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Achieving Accuracy in Early Stage Tumor Identification Systems based on Image Segmentation and 3D Structure Analysis

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Abstract

Cancer is a disease which can be removed if early stage tumor identification systems efficiently and accurately work at cancer hospitals. As the accuracy in detection of tumor means to detect exact size of the tumor. Because the best way to beat cancer is early stage tumor diagnosis and quality treatment. In this research article an accuracy module is proposed for computer aided tumor diagnosis system. The ultimate proposed CAD gets image of tumor infected lung and breast images from different state of the art early stage tumor detection methodologies as micrographic and mammographic based imaging systems. For accuracy in detection of early stage tumor, image enhancement and segmentation techniques are applied according to the imaging problems at input image. Also for accurate estimation of tumor the 3D image construction and 3D structure analysis are tried to realized. The realization of the proposed CAD proves that the accuracy module can assist well the computer aided tumor diagnosis systems with almost near to 100% accuracy in early stage tumor detection and size estimation for breast and lung cancer.

Keywords: Computer Aided Tumor Detection, Accurate identification

1. Introduction

The leading cause of cancer death throughout the world is lung cancer because more people die because of lung cancer than any other types of cancer (Fatma Taher et al 2010 and Younis M.Abbosh et al 2010). Similarly the breast cancer is also a leading causes of women death in all around the world . An early detection of lung cancer and breast cancer can greatly improve the survival rate of the tumor infected patient. So far in most of the cancer hospitals diagnosis of cancer is carried out by the human which put heavy reliance on human interpretation in the area of life and death. Therefore there is great need for new technologies and methodologies to diagnose the lung and breast cancer automatically and accurately in its early stage. Currently the research community has provided several of techniques for detecting early stage tumor in lungs and breast which are discussed in section 2. If these detection methodologies are integrated with an efficient reliable and robust computer aided diagnosis system, then the automation, accuracy and sensitivity of early stage tumor identification can be improve. The successful applications of image processing and artificial intelligence techniques could greatly ease the burden of the very large number of examinations performed and provide accuracy in detection because this is an area where artificial Intelligence could truly be a matter of life and death (Jhon Kotre 1993).

In the proposed computer aided diagnosis system, the input images for accurate early stage lung and breast cancer detection are taken from different state of the art early stage tumor detection methodologies as micrographic and mammographic based imaging systems which are discussed in section 2. In accuracy module the image enhancement techniques are applied as preprocessing. Preprocessing deals with the input image problems such as contrast enhancement, blurr removing, noise removal and edge enhancement. Once the image is enhanced well then it can be segmented efficiently. As the input images are from reliable early stage tumor detection methodologies so the focus of proposed CAD is accuracy in detection, for this first a dynamic approach is applied which is comprises of edge detection operators as Canny, Sobel, pewit and log. Why the approach should be dynamic because sometime one technique gives accurate result at some image but the same technique could not provide accuracy at another type of image because these segmentation techniques depends on the nature of image. After edge detection the feature extraction is applied for extracting tumor area. The formulation for 2D area calculating and proving accuracy are given in (Fatema Taher et al 2008), but it is not reliable because it is in 2D and exact tumor size could not fit in 2D. So for this the CAD must be capable of detecting the depth of the tumor. Therefore 3D image reconstruction and 3D structure analysis for estimating tumor areas are good approaches. There are number of algorithms are presented for 3D image construction and this articles referenced one of them which is given in (Christopher K. et al 2010). After accurate tumor detection and estimation the further work for accurate tumor stage classification and achieving treatment quality is given in (Waqas Haider 2011). The rest of the paper is organized as follows in section 2 the early stage lung and tumor detection methodologies are discussed. Section 3 will brief some recent work in the domain of image processing, artificial intelligence and early stage tumor detection. In section 4 the proposed CAD model is given and expressed. Experiments and discussions are given in section 5 and finally conclusion and future work is given section 6.

2. Early Stage detection methodologies review

Mammographic imaging and electromagnetic imaging are the two main categories of recent methodologies for detecting early stage breast and lung tumor. Mammography is technique which helps in early detection of tumor and it plays a very important role in cancer treatment and allows faster recovery for most of the patients. It is a specific type of imaging that uses X-Ray system, high contract and high resolution film for examination of the breasts. In (Hala et al 2010 and M.Asad et al 2011) the systems are proposed for early stage breast tumor identification. These systems are based on mammographic images feature extraction and yet these systems are still required accuracy in detection and off course exact tumor stage classification and treatment quality module. Similarly a learning algorithm is presented in (Maurice Samulski et al 2011) for multi view mammography detection system and the presented work is in the domain of performance of detection system. Also X-ray mammography is inexpensive and reliable but the patient is exposed to the ionizing radiation which causes problems for patient (Punal et al 2010).

Electromagnetic imaging is another approach to detect early stage breast tumor detection. The key feature of detection of microwave technology is the differential backscatter response from tissues based on their water content, so a healthy and infected tissue has different responses. This approach avoids patient exposure to ionizing radiation and it doses not require breast compression. Microwave imaging detects tumors of very small volume which can be missed by mammography imaging (Susan C. et al 1999, Xu Li et al 2005 and Magda E et al 2011). According to current research of active microwave breast imaging, it has three categories based on imaging technology, for example microwave hybrid approaches , microwave tomography (Alvaro D. et al 2011, Julient R. et al 2011, Masaomi T et al 2001 and Florian S. 2011), and ultra-wideband (UWB) radar techniques (Shakti K. et al 2005, Reza K.. et al 2011, N.A Simonov et al 2011, Douglas J. 2009, Dan Zhang et al 2011 and Dauglas J. et al 2008). In microwave hybrid approaches microwave signals are induced into the breast to heat tumors and ultrasound transducers detect the pressure waves generated by tumor expansion. In tomographic image reconstruction, the nonlinear inverse scattering problem has been resolved to restore the image of the dielectric properties of the breast e.g in (Alvaro D. et al 2011) UWB radar approach solves a simpler computational problem by seeking only to identify the presence and location of significant scatters such as malignant breast tumors by using high bandwidths and large antenna apertures to improve spatial resolution at microwave frequencies.

3. Image processing with artificial intelligence in early stage breast and lung tumor identification

In this section some recent work in the domain of identification of early stage lung cancer and breast cancer with image processing and artificial intelligence are highlighted. The article (John Kotre 1993) highlights the applications of image processing and motivation to work in medical imaging. It shows some tomographic image reconstruction work for early stage breast cancer identification. The article (W.Wang et al 2006) shows the identification of lung cancer with image processing in it frequency domain image enhancement's (e.g wavelet transformation) and segmentation algorithm is applied for lung tumor identification. The author of (Christopher Koehler et al 2010) utilized 3D imaging and artificial neural network based method for lung cancer detection and localization. In (V.P Gladis et al 2011) the image processing and artificial neural network is applied for brain tumor identification. The author targeted to motivate research community to work in brain tumor segmentation and identification. In (Fatma T. et al 2008) the image segmentation is applied for lung cancer tumor identification. The method focuses on sensitivity, accuracy and specificity of CAD system. Focusing accuracy the article shows 85% accuracy in the case of early stage lung cancer identification. In the proposed CAD system which will be express in next section will be approach 100% accuracy for both lung and breast cancer early identification. The article (S.Aravind et al 2011) presented a CAD system based on image processing and artificial intelligence for early stage lung tumor automated detection. In it focusing accuracy the results are 90% for the case of lung cancer identification. In (Saleh A. et al 2011) the presented CAD is an integration of ultra wide band based imaging and artificial neural network for early stage breast cancer identification. The given accuracy results are 93.1%. After analyzing the recent research there is still a need of hybrid CAD system which can detect all type of tumors as brain, lung, breast etc. In the proposed CAD the lung and breast tumor are realized. Targeting accuracy of CAD the proposed method is attempted to get 100% accuracy by providing exact size of the tumor. Therefore an accurate and hybrid computer aided tumor diagnosis system based on image processing and 3D structure analysis is expressed in next section. This article focuses for achieving accuracy in early stage lung and breast tumor identification and in (Waqas Haider 2011) the classification and treatment quality is focused.

4. Proposed CAD Model

The proposed CAD for early stage breast and lung tumor is composed of three main phases as shown in figure one. To work with and adopt at cancer hospitals, at the detection phase the state of the art detection methods and technologies as discussed in section 2 could be used and can be integrated with the proposed accuracy phase as shown in figure one. In the proposed work the input image as a first image to process are required to take from those imaging techniques which are discussed in section two. The purpose to utilize such image comprises of several factors. As the proposed CAD required accuracy in detection so it is necessary to utilize such image which should make sure the CAD system that it has been efficiently analyzed , in this article for experimenting accuracy in detection and for tumor estimation the breast images are taken from (MIAS database). In accuracy phase the accurate detection of tumor is applied with the help of dynamic image processing techniques as shown in figure one. As the techniques should be dynamic because of different nature of image problems at detection phase. Some images required different type of enhancement techniques to achieve accuracy and similarly for segmentation and feature extraction the techniques vary accordingly. For the realization of this fact different edge detector operators are applied and each produce different result and the result which approach accuracy is adopted for a particular nature of image. Once the applied segmentation technique detected the region of tumor then feature extraction is applied. After getting the area of tumor infected region then for calculating area of that region the formulation could not rely on 2D so for it 3D image reconstruction is applied . The 3D image reconstruction in case of tumor size estimation required multiple images to construct exact tumor 3D image , so due to lack of experimental resources for it, at this novel experimental stage the 3D structure analysis is applied with 3D graph which is constructed using MATLAB utilities. After 3D graph generation which is of course not exact but could be realized for making formulation of calculating exact tumor size which is formally given in equation 2. Similarly the proposed CAD then approach exact stage classification and treatment quality which is describe briefly in (Waqas Haider 2011).

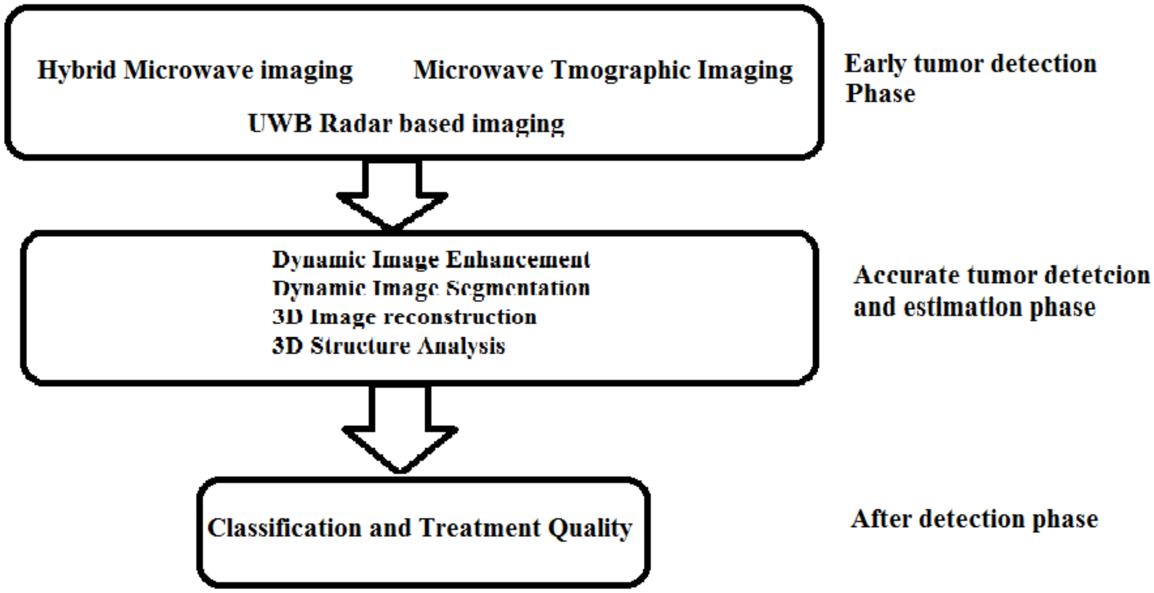

Figure 1. An Accurate Computer Aided Tumor Diagnosis System abstract View

5. Experiments and discussion

Experimenting accurate detection and tumor area estimation the images are taken from MIAS databse. The test images are shown in figure two.

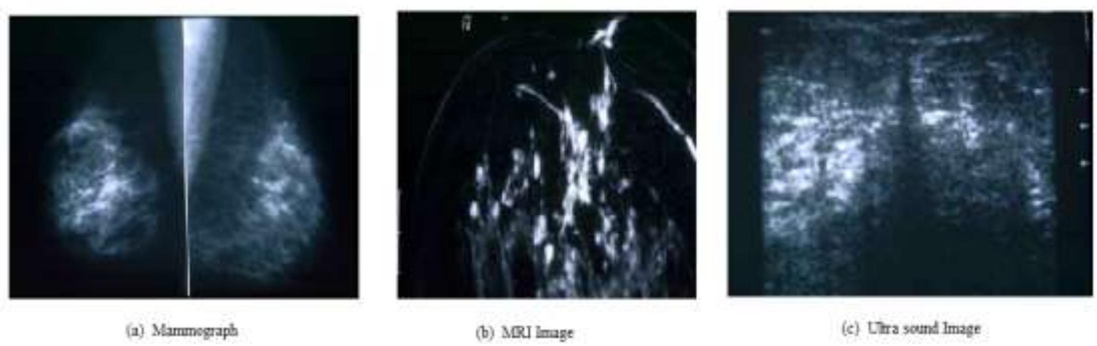

Figure 2. Breast Tumor Images

Edge detection operators are applied and each image is analyzed for accuracy in detected edge, after applying canny, prewitt , log , sobel and Robert operator the analysis shows that for these test images sobel has good results in detecting tumor boundaries. In figure 3 the simulation results prove the suitability and dynamics of image segmentation techniques and in this case sobel got the suitability.

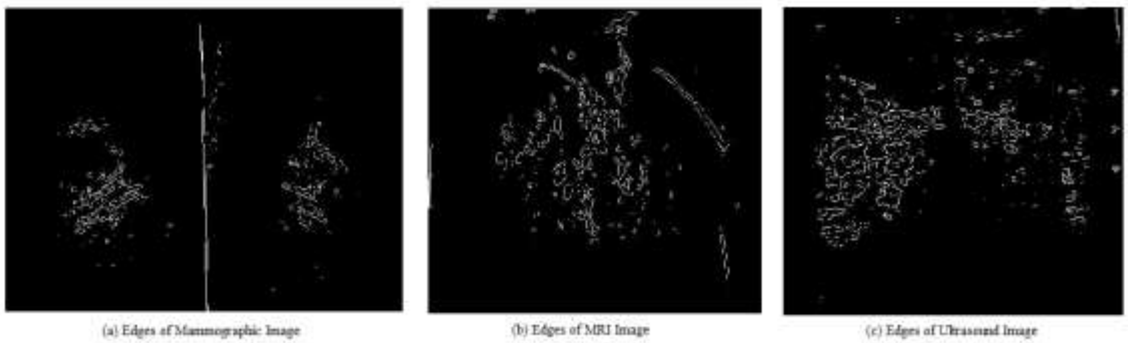

Figure 3. Tumor Boundary Detection with sobel operator

Here the experimental point need to be cleared , as the proposed CAD is segmenting tumor region with dynamic segmentation technique so the same procedure could be applied to those early stage tumor images which may be retrieved from the techniques discussed in section two. As the focus of the article is accurate early stage tumor identification and tumor size estimation. The early stage tumor would probably a small region which could be segmented further by applying morphological operation and is given in equation 1 as follows:

$$ESTRS(x,y,z) = EI(x,y,z) - PIB(x,y,z) \text{.............}(1)$$

Where ESTRS is a early stage tumor region segmentation , EI is edged image and PIB is point inside boundary. Here the realization of the segmentation procedure is over three dimensional image because in order to get accuracy in detecting tumor size the input image must be in 3D and later on segmentation would be applied accordingly, but here due to lack of experimental resources the realization of proposed CAD is unable to make use of 3D image construction. As 3D image reconstruction for such case required images of the same patient at different angles. Therefore just the segmentation and estimation of tumor area from 3D image are realized. In equation 1 ESTRS(x,y,z) will generate a tumor region which is realized and explored in figure 4 as 3D structure analysis for exact tumor size estimation.

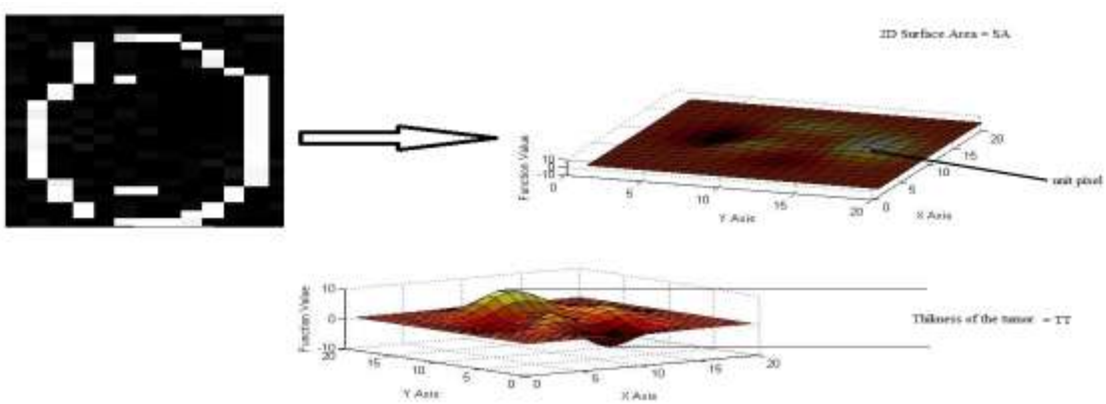

Figure 4. 3D structure analysis for estimating accurate tumor size abstract view

To calculate the tumor size the foundation formulation is given as follows:

$$SOT() = \sum_{i=1}^{n} [SA(p_i) + TT(p_i)] \text{.............}(2)$$

Where SOT ( ) size of tumor function , SA is the 2D surface area and TT is the tumor thickness. As to measure tumor size in cm or any other scale is a later job here the CAD has just pixel to manipulate size. So from equation 2 it can be seen that the size of the tumor would be equal to total number of pixels in 2D surface (e.g SA(Pi)) plus total number of pixel in thickness of the tumor (e.g TT(Pi)). The formulation given in equation 2 may be matured in future work as once the availability of experimental resources for 3D imaging is sured.

6. Conclusion and Future Work

In this article an accurate computer aided tumor diagnosis system is proposed for accurate early stage breast and lung tumor identification and classification. In accurate tumor detection and tumor size estimation phase , the edge detection operators , segmentation technique as morphology and 3D structure analysis are realized on breast tumor images. The proposed methodology can ensure 100% accuracy in detection and size estimation of early stage tumor. To achieve high accuracy the requirement is 3D image construction with methodologies discussed in section 2 and 3D area finding algorithms maturity. The formulation and methodology for proving accuracy could be taken from (Fatma Taher et al 2008). On the bases of accurate identification in (Waqas Haider 2011) exact tumor stage classifications and treatment quality is addressed.

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