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An Integrated Approach of Noise Reduction in Color Image Using Soft Computing

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Abstract

During image pre-processing, noise reduction is considered as one of the essential step hence considered as an active area of research in image processing. Various filtering techniques are available for removing the noise from the image with their own set of merits and demerits. But most of the previously developed algorithms are either limited to reduce only a specific type of noise or fails in preserving the fine structures of the images like edge, boundaries etc. because of which loss of information occurs within the images. So, this does not lead to an effective noise reduction mechanism. In this paper, an integrated approach is proposed that will make the system intelligent enough so that it will not only limited to reduce the noise effectively by preserving the fine structures but later on will also be able to classify the images by checking them for noise present in them.

Keywords: *Noise, Image, Salt-and-Pepper, Speckle, DWT, Neural Network, De-noising, Noise Reduction, Wavelet, Pixel*

1. INTRODUCTION

In order to sense the environment or to convey information perception of color is significant to humans and other creatures because they regularly use these color features in order to recognize an object in the environment. A color image plays a very significant role in our day to day life. For example they are used in television, computers and in various area of research and technology. But these color images usually gets corrupted due to occurrence of some unwanted signal also known as noise during their transmission, acquisition and retrieval from different sources like storage media etc. Usually some corrupted pixels mixes with the pixels of the original image and results in a degraded image. The quality of image is degraded after the introduction of noise and it becomes almost impossible to deliver the actual intensity. Unwanted signal sometimes also appears in the form of noise in an image and different type of noise affect the output of image in many ways. Some most common types of noises in images are Salt-and-pepper noise (Impulse noise), Amplifier Noise (For ex: Gaussian Noise), Shot noise, Quantization noise (For ex: uniform noise), Film grain noise, Non-isotropic noise, Periodic noise and Speckle noise (For ex: Multiplicative noise). During image capturing, sensors may become the source of noise in the image due to improper intensity of light coming. Such phenomenon can be easily observed in night when there is dark outside. In that case image captured by a digital camera often creates noise with some sort of dots or grains in it. Images can be affected by different types of noise depending upon the different circumstances under which they are captured. Whenever an image is sent electronically through medium or via any communication network it mingles with some unwanted signal (noise) and gets distorted due to some sort of interference between these signals. Sometimes, noise introduced in an image due to compression of an image. Due to noise in the image signal whole image becomes noisy and the result of which is the original intensity of the image signals get reduced. The resultant image is a degraded image which gives unpleasant view. Therefore noise reduction mechanism is taken into consideration to obtain clear and high quality image. Noise reduction is a mechanism to reduce these unwanted corrupted pixels in order to retain the smoothness of an image without any loss of information.

Noise reduction is considered as a necessary and important step in analysis of an image and computer vision applications. Its goal is to remove unprofitable information which may corrupt various image processing steps and finally the image itself. In the recent years, noise reduction has proved to be an active area of research in processing of an image. It is considered as one of the significant process in the pre-processing of an image. Various techniques of noise reduction has been implemented and discovered till date each having some sort of its merits, demerits and assumptions. The proposed intelligent system is capable of reducing various

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types of noise such as salt-and-pepper noise, speckle noise from the color images and later on will also be able to classify images by identifying noise in them.

2. VARIOUS SOURCES OF NOISE IN DIGITAL COLOR IMAGES

Noise is measured by the quantity of pixels which are corrupted. It can be introduced in various ways which depends on the circumstance of captured image. Some factors which are responsible for the introduction of noise in the digital images are as follows.

i. Dust particles present over the lens of capturing devices can introduce noise. For example if sometimes dust particles are left over the surface of scanner then it may be viewed as dots in the scanned image.
ii. Noise can be introduced due to the interference of the image signal with an unwanted signal when it is sent electronically via a satellite or communication network
iii. It may be arise during the image compression and decompression.
iv. Faulty equipment, sensors, imperfect impingement of light over sensor etc. can also introduce noise in image.
v. Bad weather, environmental conditions, insufficient light sources and temperature of sensors are other causes of noise in the image.

3. LITERATURE REVIEW

Image de-noising is one of the fundamental steps during Image processing. Various image de-noising algorithms are proposed till date, which are broadly categorized into two categories.

i. Spatial Domain Filtering
ii. Transform Domain Filtering

In spatial domain filtering, filtering is performed in spatial domain which makes use of linear and non-linear filters whereas in transform domain filtering, filtering is performed in transform domain. Various images de-noising algorithm which uses wavelet transform falls under transform domain filtering. For impulse noise reduction from a color image a fuzzy two step filter is proposed by Schulte [1]. In case of highly corrupted images, Ibrahim [2] provided a simple adaptive median filter in order to remove impulse noise from the image. M Rama Bai, Dr. V Venkata Krishna and J SreeDevi, [3] suggested that during image processing edge plays a very significant role and hence their detection is of great importance. Mitra Basu [4] presented a survey of edge detection techniques which were Gaussian based.

J. Harikiran et. al [5] proposed an image fusion technique for the removal of impulse image noise. In order to remove salt and pepper noise from an image an improved algorithm of median filter was proposed by Rong Zhu et al [6]. K. Ratna Babu et al. [7] developed another method of modified median filter in order to remove salt and pepper noise from an image. Within the framework of wavelet analysis, Y Murali Mohan babu et. al. [8] proposed a naval Bayesian based algorithm.

Another hybrid threshold approach using wavelet is proposed by Manish Goyal et al [9] for speckle noise reduction. T. Sreekanth Rao et. al [10] suggested a method based on wavelet transform for image de-noising of the non-logarithmic data. Tuan- Anh Nguyan et. al. [11] discovered another spatially adaptive de-noising technique for a single image being corrupted due to Gaussian noise. Rashi Agarwal et. al. [12] presented a bit plane average filtering technique for the removal of Gaussian noise.

Anutam and Rajni [13] demonstrated the performance analysis for de-noising of the images using various wavelet thresholding techniques at different level of decomposition. They compared various filters and wavelet based methods. The images used in the experiment were greyscale images. The types of noise taken into consideration were the Gaussian Noise and Speckle Noise. C Srisailam et. al. [14] proposed a new way of image de-noising in color images using the method of wavelet thresholding for the removal of Gaussian Noise. Here the color images of size 512x 512 pixels at different noise levels have been compared.

4. PROPOSED METHODOLOGY

The image consists of different type of noises which must be detected and removed in order to improve the quality of color image. There are various factors which affect the pixel of images and make them noisy. Different approaches are followed to reduce noise in the image and upgrade its quality. The proposed model is an integrated approach which reduces noise effectively by preserving any loss of information and later on will also be able to classify the images by detecting noise inside the images.

The proposed model uses two technologies which are as follows:

i. Discrete Wavelet Transform (DWT)
ii. Neural Network

Discrete Wavelet Transform (DWT) Implementation

Initially noise is reduced using DWT in color images. In this process, firstly the color image is decomposed into

three different channels Red, Green and Blue (R, G, B) using the 'sym4' wavelet and the transformation is performed down to level 2. The DWT used in this process is 2-Dimensional Discrete Wavelet Transform. After this each layer consists of large no. of coefficients with low SNR and small no. of coefficients with High SNR. The coefficients with low SNR values are referred as noisy coefficients. These noisy coefficients are removed by applying the appropriate threshold. The threshold that is used in this case is soft threshold. After this each layer (i.e. Red Green and Blue) will get de-noised and finally they are merged to obtain de-noised image as an output. Thus, DWT is performed on sufficient image samples of color image database so as to obtain data to train the neural network.

Neural Network Implementation

De-noised images are obtained with the help of noise reduction mechanism (DWT). Then each de-noised image is subtracted from its corresponding original image to obtain the footmarks between the original image and de-noised image. Now, feature matrix is formed by calculating various features such as Mean, Median, Mode, Variance, Co-Variance, Standard Deviation, Correlation-coefficients and Peak Signal to Noise Ratio (PSNR). This feature matrix is then normalized to obtain its cumulative sum. The dataset so generated will be given as input to train the neural network. Now, the intelligent system will be able to detect noise of various types in the color images.

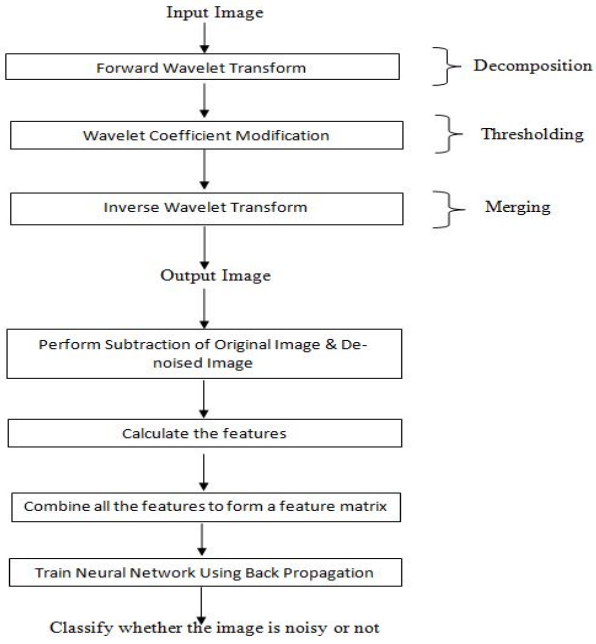

Fig 1: Block Diagram of the Proposed Methodology

An algorithm that is used to de-noise the image and make system intelligent can be defined in series of steps which are as follows

1. Read the image from the image database.
2. Select a noise type and add it to the image in order to make it noisy.
3. Separate the noisy image into three different channels or layers (R, G, B)
4. Perform De-noising of each individual channel or layers.
5. Finally merge each channel to form the RGB Image.
6. Perform the Subtraction of the Original Image and De-noised Image.
7. Calculate the following features:

i. Mean provides the average value of an array.
ii. Median is defined as the middle element which separates the higher half from the lower half of the data sample.
iii. Mode is defined as the most frequently appearing number in the data set.
iv. Variance is defined as the measurement of spread between the different data values in a set.
v. Co-variance tells that up to what extent the two random variables changes together.
vi. Standard Deviation is used to quantify the extent of dispersion or variation among the set of data.
vii. Correlation-Coefficient demonstrates some sort of dependence and correlation between two or more data values and random variables.
viii. Peak Signal to Noise Ratio (PSNR) is a standard measurement unit in signal processing which represents the ratio between the signal's maximum possible power and the corrupting noise power.

8. Combine all the features to form a feature matrix
9. Train the Neural Network by making use of Back Propagation

Once the Neural Network is trained the system will become intelligent and will be to classify the images by checking whether the image contains any noise or not. Here Back propagation is used as learning algorithm to train the neural network

5. RESULTS

The proposed approach has taken into consideration the color images of jpeg format. Sample of same size of color images are taken as the input data. De-noised images are obtained by applying DWT on various type of noisy images affected with Salt-and –Pepper Noise and Speckle Noise with different noise variance.

(a) (b) (c)

Fig 2: De-noising of a corrupted cameraman image affected from Salt-and-Pepper Noise of Noise Variance 0.01.

(a) Original Image (b) Noisy Image (c) De-Noised Image

(a) (b) (c)

Fig 3: De-noising of a corrupted cameraman image affected from Speckle Noise of Noise Variance 0.01.

(a) Original Image (b) Noisy Image (c) De-Noised Image

Table 1: PSNR value calculated in the proposed method

Peak Signal To Noise Ratio (PSNR)		
Noise	Noise Variation	Proposed PSNR
Salt-and-Pepper Noise	0.001	33.2827
	0.002	32.1030
	0.003	31.6261
	0.004	31.2115
	0.005	30.8958
	0.01	29.9336
Speckle Noise	0.001	34.8987
	0.002	34.3954
	0.003	33.9210
	0.004	33.5199
	0.005	33.1802
	0.01	31.9056

The confusion matrix after performing the training of neural network is shown below:

Fig 4: Confusion Matrix

The training confusion matrix is showing that among 100% of the image samples 44.3% of the image samples are trained properly.

Validation Confusion matrix is showing an overall result of 73% which demonstrates that validation is performing effectively for 73% of the image samples out of 100% image samples.

Test Confusion matrix is showing an overall result of 60% which means that 60% of the images are tested effectively. This also points to the effective working of the system.

The graph for ROC (Receiver Operating Characteristic) for the Neural Network Training is shown below:

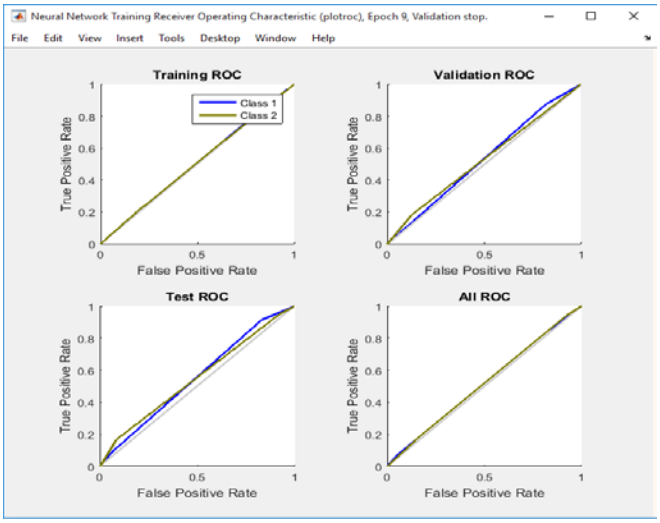

Fig 5: Plot of ROC (Receiver Operating Characteristic) for Neural Network Training

The plot of ROC i.e. (Receiver Operating Characteristic) for the Neural Network Training is showing a line at an angle of 45 degree for each training, testing and validation from the x axis. The plotted graph showing the different classes of image noise which are closely aligned with this line which shows that the system is working effectively for different classes of noise. The system is working effectively for training, testing and validating the different samples of the images taken.

The graph for the Neural Network Training Performance is shown below:

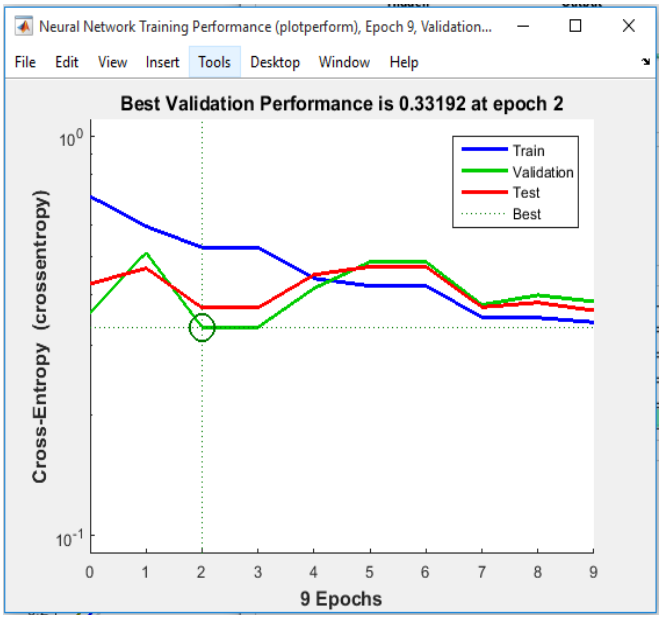

Fig 6: Neural Network Training Performance Graph

The Neural Network Training Performance Graph is showing a dotted line for the best performance and from the plotted graph it can be seen that the line for training, testing and validation are also aligned closely to the line representing best performance which shows the overall effective working of the system.

6. CONCLUSION AND FUTURE SCOPE

The proposed work has demonstrated an integrated approach of noise reduction from the color images by making use of the soft computing. This methodology is different from all previously existing approaches as here the system is made intelligent as it not only performs de-noising of images but later on also classify the images by identifying noise present in them. The system is made intelligent by the use of the soft computing component called Neural Network which detect noise present in the image and makes the system capable of predicting whether an image contains any noise or not.

As, a result of the experiment the values of the calculated features are demonstrating that the images are effectively de-noised. Unlike previous approaches which were capable to work over a particular type of image noise, this approach is capable to work over a number of image noise e.g. Speckle Noise, Salt-and-pepper noise etc. Thus the overall results observed are found to be quite satisfactory.

Limitation

Although the system became intelligent still it has some limitations. The proposed approach works only on the images of same size and also the system only accepts the images in particular format. The proposed approach works only on the images of jpeg format with .jpg extension.

Future Work

In future, the performance of the system can be improved by making use of different image database and different algorithms so that the overall result can be made more precise. Moreover, the whole system can be made to work online. In order to extend the functionality of the system, one can design the system in such a way so that the system can accept the images of different size and different formats.

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