Research on Mammogram Enhancement

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Abstract—Computer-assisted analysis of mammogram may provide clues for diagnosis of early tumors. Compared to ordinary images, mammograms feature vagueness and inhomogeneity. Hence, it's of great importance to enhance the contrast of mammograms. This paper introduced traditional algorithms of image enhancement, and presented the region-based and feature-based algorithms for mammograms. In addition, three quantitative evaluations of contrast enhancement proposed by Bovis and Singh at University of Exeter in UK are introduced.

Keywords—mammogram; image enhancement; algorithm; feature; algorithm evaluation

I. INTRODUCTION

One of the major concerns in the field of computer vision is how to obtain useful data and display them clearly on the computer screen after reading medical image data on computer error-free. Image enhancement refers to the process of highlighting some information in an image in terms of given requirements and attenuating or removing some information not required, in order to make processed images more applicable than unprocessed ones and to human visual features or machine recognition system in a given application. Compared to ordinary images, mammograms feature vagueness and inhomogeneity. Although plenty of micro-calcifications and phyma in breast lesions are highlighted on display, quite a lot located in breast lesions with high density are invisible to the naked eye. Therefore, it's of great importance to enhance the contrast of mammograms.

II. TRADITIONAL ALGORITHMS OF IMAGE ENHANCEMENT

Algorithms of image enhancement fall into direct and indirect methods. Direct algorithm enhances by means of histograms, while indirect algorithm defines contrast first and then enhance it. Image enhancement covers a great range such as contrast enhancement, denoising, background removal, edge sharpening and filtering. The enhancement of mammograms of breast lesions is to sharpen the edge of nidus or region of interest (ROI) for the purpose of enhancing the contrast between the focus region and the background. Most of traditional contrast enhancements are global and neighbor-based, such as global (local) histogram equalization and unsharp masking (UM), which may lead to underenhancement or overenhancement. In global histogram equalization, contrast reduction may result from neighbor gray levels with a small number integrated into one gray level in the process of equalization. To overcome the problem, calculation of the equalization function of a small region can be made and thus combination of neighbor pixels could be reduced in this equalizing process. Compared to global equalization, this method may make image contrast reduce flatly, which is the so-called adaptive neighborhood histogram equalization (ANHE).

III. REGION-BASED IMAGE ENHANCEMENT ALGORITHM

Local enhancement is a good way to solve the problem of inhomogeneity of breast lesion mammograms. Generally speaking, there exist two regions: one is the unfolded region obtained by the segmentation algorithm, another is the folded region gained by the region-growing algorithm. Region-based algorithm could enhance details of anatomy under the circumstances of implicit introduction of man-made noise. The literature [1] shows that this algorithm can resolve calcifications in the breast lesion images with a low contrast between micro-calcifications and breast lesion tissues and high density.

IV. FEATURE-BASED IMAGE ENHANCEMENT ALGORITHM

With the development of image enhancement, feature-based image enhancement algorithm could enhance phymas and calcifications of an image better. This algorithm involves two major methods: one is to enhance the Suspicious Region, i.e., Region of Interest[2-15]; the other is to remove the background tissues[16-17].

Wavelet transformation is a method of linear time-frequency expansion, in which change of wavelet parameters according to various needs may enhance ROI in an image and restrain unrequired signals in the process of wavelet decomposition and mammogram reconstruction. The literature [18] proposed a novel two-dimensional discrete WT method, in which one arithmetic operator is applied to the gained wavelet parameter and then the enhanced image is reconstructed. The literature [19] made a wavelet decomposition to the original image and then calculate the high-frequency components with the following nonlinear arithmetic operators. If the gained value is less than the threshold value, the high-frequency components are restrained, otherwise, enhanced.

\[ f(y) = a[\text{sgn}(c(y - b)) - \text{sgn}(-c(y + b))] \]
The second method is Target to Background Contrast Ratio Using Standard Deviation (TBCs) based on standard deviation. The evaluation equation of TBCs is

$$TBC_s = \frac{(\mu_T - \mu_B)^2}{\sigma_T^2 + \sigma_B^2}$$

Just like DSM, the higher TBCs is, the better enhancement effects are. A negative TBCs indicates no enhancement in the image contrast.

The third method is Target to Background Contrast Ratio Using Entropy (TBCe) based on entropy. The entropy in a given region is calculated as follows,

$$\epsilon = \frac{1}{l} \sum_{i=1}^{l} f(i) \log_2 |f(i)|$$

Where, \( L \) is the gray level in the given region, \( f(i) \) is the frequency of each gray level:

$$f(i) = \frac{h(i)}{\sum_{i=1}^{l} h(i)}$$

The evaluation equation of TBCe is

$$TBC_e = \frac{(\mu_T - \mu_B)^2}{\epsilon_T^2 + \epsilon_B^2}$$

If TBCe is less than 0, there’s no enhancement in the image; if it’s more than 0, the higher TBCe is, the better effects of image enhancement are.

REFERENCES


Figure 1. The non-flat “ball-shaped” three-dimentional structure element.
Figure 2. Breast lesion removal and calcification extraction