A Novel Technique for Image Enhancement and Denoising with Wavelets

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Abstract- *Images are used in a variety of fields for image analysis and image understanding. Digital images are usually degraded by various types of noise due to sensor problems, weather problems and so on. In this paper, we represent a new technique for removing noise from images. Image enhancement is based on the multi scale singularity detection with an adaptive threshold whose value is calculated with different ways. Wavelet transforms are used because of their inherent property that they are redundant and shift invariant. In different scales of an image intensity changes occurs, so there is need of optimal detection that requires the use of operators of different sizes. Therefore, a vision filter must be a differential operator, and it must be capable of being tuned to act at any desired scale and the wavelets are ideal for this. Principle objective of Image enhancement and denoising is to process an image so that result is more suitable than the original image for specific application. This paper will provide an overview of underlying concepts commonly used for image enhancement.*

Keywords- *Spatial domain, Frequency Domain, Discrete Wavelet transforms (DWT), Daubechies Wavelets, Neuro-Fuzzy Logic, Peak Signal to Noise Ratio(PSNR) and Mean Square Error(MSE).*

I. INTRODUCTION

Image enhancement is a process that reduces noise, removing artifacts and preserve details in an image. Its purpose is to amplify certain image features for analysis, diagnosis and display. This technique can be performed by either suppressing the noise or the image contrast. Image enhancement is the improvement of digital image quality (wanted e.g. for visual inspection or for machine analysis), without knowledge about the source of degradation. If the source of degradation is known, one calls this process image restoration. Both of these processes are iconical processes i.e. input and output is images. We use wavelet transforms because of their inherent property that they are redundant and shift invariant These transforms are used to decompose the given low resolution image into frequency components i.e., sub bands. The enhancement methods can broadly be divided into the following two categories [3][4]:

- Spatial Domain Methods
- Frequency Domain Methods

In spatial domain techniques [5], we directly deal with the image pixels. In this method pixel values are manipulated to get desired enhancement results. In frequency domain methods, the image is first converted into the frequency domain. In this process, the Fourier Transform of the image is computed first. All of the required enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get back the resultant image. All required enhancement operations are performed so that modification is done in the contrast of an image, in brightness of an image etc. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied to the input values. Image enhancement simply means, transforming an image f in to an image g using T. (Where T is the transformation. The pixel values in images f and g are denoted by r and s, respectively. The pixel values r and s are related by the expression,

$$s = T(r)$$

Where T is a transformation which maps a pixel value r into a pixel value s. The results of above transformation are mapped into the grey scale range as we are dealing here only with grey scale digital images. Therefore, the results must be mapped back into the range [0, L-1], where $L=2^k$, k being the number of bits in the image being considered. Therefore, for an 8-bit image the range of pixel values will be [0, 255].

II. DAUBECHIES WAVELETS

The DWT is an application of the wavelet transform using a discrete set of the wavelets that scales for different numerical reasoning and functional study. In DWT, filters of different cut off frequencies are provided to annals the signal at different levels. The DWT divides signals into sub bands with smaller bandwidths and slower sample rates, namely low-low, low-high, high-low and high-high. We get four different sub bands from one level of transforms first low pass sub band having filthy approximation of source image and three high pass sub bands that exploit image details across different directions HL for horizontal, LH for vertical and HH for diagonal details. Two-dimensional discrete wavelet transform (2-D DWT) decomposes an input image into four sub bands, one average component (LL) and three detail components (LH, HL, HH) as shown in Figure:

LL	LH
HL	HH

Fig. 1. Subbandsof 2D DWT

In image processing, the multi resolution of 2-D DWT has been employed to perceive the edges of an original image. The conventional edge detection filters can offer the comparable outcome as well. Though, 2-D DWT can distinguish three kinds of edges at an instance while conventional edge detection filters cannot. Hence, dealing out the times of the conventional edge detection filters is slower than 2-D DWT. Daubechies DWT has the following Features:

- Daubechies are the most common and known orthogonal wavelet family.
- The Daubechies Wavelet Transforms are defined in the same way as Haar Wavelet Transforms but the only difference between them consists in the scaling signals. Daubechies wavelet has a high frequency coefficient spectrum than the Haar wavelet. Therefore audio –denoising and compression is done more pleased with them.

III. THRESHOLDING

Image thresholding is a simple, another effective tool of partitioning an image into a foreground and background. It is a type of image analysis technique which is further part of the segmentation that isolates objects by converting gray scale images to binary images. Image thresholding is most effective in those images where high levels of contrast are present.

Common image thresholding algorithms include histogram and multi-level thresholding.

IV. NEURO-FUZZY LOGIC

Neuro-fuzzy refers to the blend of artificial neural networks and fuzzy logic. A neuro-fuzzy system is a sort of fuzzy system that uses a learning algorithm derived from or stimulated by neural network theory to agree on its parameters (fuzzy sets and fuzzy rules) by dispensing data samples. Modern neuro-fuzzy are usually represented as a special multilayer feed forward neural network. We generally use the term neuro-fuzzy for approaches that the following explains:

- A neuro-fuzzy is based on a fuzzy system which is trained by a learning algorithm derived from neural network theory. The procedure of learning operates on local information, and allows only local modifications in the fuzzy system.
- A neuro-fuzzy system can be recognized as a three layer feed forward multi layer neural network. The first layer performs input variables, the middle (hidden) layer performs the fuzzy rules, and the third layer represents the output variables.

- A neuro-fuzzy system can always be represented as a system of fuzzy rules (i.e. before, during, after learning).

Since the time when neuro-fuzzy systems became popular in industrial applications, the society perceived that the development of a fuzzy system with good performance is not an easy task. The problem of finding membership functions and appropriate rules is frequently a tiring process of attempt and error. This led to the idea of applying learning algorithms to the fuzzy systems. The neural networks with effective learning algorithms have been represented as an alternative to automate or to support the development of a tuning fuzzy system. Gradually, its applications spread into all areas of knowledge, like, data classification, data analysis, imperfections detection and support to decision-making. Neural networks and fuzzy systems can be combined to join its advantages and cure its individual illness.

A. *Combining Fuzzy system with Neural Networks*

Both neural network and fuzzy systems have something in common. They can be used for solving a problem, even if there does not exist any mathematical model for the problem. They solely do have some advantages and disadvantages which almost disappear by combining both conceits. Neural networks can only come into existence if the problem is expressed by a sufficient amount of observed examples. These observations are worn to thrown-in the black box. Also, no prior knowledge about the problem needs to be given. On the other hand, a Fuzzy System demands linguistic rules instead of learning examples as prior knowledge. If the knowledge is incomplete, wrong or contradictory, then the fuzzy system must be tuned.

V. PERFORMANCE EVALUATION

A. *PSNR*

The ratio between the reference signal and the distortion signal of an image is called as the peak signal to noise ratio, given in decibels. In general, a higher PSNR value should correlate to a higher quality image. So PSNR is defined as:

$$PSNR= 10 \log_{10} L^2/MSE$$

Here L reflects the maximum possible pixel value of the image [1] .If the K channel is encoded with a depth of 8-bit, then L = 2^8 - 1 = 255. PSNR is usually expressed in terms of the decibel scale .If a signal to noise ratio is high, then the mean square error will be minimized.

B. *MSE*

The average squared difference between the reference signal and distorted signal is called as the Mean squared error. It can be easily calculated by adding up the squared difference of pixel by pixel and dividing by the total pixel count. Let mxn is a noise free monochrome image I, and K is defined as the noisy approximation [1] .Then the mean square error between these two signals is defined as:

$$MSE=1/mxn \sum^{m-1}_{i=0}\sum^{n-1}_{j=0}[I(i,j)-K(I,j)]^2$$

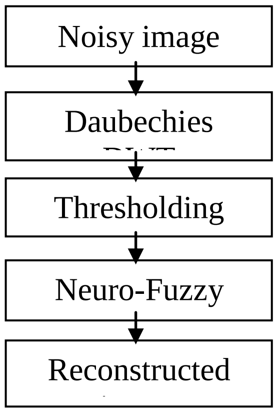

Fig. 2. Module Diagram

VI. RELATED WORK

A lot of research work has been done by different researchers and scholars in the image enhancement field. There are varieties of techniques for image enhancement.

There is a concept of combining adaptive filters with neural networks so that it may be

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able to collect high level information about the image contents. These types of filters have no need of specific knowledge and can be applied to broad categories of images [6].

A new method for fingerprint matching is based on the features extracted by using a new multiresolution analysis tool called digital curvelet transform is proposed. This method is applied on a small set of database. It also compares different wavelets results with curvelet transforms that are applied on given set of database. It also suggests for modifying given method to work for larger databases and to attain even lower computational complexity [7].

For overcoming the problem of failing of histogram equalization on discrete images, a local-mean based method is proposed. Experimental results prove that enhancement performance is approved and speed of obtaining enhancement results is also improved [8].

Another hybrid filter for denoising and enhancing digital images is presented in this paper [9]. This method works where image is degraded with salt and pepper noise. This hybrid filter is a combination of nonlinear switching median filter and neuro-fuzzy network. This filter is not only quite effective in removing impulse noise, but also preserves image features. This filter is suitable for real time implementation.

Patil Pradeep M. et. al studies different image resolution enhancement techniques by using wavelet transforms. Basic functions of wavelet transforms are obtained using the scaling and translation of a the scaling function. Wavelet transforms are located in both time and frequency domain. Different enhancement techniques are compared such as Wavelet Zero Padding (WZP), Cycle Spanning (CS), Dual-Tree Complex Wavelet Transform (DT-CWT), Discrete Wavelet Transform (DWT), Stationary Wavelet Transform (SWT). Combination of DWT-SWT gives better results as compared to other methods [10].

Yashu Rajput et. al. presents a method for medical image enhancement, which is based on non-linear technique. This technique is a combination of histogram equalization and the discrete wavelet transforms. Experiment results prove that DWT removes noise from given images, enhances image contrast and preserves the original image quality [11].

VII. CONCLUSION

Image enhancement is applied in every field where images are ought to be understood and analyzed. It offers a wide variety of approaches for modifying images to achieve visually acceptable images. The choice of techniques is a function of the specific task, image content, observer characteristics, and viewing conditions. Wavelet transform is capable of providing the time and frequency information simultaneously. The frequency and time information of a signal .But sometimes we cannot know what spectral component exists at any given time instant. The best we can do is to investigate that what spectral components exist at any given interval of time. DWT is a linear transformation that operates on a data vector whose length is an integer power of two, transforming it into a numerically different vector of the same length.

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