Implementation of Medical Image Enhancement Technique using Gabor Filter

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Abstract

Significant improvement in contrast of masses along with the suppression of background tissues is obtained by tuning the parameters of the proposed transformation function in the specified range. The early detection of the cancer is a challenging problem, due to the structure of the cancer cells. The manual analysis of the sputum samples is time consuming, inaccurate and requires intensive trained person to avoid diagnostic errors. The segmentation results will be used as a base for a Computer Aided Diagnosis (CAD) system for early detection of cancer, which improves the chances of survival for the patient. In this paper, we proposed gabor filter for enhancement of medical images. It is a very good enhancement tool for medical images.

Keywords: Gabor filter; Image Enhancement.

1. Introduction

Lung cancer is considered to be as the main cause of cancer death worldwide, and it is difficult to detect in its early stages because symptoms appear only at advanced stages causing the mortality rate to be the highest among all other types of cancer. More people die because of lung cancer than any other types of cancer such as: breast, colon, and prostate cancers. There is significant evidence indicating that the early detection of lung cancer will decrease the mortality rate. The most recent estimates according to the latest statistics provided by world health organization indicates that around 7.6 million deaths worldwide each year because of this type of cancer. Furthermore, mortality from cancer are expected to continue rising, to become around 17 million worldwide in 2030 (Dignam J J et al, 2009). There are many techniques to diagnosis lung cancer, such as Chest Radiograph (x-ray), Computed Tomography (CT), Magnetic Resonance Imaging (MRI scan) and Sputum Cytology (T. C. Kennedy et al, 2005). However, most of these techniques are expensive and time consuming. In other words, most of these techniques are detecting the lung cancer in its advanced stages, where the patient’s chance of survival is very low. Therefore, there is a great need for a new technology to diagnose the lung cancer in its early stages. Image processing techniques provide a good quality tool for improving the manual analysis. A numbers of medical researchers utilized the analysis of sputum cells for early detection of lung cancer (Z. Daniele et al, 2004). For this reason we attempt to use automatic diagnostic system for detecting lung cancer in its early stages based on the analysis of the sputum color images (A. Sheila et al, 2010). In order to formulate a rule we have developed a technique for unsupervised segmentation of the sputum color image to divide the images into several meaningful sub regions.

Image segmentation has been used as the first step in image classification and clustering. There are many algorithms which have been proposed in other articles for medical image segmentation, such as histogram analysis, regional growth, edge detection and Adaptive Thresholding (K. McCrae et al, 1994). Review image of segmentation techniques can be found in (L. Lucchese et al, 2001). Other authors have considered the use of color information as the key discriminating factor for cell segmentation for lung cancer diagnosis (S. Shah et al, 2007). Figure 1 shows the beginning stages of cancer. In literature survey stage, we tried to get enough information related to our topic of research. Reading papers, collecting database, and making interviews with specialists, our tested database taken from IMBA Home (VIA-ELCAP Public Access) (K. McCrae et al, 1994).

1.2 Brief Theory

In digital image processing some general image intensification method like average value filter, the low pass filtering, the edge enhancement and so on mainly aim in the image the stochastic noise, but in the fuzzy image's grain line flaw belongs to the constitutive noise, therefore is not ideal to the image's enhancement effect.
Fig. 1 The beginning of cancer

The essential procedure is to the primitive gradation image after the low-pass filtering, the histogram transformation and so on general image intensification method carries on processing, carries on the binaryzation and refinement processing. This way's basic flaw will be the binaryzation and refinement processing will not only lose the useful pictorial information. Also has some algorithms is carries on the image enhancement on the primitive gradation image. The people proposed uses has the direction and the frequency selection characteristic bandpass filter carries on image enhancement processing the thought. Figure.2 shows the basic diagnosis Process.

Fig. 2 Diagnosis Process

1.3 Importance of Enhancement

One of the most important stages in medical images detection and analysis is Image Enhancement techniques which improves the quality (clarity) of images for human viewing, removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations.

The original image might have areas of very high and very low intensity, which mask details. An enhancement technique reveals these details and adjust their operation based on the image information (pixels) being processed. In this case the mean intensity, contrast, and sharpness (amount of blur removal) could be adjusted based on the pixel intensity statistics in various areas of the image. We can define image enhancement as away to improve the quality of a digitally stored image by manipulating the image with MATLAB software. It is quite easy, for example, to make an image lighter or darker, or to increase or decrease contrast. MATLAB also supports many filters for altering images in various ways. The enhancement technique differs from one field to another according to its objective. Image enhancement techniques can be divided into two broad categories:

1. Spatial domain techniques, which operate directly on pixels, and
2. Frequency domain techniques, which operate on the Fourier transform of an image.

As we work on medical images, we tried out three types of enhancement techniques: Gabor filter, Fast Fourier transform and auto enhancement. To talk about the better method we should use a theory to determine this unfortunately, there is no general theory for determining what `good' image enhancement is when it comes to human perception.

- Spatial Domain Method

The value of a pixel with coordinates \((x; y)\) in the enhanced image \(^* \mathbf{F}^*\) is the result of performing some operation on the pixels in the neighborhood of \((x; y)\) in the input image, \(\mathbf{F}\). Neighborhoods can be any shape, but usually they are rectangular (Venkateshwarlu et al., 2010).

- Frequency Domain Method

Image enhancement in the frequency domain is straightforward. We simply compute the Fourier transform of the image to be enhanced, multiply the result by a filter (rather than convolve in the spatial domain), and take the inverse transform to produce the enhanced image (Venkateshwarlu et al., 2010).

2. Gabor Filter Approach

The Gabor filter was originally introduced by Dennis Gabor, we used it for 2D images (CT images). The Gabor function has been recognized as a very useful tool in computer vision and image processing, especially for texture analysis, due to its optimal localization properties in both spatial and frequency domain (Jianwei Yang et al., 2003).

The image presentation based on Gabor function constitutes an excellent local and multi-scale decomposition in terms of logons that are simultaneously (and optimally) localization in space and frequency domains (Gabriel Cristobal et al., 1994).

A Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. Because of the multiplication-convolution property (Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian.
The Gabor function is can achieve the time-frequency only to measure that does not permit to relate the world of mortals the function. Wavelet and the Gabor function unifies Shannon may realize one kind to use in the texture division the auto adapted Gabor filter, it can determine the texture under the time-frequency best significance the edge. It is precisely because the Gabor function has above characteristic. Many fingerprint recognition system has used in recent years the Gabor filter in the pretreatment. Here Gabor filter algorithm has further used the fingerprint image partial directional characteristic, its main basis is in does not contain in the characteristic point partial neighborhood: The grain line has the consistent directivity; Looked along the vertical Yu Wenxian direction that the fingerprint grain line forms a plane sine wave approximately. Besides the pattern area and so on minority unusual region, in a small local region, the fingerprint grain line's distribution has the good frequency characteristic and the directional characteristic. Based on this nature, the use has the direction and the frequency selection characteristic bandpass filter may realize the very good enhancement effect. The two dimensional Gabor function is a harmonic generator, by has the spot frequency and the direction plane sine curve is composed.

We constructed one to have the frequency selection characteristic and the choice of direction characteristic Gabor filter. Figure 5 has given 0° direction Gabor filter's functional digraph. Because sine function's Fourier transformation responds for the impact, the gaussian function Fourier transformation was still the gaussian function, therefore the Gabor filter's frequency response for the impact function and gaussian function's convolution, may see from its frequency response's image, the Gabor filter have the very good bandpass nature.

2.1 Gabor filter's improvement

In order to overcome this shortcoming which the traditional Gabor filter bring, this article F(x, T1, T2) substitutes for the cosine function with one periodic function, has constructed a new filter function. It has the different frequency cosine curve merge by two to become, function curvilinear figure as shown in Figure 6, above x axis's cosine curve cycle is T1 above x axis's cosine curve cycle is T2. \( F(x, T1, T2) \) expands the cyclical form, expresses as follows with the mathematical formula:

\[
F(x, T1, T2) = f(x + (T1/2 + T2/2)) = f(x) \text{ the function } F(x, T1, T2) \text{ cycle is } T1/2 + T2/2, \text{ the graph curve about the y axial symmetry.}
\]

After the improvement Gabor filter frequency performance in is not revolves the center frequency the bandpass filter, but is and group of low-pass filtering related association bandpass filter, the related low-pass filtering favors the useful low frequency ingredient to pass, can thus the clear performance fingerprint image textural property. Parameter choice to Gabor: Filter’s performance is playing the decisive role, but their choice is not an easy matter. In computer vision texture analysis aspect, the people proposed some parameter selection principle, these principles are based on compare the human brain vision nerve the output and Gabor: The function response obtains. But to the fingerprint image, did not have the special fixed parameter method.

2.1 Based on grain line frequency choice improvement in former Gabor

In the filter, the parameter choice is establishes including the filter window's size depending on the experience. However must estimate the crestline and the valley line.
width is also a difficult problem in fact accurately, we use the method which the grain line frequency estimated sketichly to calculate their width. It was deciding the Gabor filter bandpass characteristic, its value is bigger the corresponding bandpass characteristic to be more obvious, however too big easy to have caused the filter not to be unstable, has the shake nearby the center frequency. If too small cannot display its bandpass attribute noise elimination the superiority. Its value’s selection is affecting the Gabor filter in y the axis Gaussian function, is also in this direction filter’s smooth degree. Its choice is relatively speaking not very important, does not affect filter's stability. But if chooses oversized, will cause the image on-line will appear too smooth in the crestline and valley, will thus cause some detail information to be fuzzy as shown in Figure 6.

Fig. 6 Different cycle response curve

3. Work approach

In the image Pre-processing stage we started with image enhancement; 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 (Rafael C et al, 2004).

Image enhancement techniques can be divided into two broad categories: Spatial domain methods and frequency domain methods. 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 (Rafael C et al, 2004). In our image enhancement stage we used three techniques: Gabor filter, auto-enhancement and Fast Fourier transform techniques.

Image segmentation is an essential process for most image analysis subsequent tasks. In particular, many of the existing techniques for image description and recognition depend highly on the segmentation results (Nunes et al, 2010). We used Thresholding and marker controlled watershed segmentation techniques. Thresholding is one of the most powerful tools for image segmentation. The segmented image obtained from Thresholding has the advantages of smaller storage space, fast processing speed and ease in manipulation, compared with gray level image which usually contains 256 levels.

Therefore, thresholding techniques have drawn a lot of attention during the past 20 years (Qingming Huang et al, 2004). Marker-driven watershed segmentation extracts seeds indicating the presence of objects or background at specific image locations. The marker locations are then set to be regional minima within the topological surface (typically, the gradient of the original input image), and the watershed algorithm is applied (Levner et al, 2007).

4. Simulation Results

![Fig. 7 Simulated results; (a) Input Image (b) Output Image (c) Average Filtered Image (d) Average Thresholding Image (e) Close Image (f) Construct Complement Image (g) Gradient Image (h) Log Filtered Image (i) Marker and object boundary Image](image)

Table 1 Comparative results

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Gabor Filter</th>
<th>FFT Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image 1</td>
<td>80.9</td>
<td>27.0</td>
</tr>
<tr>
<td>Image 2</td>
<td>79.5</td>
<td>25.6</td>
</tr>
<tr>
<td>Average</td>
<td>80.2 %</td>
<td>26.3 %</td>
</tr>
</tbody>
</table>

Conclusion

From the figure original image is enhanced by various filter methods and finally we got the marker of especially for diagnosis purpose, also from the comparative with FFT filter the average peak signal to noise ratio if good so our image is enhance for our requirement.

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