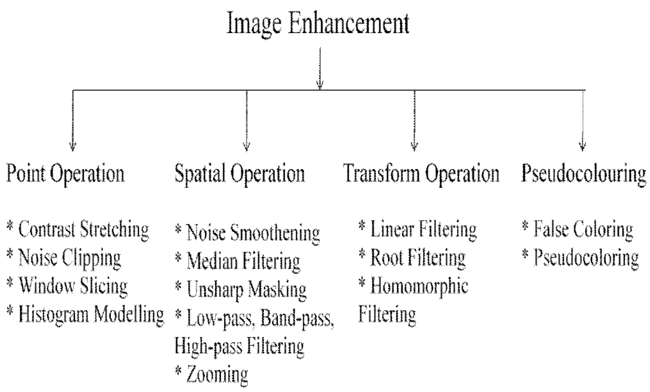

Fig. 1: Image De-noising Techniques

V. PROPOSED METHODOLOGY

We will use tools of MATLAB for simulation and de-noising of color images. The steps for work methodology are as follows.

- For image enhancement a parameter based transformation function is used.
- Initial fitness value is determined.
- PSO is applied to optimize the parameter values so as to get large fitness value i.e. to get enhanced version of input image.

VI. CONCLUSION

In this review paper, we carry out through review on various method proposed for de-noising of digital color image. During study all the research papers have given very wise and acceptable results. We also found that various algorithms proposed by researchers are unique and also filters used for de-noising are distinct. In our future work, we will further study the algorithm based on the Particle Swarm Optimization, for enhancement of gray level image. This algorithm can be applied for the de-nosing of digital color image.

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