A Comparative Analysis of MRI and CT Brain Images for Stroke Diagnosis

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***Abstract*—The advances in medical imaging have led to new multi dimensional imaging modalities that have become important clinical tools in diagnostic radiology. The two modalities capable of producing multidimensional images for radiological applications are Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). Normally the first radiologic examination in suspicion of stroke is brain CT imaging. But MRI provides high resolution images with excellent soft tissue characterization capabilities. A comparative analysis for the diagnosis of stroke on CT and MRI images is presented in this paper. The algorithm proposes the use of Digital Image processing tools for the identification of infarct and Hemorrhage in human brain. Preprocessing of medical images is done by median filtering. Segmentation is done by Gabor filtering and seeded region growing algorithm. The method is demonstrated on the CT and MRI brain images having different types of infarcts. The results of the method are evaluated visually. The proposed method is promising for detection of stroke and also establishes that MRI imaging is superior to CT imaging in stroke detection.**

Keywords -CT image, MRI, Infarct, Gabor filter, seeded region growing, median filtering.

I. INTRODUCTION

Stroke is a cerebrovascular accident affecting the blood supply to the brain. Without proper treatment, it leads to death or long term disability. As many as 35 % of the people who experience stroke become permanently disabled, losing their speech, sight, mobility and the ability to perform the simplest life tasks.Stroke can be subdivided into two types : ischemic and hemorrhagic. About 85 % of all strokes are of ischemic type. It occurs as a result of an occlusion of arteries due to thrombus [1]. Hemorrhagic stroke occurs when a weakened blood vessel ruptures. There is a possibility for co-occurance of both ischemic and hemorrhagic strokes.

The clinical diagnosis of an ischemia stroke is difficult and it has to be supported by brain imaging. There are many brain imaging modalities used in stroke diagnosis. The commonly used ones are Computed tomography (CT) and Magnetic Resonance imaging (MRI).CT remains the most important and most popular brain imaging tool because of its wider availability, lower cost and sensitiveness to early stroke. In CT images, a hemorrhage appears as a bright region well contrasted against its surrounds and ischemic stroke appears as a dark region with the contrast, relative to its surrounds. Blood is readily visible in CT image as a distinct hyperdense lesion which makes detection of hemorrhagic stroke more convenient than ischemic stroke. But the primary sign of ischemic stroke, a hypodense lesion is not perceivable in first few hours after stroke onset. So the detection of ischemic stroke is not an easy job. But the advances in MRI technology have improved the potential for visualization of small lesions in brain images. This has resulted in the opportunity to detect cerebral microbleeds and small hemorrhages in the brain associated with the risk of ischemic stroke and intracerebral bleeding.

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To improve the visual perception of stroke detection, an algorithm is proposed in this paper. Medical images are pre-processed using image enhancement techniques to remove strong speckle noise. Median filtering is used in this work. Gabor filtering is employed for the diagnosis of human brain infarct. A comparison is done using seeded region growing method to recognize the stroke area. The algorithm is implemented on both CT and MRI images of hemorrhagic and ischemic stroke.

II. RELATED WORK

A large number of techniques for analyzing image texture have been proposed in the past two decades. Most existing work on stroke detection mainly focuses on hemorrhagic stroke detection [2]. More recently, Wavelet based texture analysis has been developed to identify the stroke affected regions [3]. Computer aided detection of early strokes and its evaluation has been reported in literature [4][5]. Methods for segmenting and enhancing infarcts from given CT slices have also been reported in literature [6]. Texture features and rule based approach are used to identify and segment infarcts .Solutions for curvelet based enhancement of early stage infarct has been proposed. A semi automated detection system for the detection cerebral micro bleeds in brain MRI has also been reported [8].

III. PRE PROCESSING

The contrast of medical images is very low and as well as have strong speckle noise. Speckle is a complex phenomenon which degrades image quality with a backscattered wave appearance which originates from many microscopic diffused reflections that is passing through internal organs and makes it more difficult for the observer to discriminate fine detail of the

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images in diagnostic examinations. Thus de-noising these speckle noise from a noisy image has become the most important step in medical image processing [6]. Median filter removes the noise present in the image while preserving the edge information. Median filtering is nonlinear and is very effective in reducing noise and preserving edges. Output pixel contains the median value of neighborhood around the corresponding pixel of the input image.

IV. GABOR FILTERS

Spatial frequencies and their orientations are important characteristics of textures in images. Gabor filtering method is exploited to extract the edge and contours of the image anatomical structure changes in object location, scale and orientation can be detected in the Gabor feature space. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. Fourier analysis has proven to be one of the most powerful tools in signal processing. However, a key problem with Fourier analysis is that spectral features from different parts of the image are mixed together. Many image analysis applications require spatially localized features. Gabor f lters are a popular tool for this task for extracting spatially localized spectral features [7]. A Gabor function in the spatial domain is a sinusoidal modulated Gaussian. The complex Gabor function in space domain is given by (1)

$$g(x, y) = S(x, y)\ w_r(x, y) \quad (1)$$

where s(x, y) is a complex sinusoid, known as the carrier, and $w_r(x, y)$ is a 2-D Gaussian-shaped function, known as the envelope.

The complex sinusoid is def ned as follows,

$$S(x, y) = \exp(j(2\pi(u_0 x + v_0 y) + P)) \quad (2)$$

where (u_0, v_0) and P def ne the spatial frequency and the phase of the sinusoid respectively.

The envelope is a Gaussian function:

$$w_r(x,y) = K\ exp(-\pi(a^2(x-x_0)_r^2 + b^2(y-y_0)_r^2)) \quad (3)$$

where (x_0, y_0) is the peak of the function, a and b are scaling parameters of the Gaussian, and the r subscript stands for a rotation operation such that

$$(x - x_0)_r = (x - x_0)\cos\theta + (y - y_0)\sin\theta$$

$$(y - y_0)_r = (x - x_0)\sin\theta + (y - y_0)\cos\theta$$

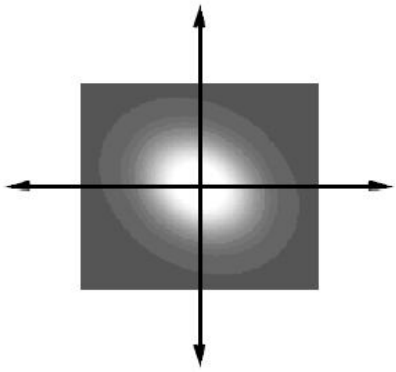

Fig. 1 A Gaussian envelope

The complex Gabor function is defined by the following parameters;

K : Scales the magnitude of the Gaussian envelope.
(a, b) : Scale the two axis of the Gaussian envelope.
θ : Rotation angle of the Gaussian envelope.
(x_0, y_0) : Location of the peak of the Gaussian envelope.
(u_0, v_0) : Spatial frequencies of the sinusoid carrier in Cartesian coordinates.
It can also be expressed in polar coordinates as (F_0,ω_0).
P : Phase of the sinusoid carrier.

Each complex Gabor consists of two functions in quadrature (out of phase by 90 degrees), conveniently located in the real and imaginary parts of a complex function.

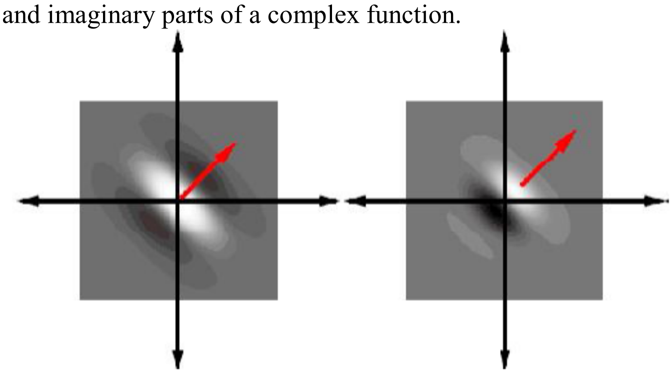

Fig. 2 Real and Imaginary parts of a complex Gabor function in space domain

The complex Gabor function in space domain is

$$g(x,y) = K\ exp(-\pi(a^2(x-x_0)_r^2 + b^2(y-y_0)_r^2))$$
$$exp(j(2\pi(u_0x - v_0y) + P)) \quad (4)$$

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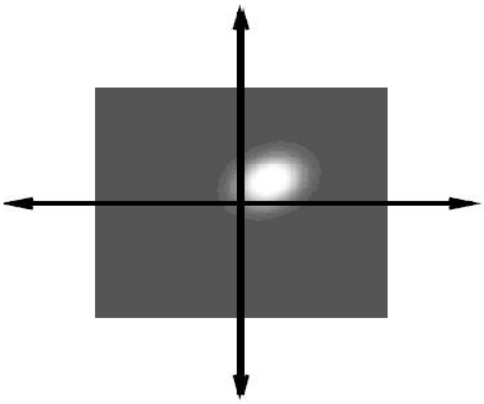


Fig. 3 Fourier transform of Gabor filter

The 2-D Fourier transform of this Gabor is as follows;

$$g(u,v) = \frac{K}{ab}\exp\left(j\left(-2\pi\left(x_0(u-u_0) + y_0(v-v_0)\right) + P\right)\right)$$

$$\exp\left(-\pi\left(\frac{(u-u_0)_r^2}{a^2} + \frac{(v-v_0)_r^2}{b^2}\right)\right) \quad (5)$$

Images are often characterized by a band of frequency rather than a single frequency and it is difficult to characterize a given image with a single filter. A set of filters are required. The filter bank should cover the spatial frequency domain such that there is a minimum overlap between filters to avoid aliasing. The frequency and orientation can be set to constant values that match psycho visual data.

V. SEEDED REGION GROWING ALGORITHM

Image subdivides an image into its constituent regions or objects. It can identify the regions of interest in a scene or annotate the data. Region-based segmentation includes the seeded and unseeded region growing algorithms and the fast scanning algorithm. Region growing is a procedure that groups pixels or subregions into larger regions based on predefined criteria for growth. The basic approach is to start with a set of 'seed' points. grow regions by appending to each seed those neighbouring pixels that have predefined properties similar to the seed. The algorithm is as follows.

Step1. We start with a number of seed points which have been clustered into n clusters, called C1, C2, … Cn. And the positions of initial seed points is set as p1, p2, …, p3.

Step2. To compute the difference of pixel value of the initial seed point pi and its neighboring points, if the difference is smaller than the threshold (criterion) we define, the neighboring point could be classified into Ci , where i = 1, 2, …,n.

Step3. Re-compute the boundary of Ci and set those boundary points as new seed points pi (s). In addition, the mean pixel values of Ci have to be recomputed, respectively.

Step4. Repeat Step2 and 3 until all pixels in image have been allocated to a suitable cluster.

The threshold is made by user and it is usually based on intensity, gray level, or colour values. The regions are chosen to be as uniform as possible. There is no doubt that each of the segmentation regions of SRG has high colour similarity and no fragmentary problem.

VI. PROPOSED METHOD AND IMPLEMENTATION

The steps in proposed algorithm are as follows:

Step 1:
Preprocessing of the input image is done using Median filter.
Step 2:
To exploit the concept of texture segmentation, Gabor filters are implemented.
Step 3:
Seeded region growing is also implemented and the results are compared.

VII. RESULTS AND DISCUSSION

Gabor filtering and Seeded Region growing were implemented on CT and MRI brain images after preprocessing. Experimental results are shown here for patients having hemorrhagic stroke and ischemic stroke. Figure 4 (a) and (b) shows the original CT and MRI images taken from a patient affected by hemorrhagic stroke. The stroke affected area is indicated by arrows.

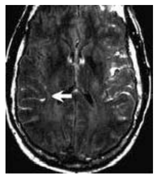
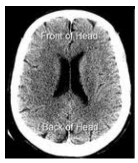


Fig.4 (a) CT hemorrhagic stroke (b) MRI hemorrhagic stroke

Figure 5 (a) and (b) shows the original CT and MRI images taken from a patient affected by ischemic stroke.



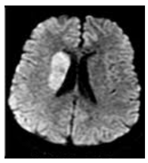


Fig.5 (a) CT ischemic stroke (b) MRI ischemic stroke

It is evident form Fig.5 that ischemic stroke detection in CT images is very difficult. But the stroke affected area can be easily identified in MRI images. After implementing the proposed algorithm for improving visual perception, the output images obtained are shown in Fig.6 and Fig.7

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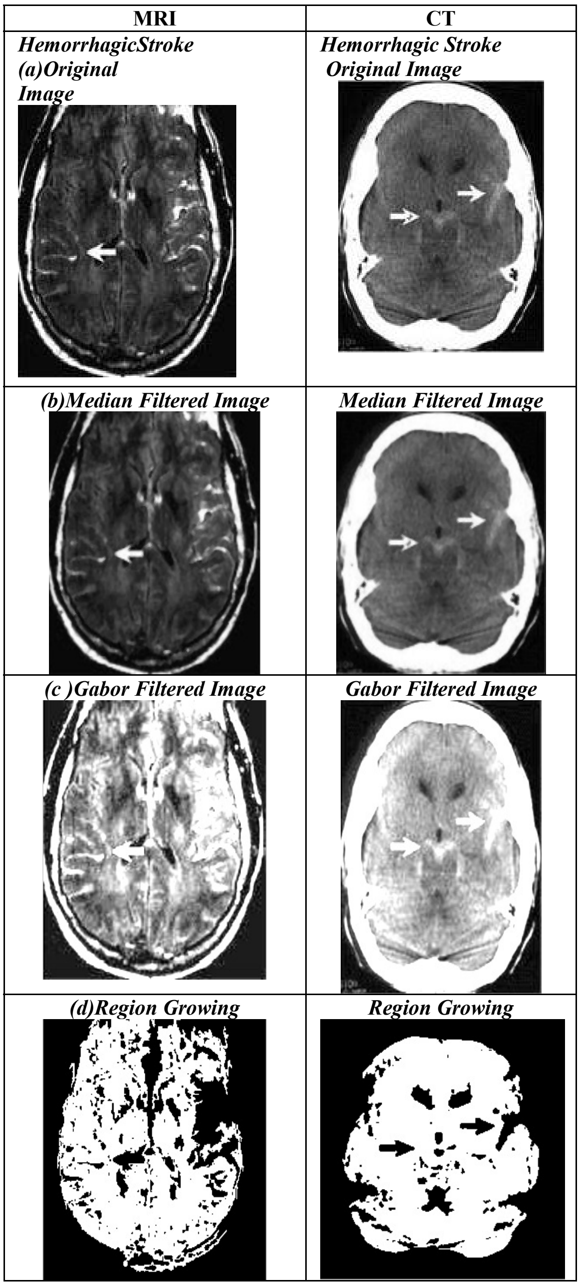

Fig. 6 (a) Original Image of Hemorrhagic Stroke

(b) Median Filtered Image (c) Gabor Filtered Image

(d) Region Growing

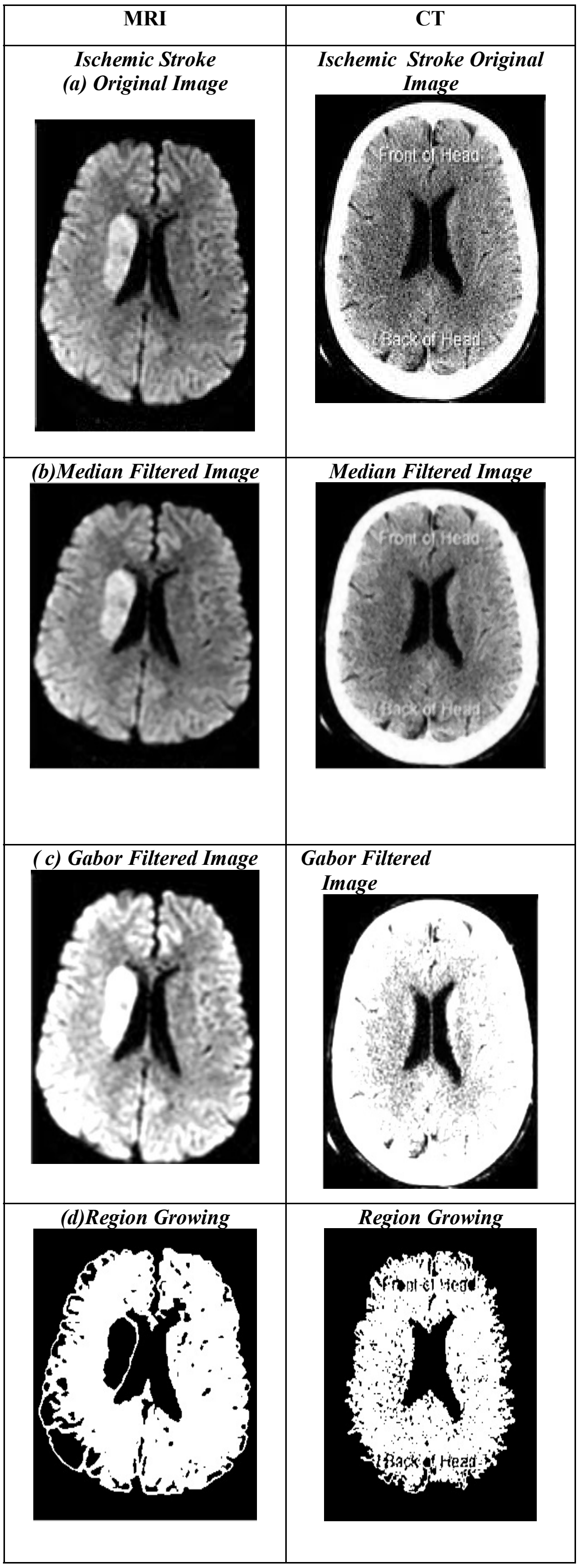

Fig. 7 (a) Original Image of Ischemic Stroke

(b) Median Filtered Image (c) Gabor Filtered Image

(d) Region Growing

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VIII. CONCLUSION

A comparative analysis of CT and MRI images for stroke diagnosis is presented in this paper. Gabor filters and Seeded region growing technique were implemented in this work for the identification of hemorrhage and infarct in human. The computational time is very less for the proposed algorithm. This work uses digital image processing tools to improve visual perception of stroke detection. It is also made clear that detection of stroke in MRI is superior to CT imaging, especially in ischemic stroke. The proposed image processing technique will help radiologists to diagnose brain infarct and reduce error rate.

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