International Journal of Electronics Communication and Computer Engineering
Volume 5, Issue (4) July, Technovision-2014, ISSN 2249–071X

Technovision-2014: 1st International Conference at SITS, Narhe, Pune on April 5-6, 2014

# Medical Image Enhancement Techniques by Bottom Hat and Median Filtering

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***Abstract* – This paper presents an efficient method for medical 2-D image enhancement technique using median and bottom hat filtering, that can also be used in image processing such as medical image reconstruction, image smoothing, feature extraction and image analysis. We present a comparison of these filters using the medical images. After filtering also the input image or actual image have some noise that may cause the of quality of the digital image. So, wavelet transform is used to remove noises from the image collected. Simulation results specify the better results.**

***Keywords* – Medical Image Analysis, Wavelet Transform, Median Filtering, Bottom-Hat Filtering, Image Enhancement.**

## I. Introduction

Image enhancement and denoising is essential in digital images in order to specify or identify the features in it. Mostly in medical applications this is widely used to examine the various defects. An image is often corrupted by noise in its acquisition and transmission. Image denoising is used to remove the additive noise while retaining as much as possible the important signal features. Visualization of medical image (such as X-ray, Computer Tomography (CT), Magnetic Resonance Image (MRI) and Position Emission Tomography (PET)), has become one of the hotspots of image processing However, medical images are usually characterized by faded features utilizing a narrow distribution of gray-levels. Because of this reason, medical image often suffers from high spatial redundancy and low contrast that can be further degraded by the noise introduced in the process of imaging. Existing algorithms in medical image analysis, in general, use partial differential equations, curvature driven flows and different mathematical models. Wavelet based methods have also been proposed for medical image analysis. In 1991, Weaver et al. [1] first proposed the use of wavelet theory in medical imaging with the application to noise reduction in MRI images. Thereafter, several algorithms have been proposed for denoising, segmentation, reconstruction, functional MRI, registration, and feature extraction using continuous wavelet transform (CWT), discrete wavelet transform (DWT), and redundant DWT (RDWT). Detailed survey of wavelet based algorithms for medical imaging can be found in [2] [3], [4], and [5]. Wavelets can only capture limited directional information due to its poor orientation selectivity. By decomposing the image into a series of high-pass and low-pass filter bands, the wavelet transform extracts directional details that capture horizontal, vertical, and diagonal activity. However, these three linear directions are limiting and might not capture enough directional information in noisy images, such as medical Magnetic Resonance Images, which do not have strong horizontal, vertical, or diagonal directional elements.

Wavelets provide a very sparse and efficient representation for piecewise smooth signals, but it cannot efficiently represent discontinuities along edges or curves in images or objects. In this, we developed a efficient method to extract the various details of an digital image mostly, medical images in order to detect the various problems.

## II. Wavelet Transform

Wavelet transforms and other multi-scale analysis functions have been used for compact signal and image representations in de-noising, compression and feature detection processing problems for about twenty years. Numerous research works have proven that space frequency and space-scale expansions with this family of analysis functions provided a very efficient framework for signal or image data.

Basis selection, spatial-frequency tiling, and various wavelet threshold strategies can be optimized for best adaptation to a processing application, data characteristics and feature of interest. Fast implementation of wavelet transforms using a filter-bank framework enable real time processing capability.

Instead of trying to replace standard image processing techniques, wavelet transforms offer an efficient representation. Multi-scale analysis has been found particularly successful for image de-noising and enhancement problems given that a suitable separation of signal and noise can be achieved in the transform domain (*i.e.* after projection of an observation signal) based on their distinct localization and distribution in the spatial-frequency domain. With better correlation of significant features, wavelets were also proven to be very useful for detection {jin_Mallat_1992a} and matching applications {jin_Strickland_1995}.

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One of the most important features of wavelet transforms is their multi-resolution representation. Physiological analogies have suggested that wavelet transforms are similar to low level visual perception.

*A. Two-dimensional Fast Wavelet Transform*

The two-dimensional wavelet transform also has its fast algorithm which is similar to the one-dimensional one. DWT can be implemented by using digital filters and down samplers. With separable two-dimensional scaling and wavelet functions, we simply take the one-dimensional FWT of the rows of f( x, y) followed by the one-dimensional FWT of the resulting columns.

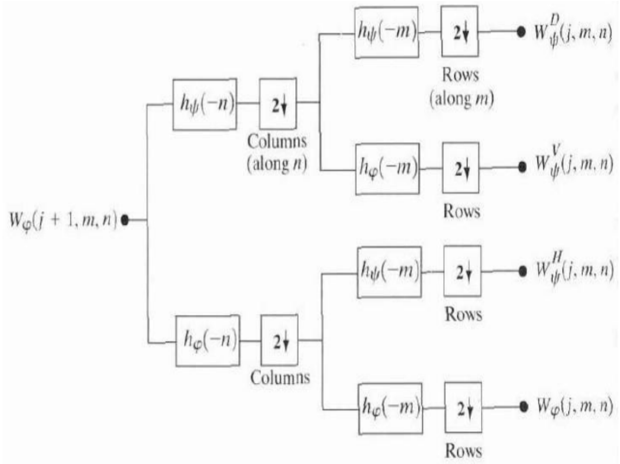



Fig.1. The two-dimensional FWT

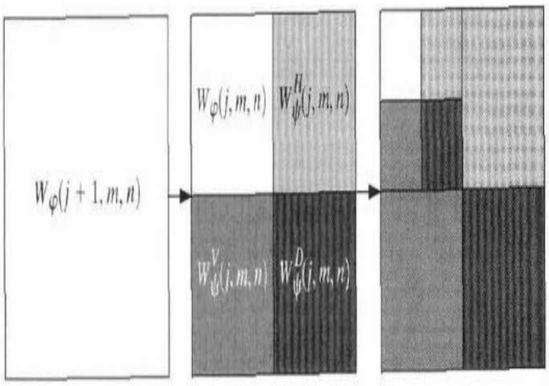



Fig.2. The resulting decomposition

The original image (matrix) can be decomposed into four sub images, we can again divide the j+1 scale approximation coefficients into four parts in smaller size. In other words, the j+1 approximation coefficients are constructed by the scale j approximation and detail coefficients. The two-dimensional IDWT reverse the processes described above. The reconstruction algorithm is similar to the one-dimensional one. At each iteration, four scale j approximation and detail coefficients are up sampled and convolved with two one-dimensional filters, one is for the sub images‘ rows and the other is for its columns. Adding the results then we can obtain the j+1 approximation coefficients. By repeating the process, we can ultimately reconstruct the original image (matrix).

$$W_\varphi^i(j,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\varphi_{j,m,n}^i\ (x,y) \qquad \textbf{(1)}$$

$$W_\varphi^i(j,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\varphi_{j,m,n}^i\ (x,y) \qquad \textbf{(2)}$$

$$i=\{H,V,D\} \qquad \textbf{(3)}$$

*B. Wavelet Shrinkage*

Wavelet shrinkage is a efficient approach for noise reduction, where the wavelet coefficients are nonlinear and reduces low amplitude values and retains high amplitude values. This paper used wavelet threshold shrinkage algorithm [6] to determine the coefficients of wavelet transform. The Calculation method of the threshold δ is:

$$\delta = k\sigma\sqrt{2\log(N)}\ ,\quad \sigma = Median(|W_{ij}|)/0.6745$$

## III. Enhancement by Median Filtering

Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. It is particularly effective at removing ‗salt and pepper‘ type noise. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels. The pattern of neighbours is called the "window", which slides, pixel by pixel over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value.

Like low pass filtering, median filtering smoothes the image and is thus useful in reducing noise. Unlike low pass filtering median filtering can preserve discontinuities in a step function and can smooth a few pixels whose values differ significantly from their surroundings without affecting the other pixels. An important parameter in using a median filter is the size of the window the median filter considers each pixel in the image in turn and looks at its nearby neighbours to decide whether or not it is representative of its surroundings.

Instead of simply replacing the pixel value with the *mean* of neigh boring pixel values, it replaces it with the *median* of those values. The median is calculated by first sorting all the pixel values from the surrounding neighbourhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighbourhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.) By calculating the median value of a neighborhood rather than the mean filter, the median filter has two main advantages over the mean filter:

- The median is a more robust average than the mean and so a single very unrepresentative pixel in a neighborhood will not affect the median value significantly.
- Since the median value must actually be the value of one of the pixels in the neighborhood, the median filter does not create new unrealistic pixel values when the filter straddles an edge. For this reason the median filter is much better at preserving sharp edges than the mean filter.

Given a set of random variables X={X1,X2,……,XN}; The median value is given by:

$$\text{Median}(X) = X_{(k+1)} = X_{(m)} \quad ;N=2k+1$$

$$\tfrac{1}{2}\{X_{(k)}+X_{(k+1)}\} \quad ;N=2k \qquad (4)$$

## IV. Enhancement by Bottom – Hat Filtering

A bottom-hat filter enhances black spots in a white background. It subtracts the morphological *Close* of the image from the image. The close performs a dilation followed by erosion. The effect is to fill holes and join nearby objects. In mathematical morphology and digital image processing, bottom hat transform is an operation that helps to highlight the dark spots in given images. Extract small, dark regions from a image The bottom-hat transform effectively inverts high-frequency regions. Bottom-hat transforms are used for various image processing tasks, such as feature extraction, background equalization, image enhancement, and others.

### *A. Image Denoising*

In this, we are adding Gaussian noise to the image and then the denoising is performed by top hat filtering. Digital images are prone to a variety of types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created. Gaussian noise is statistical noise that has its probability density function equal to that of the normal distribution, which is also known as the Gaussian distribution. A special case is white Gaussian noise, in which the values at any pair of times are identically distributed and statistically independent.

Wavelet Transform can automatically change the width of the window based on the gray level of the signal frequency: for high signal frequency, narrow the time window and widen the frequency window, and can give the details otherwise it can describe overall behavior. Median filtering can reduce dimness caused by image smoothing [2].Since median filtering cannot extract any details using top hat filtering identification of features can also be done. Smoothing can reduce high frequency noise in an image while creating an image where a pixel and its neighbors are correlated with each other

### *B. Extraction and Detection of features in Image*

Bottom Hat filtering performs morphological, operation on the grayscale or binary input image. Bottom-hat filtering computes the morphological closing of the image and then subtracts the result from the original image uses the structuring element SE.SE must be a single structuring element object, not an array containing multiple structuring element objects. Use a disk-shaped structuring element to extract washers that are smaller than the specified size.

The Morphological Bottom Hat object performs Bottomhat filtering on an intensity or binary image. Bottom-hat filtering is the equivalent of subtracting the result of performing a morphological closing operation on the input image from the input image itself. This top–hat filtering object uses flat structuring elements only.

The bottom-hat is defined by equation:

$$Ith = Ig - (Ig \,.\, B) \qquad (5)$$

Where, Ig is the smoothed version of the input image, B the structuring element, the morphological closing operation. By using Bottom-hat transform, it is possible to obtain details of the image as the edge, surface and size. This process allows extracting the dark features. In this case, the background image is enhanced for better identification of the image. The detailed steps are in Fig.3:

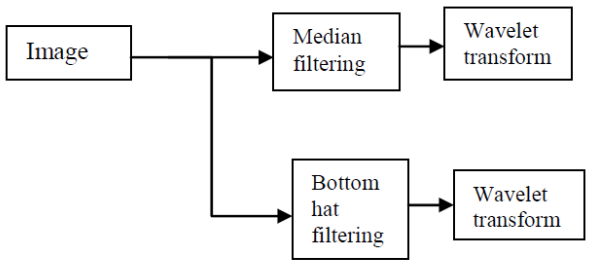



Fig.3. The algorithm of image comparison

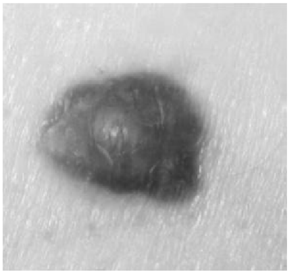
### *C. Medical Image Detection*

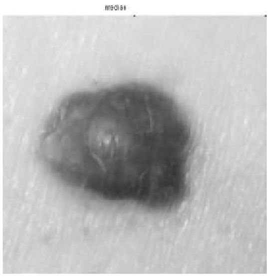
In Medical images, the tumour detection, cancer detection can also be done using this method. The bottom-hat transformation which owes its original name to the use of a cylindrical or parallelepiped structuring element function with a flat bottom SG is useful for enhancing detail in the presence of shading. The effect of erosion and dilation operations is better for image edge by performing the difference between processed image and original image, but they are worse for noise filtering. As opposed to erosion and dilation, opening and closing operations are better for filtering. But because they utilize the complementarily of erosion and dilation, the result of processed image is only correlative with the of image. The convexity and the concavity of the image edge concavity of the image edge. Accordingly, what we get is only the convex and concave features of the image by performing the difference between processed image and original image, but not all the features of image edge.

Medical imaging enables a range of less-invasive, highly targeted cancer therapies that translate into better and more comfortable care for patients. Because they are less invasive, these treatments mean fewer complications, shorter hospital stays, and, in many cases, no incisions or surgery. Thus, the patient benefits in two ways—better care and more comfortable, convenient care. In this paper a noval method for detection of cancer and tumours are present.

## V. EXPERIMENTAL RESULTS

The proposed methods provides better image enhancement than other techniques, for performance evaluation compared with median filter, bottom hat extracts more information from the images. This section contains the evaluation results, in which the image is filtered using median and bottom-hat filtering and then transformed using wavelet transform for image enhancement. These methods can be useful for medical image reconstructions and can be used for various tumour detections. Even though certain disadvantages existed such that Applied to binary image, the filter allows getting all object parts, which were added by closing filter, but were not removed after that due to formed connections/fillings. The result shown in Fig: 4 and 5


(a)


(b)

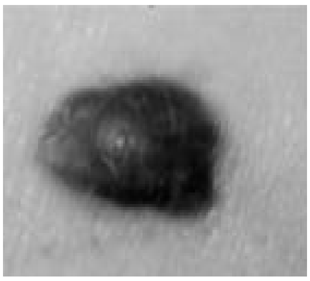
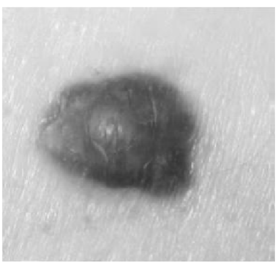
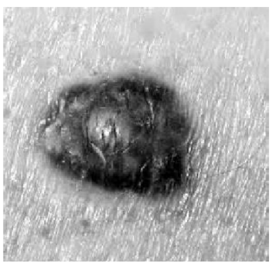


Fig.4. a) black blue tumour (original image) (b) The image processed by Median (c) the image processed by Wavelet


(a)


(b)


(c)

Fig.5. a) black blue tumour image (original image) (b) The image processed by Bottom hat (c) the image processed by Wavelet

## VI. CONCLUSION

The paper studies the extraction of various features of a digital image and provides a viable method for applicable in medical images .This paper a novel approach of wavelet transformation and denoising and detection of features by Bottom hat filtering. After Top Hat filtering image is smoothed Comparisons can be made with different type of images, a new proposal to detect the image objects and background was propounded, that is based on the use of morphological connected transformations. Medical image diagnosis of cancers and tumor detection is presented. Also, morphological contrast enhancement transformations were introduced. It is further suggested that the proposed threshold may be extended to the compression framework, which may further improve the enhancement performance.

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