Survey on Effective & High Performance Optimized Techniques For Analysis Of Echocardiographic Image In Bioinformatics

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Abstract - *The diagnosis of human heart disease is mainly done by echocardiography technique and hence there is many researchers conducted on efficient echocardiography image analysis since from last decade. Echocardiography helps t provide valuable information over heart abnormalities in order to make right decision on medical treatment. The images of echocardiography is having information clinically relevant including the structure of heart (shape and size), hearts location, heart's pumping capacity and severity of damage in heart tissues. Using such information the assessment over heart diseases such as regurgitation and stenosis is performed. But the present medical services are based on echocardiography imaging as well as its information analysis. It is required to perform manual analysis of anatomical structures such as right atrium, left atrium, right ventricle and left ventricle and then calculate its length, area, stroke volume, diameter, fractional shortening, and ejection fraction from input echocardiography image. This leads the dependency of having special resource to analyze the echocardiography image accurately in order detect the heart cavities. Any false analysis from image leads to incorrect diagnosis and hence it is required to have specialized expert operator.*

Key Words: Image processing, Echocardiographic, Optimized Techniques, Bioinformatics

1.INTRODUCTION

Image processing is one of the rapidly developing domains of computer science. Technological improvements in digital imaging, computer processors and mass storage devices have fuelled its growth. Areas, which conventionally used analog imaging to digital systems, are currently undergoing a change. Medicine, Film and Video Production, Photography, Remote Sensing, and Security Monitoring are a few important examples of it [1]. In several domains of science and engineering, processing color and gray scale images or the other two-dimensional signals has become a momentous tool for research and investigation. These and the other sources produce huge amount of data every day, more than what could ever be examined manually. The massive volumes of digital image produced each day by these and other sources are beyond the limits of manual assessment. Extracting precious information from images is the fundamental task of digital image processing. Theoretically, computers accomplish this with negligible or no human involvement [2]. There are three categorical levels of image processing algorithms. Techniques that directly handle the raw, perhaps noisy pixel (picture element) values such as denoising and edge detection belong to the lowest level. In the middle are algorithms like segmentation and edge linking which makes use of low-level results for more enhancements. Techniques that endeavor to derive semantic significance from the information that are provided by the lower levels occupy the top most level [3].

Digital image processing enables the expansion of image features of interest at the same time mitigating details unrelated to a given application and then extract precious information related to the scene from the improved image. Though lot of algorithms exists in the literature for performing miscellaneous image processing tasks a majority of them appear to be not directed by any unifying criterion. Diagnostic interpretation of this new digital data continues to be predominantly qualitative, subjective, and vulnerable to observer variability, though significant improvements have been made in medical imaging technology in the prior decades. Medical imaging equipment is taking on a more and more decisive role in healthcare, as the industry is fighting to diminish the patient costs and perform timely disease diagnosis by means of noninvasive methods. Medical imaging signifies the steps and succession of activities used for producing the images of a body (or relevant parts) for clinical methods. In the widest sense, it is a part of the biological imaging and it incorporates radiological sciences, endoscopy. Measurement and recording methods which produce data having a propensity to be denoted as maps (i.e. comprising positional information) but are not fundamentally intended to create images, like Electroencephalography (EEG) and Magneto encephalography (MEG) and others are to be treated as categories of medical imaging.

Advanced medical systems like Computed Tomography, Magnetic Resonance Imaging (MRI) and Ultrasound are flattered more and more commonly. It also continues to mature, as this technology becomes more commonplace. The major new imaging applications developed every year to assist the diagnosis and monitoring of disease fuels stipulation and this results in improved deployment and use. Dramatic increases in the size and complexity of imaging data has taken place during the past decade as this cycle of growth has continued unabated. Subcutaneous body structures such as tendons, muscles, joints, vessels and internal organs are visualized for possible pathology or lesions using an ultrasound-based diagnostic imaging technique called Ultrasonography. M-mode, Two-dimensional Doppler, and Color Doppler are the major types of Ultrasonography. The simplest method in M-mode Ultrasonography focuses a single beam of ultrasound at the section of the heart being studied.

Realistic two-dimensional images are produced in computer-generated “slices” by the most comprehensively used Two-dimensional Ultrasonography. Turbulent flow because of narrowing or blockage of blood vessels can be detected by Doppler Ultrasonography as it shows the direction and velocity of blood flow [4]. Color Doppler Ultrasonography shows different rates of blood flow in different colors. Diagnosis of disorders affecting the heart and the arteries and veins in the trunk, legs, and arms are normally assisted by Doppler ultrasonography and Color Doppler ultrasonography [5]. Figure 1.1 depicts a measurement of the heart's left ventricle by Echocardiogram in the parasternal long-axis view.

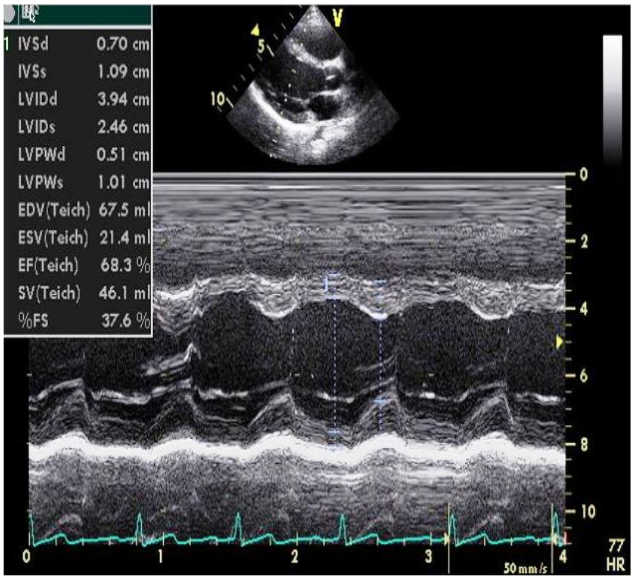

Fig-1: The measurement of the heart's left ventricle

Ultrasound based diagnostic imaging technique called Echocardiogram identifies several aspects of the heart leading to different cardiac problems. Echocardiography used to diagnose cardiovascular system using pulsed or continuous wave Doppler ultrasound estimates the blood velocity and cardiac tissue at any given peak [6]. The size, shape, and movement of the heart's valves and chambers and also the flow of blood through the heart can be shown by the ultra sound waves which bounce back or echo off the heart. This allows the estimation of cardiac valve areas and function, any abnormal communications between the left and right side of the heart, any leaking of blood through the valves (Valvular Regurgitation), and calculation of the cardiac yield as well as the Ejection fraction. Flow-related measurements can be enhanced by using them with ultrasound Doppler [7]. Abnormalities in heart wall motion can be detected and the volume of blood being pumped from the heart with each beat can be measured using Echocardiography. The structural cardiac abnormalities in the valves, congenital defects, enlargement of heart chambers and walls found in patients with high B.P, and heart failure can be detected by this procedure [5, 8]. There are number of other processes which are used for the analysis of echo images in order to detect the heart abnormalities rightly, however all such techniques are majorly depends on expertise to analyze the readings from echo images. This may leads to many problems such as time consuming, possibilities of major inaccuracies and dependencies.

In this research work, we are developing a CAD system which analyzes the echo images and provide clinically relevant information to cardiology specialists for decision making. There are two image modalities, two-dimensional echo (2D Echo) and color Doppler, being dealt in this research work. The 2D echocardiography is the backbone of cardiac ultrasound. Almost all studies are done with reference to the 2D images. The long-axis, short-axis, and apical four-chamber are the three basic orthogonal views used for 2D imaging analysis. Doppler echocardiography is the most direct and theoretically accurate technique for assessing blood flow. Combining blood velocity with the cross-sectional area of the orifice through which the blood is flowing provides the basis for quantifying blood flow. Color Doppler flow is the initial approach currently used for the diagnosis of mitral regurgitation and stenos is. Basically 2D echo images provide quantitative information whereas color Doppler images provide qualitative details.

2. RELATED WORK

2.1 Echocardiography

The use of ultrasound in the diagnosis of cardiac disease has been available for more than four decades with the diagnostic potential of this modality first recognized in 1954 when the first continuous recordings of the heart walls were recorded. The term “*Echocardiography*” was adopted to describe the utility of sound in cardiology in which returning echoes are reflected from the boundaries of the cardiac structures. Echocardiography has emerged as the primary tool for assessment of the cardiovascular system because of the following advantages: it is noninvasive, safe, no known risk to the patients or technicians, hemodynamic and diagnostic data can be provided. The basic principles of echocardiography, including the mechanical features of echocardiographic equipment are no different from diagnostic ultrasound in general. Nevertheless, there are aspects of echocardiography that set it apart from general echocardiography. Because the heart is a moving organ, and because echocardiography must additionally capture that movement, an understanding of echocardiography requires the knowledge of both cardiac anatomy and physiology. This technique has become widely employed as a common cardiac investigative tool. It has revolutionized the investigation of gross cardiac pathology and has become an integral component in the routine clinical assessment of the cardiac patient. In fact echocardiography is the most frequently used imaging procedure in the diagnosis of heart disease and rivals the more traditional techniques such as chest radiography and electrocardiography (ECG). Echocardiography is used to evaluate cardiac chamber size, wall thickness, wall motion, valvular anatomy, valve motion, the proximal great vessels and the pericardium. Anatomic relationships can be determined and cardiac function can be assessed. This technique is a sensitive tool for detecting pericardial and pleural fluid, identifying mass lesions within and adjacent to the heart, characterizing congenital cardiac defects and diagnosing valvular and myocardial pathology.

2.2 Echocardiography Image Processing

Segmentation subdivides an image into its constituent regions or objects. The level to which the subdivision is carried out depends on the problem being solved. The segmentation will end when the objects of interest in an application have been isolated. Segmentation of nontrivial images is one of the most difficult tasks in image processing. Anthony, et al discussed various methods for segmenting an image such as finding gray level discontinuities like points, lines, and edges [Anthony, 2001]. Object segmentation in medical images is an actively investigated research area. Donka, et al, proposed a Monte Carlo algorithm for extracting lesion contours in ultrasound medical images [Donka, 2011]. Threshold method of segmentation, which is another popular method, has also been proposed by Ruey and others [Ruey-Ming, 2009]. Gonzalez gives an elaborate explanation of morphological approach to segmentation called watershed algorithm [Gonzalez, 2010]. However, no discussion on ultrasound medical image segmentation is dealt in these literatures.

Alison Noble, et al [Alison, 2006] reviews ultrasound segmentation methods, in a broader sense, focusing on techniques developed for medical echocardiography ultrasound images. Ultrasound image segmentation is strongly influenced by the quality of data. There are characteristic artefacts which make the segmentation task complicated such as attenuation, speckle, shadows, and signal dropout; due to the orientation dependence of acquisition that may result in missing boundaries. Further complications arise as the contrast between areas of interest is often low. Alison Noble, et al discussed the classic approach for segmenting short-axis echocardiography images using techniques based on mathematical morphology. He also discusses segmentation of the left ventricle being considered as a region-based or pixel-classification problem. In this case, the goal is to label pixels as either belonging to the blood pool or myocardium. Another approach is Artificial Neural Network (ANN) based methods have been used as well for region-based segmentation. The drawback, of course, is the overestimate of cavity areas. Finally, there is a very limited literature explicitly on segmentation and analysis of the myocardium and epicardial border detection.

Chang Wen Chen, et al [Chang, 1998] had proposed a novel method for image segmentation using adaptive techniques and morphological operations. Traditional statistical image segmentation algorithms, as simple as thresholding or as complicated as K-mean and even fuzzy K-mean clustering, all classify the pixels into clusters based only on their intensity values. The method proposed in this reference is an algorithm that includes not only the 2-D spatial constraints characterized by Gibbs random fields, but also the adaptive capability specified through iterative estimation of local means of each region. The method comprises of morphological operations and binary image segmentation which does not work for ultrasound images, as the edge details of endocardium boundary should not be tampered. However, it is important to note that K-Means clustering technique is useful for ultrasound image segmentation.

Three algorithms were proposed by Carlos Ordonez [Carlos, 2006] using DBMS SQL and C++ and demonstrated how K-Means can be of practical importance for clustering large data sets. Several efforts are being made to integrate the DBMS and data mining algorithms to achieve speed and remove unnecessary import/export of data between application and database domains. The focus here is to implement the K-Means algorithm through SQL statements. However, the running time achieved with the type of hardware setup may not outperform other designs [Khaled, 1998]. The reasons are the use of time consuming UPDATE statements and more number of tables.

An approach to speed up the K-Means was suggested by Khaled Alsbti, et al, based on k-d tree structure [Khaled, 1998]. The main intuition behind their approach is as follows. All the prototypes are potential candidates for the closest prototype at the root level. However, for the children of the root node, it is possible to prune the candidate set by using simple geometrical constraints. Clearly, each child node will potentially have different candidate sets.

The bottleneck in K-Means algorithm is the distance computation. Using SQL and User Defined Functions (UDF) a new technique was proposed by Sasi K. Pitchaimalai, et al which mainly used a costly approach of deleting the table entries first and then inserted the new records [Pitchaimalai, 2008]. The UDF presents some interesting results. The times scale linear with increasing n but increase slightly or almost same with a higher d, k, m. This approach concludes that for clustering SQL and UDF offer the same performance. Many recent literatures suggest that using a SQL user defined function in a query performed up to 4 times slower than the equivalent inline logic, i.e. normal SQL. Therefore, the UDFs should be used only when necessary [Pitchaimalai, 2008].

3. LITERATURE SURVEY

Navneet Kaur et al. (2013) , This paper had presented the use of image segmentation in lesion segmentation which is needed for monitoring and quantifying lesion. It had also illustrated the k-means clustering method which is an iterative technique that is used to partition an image into clusters in which there is choice of k clusters along with the types of clustering that is hierarchical clustering and partitioned clustering. It has also given the description over the region growing segmentation which is partitioning of an image into homogeneous connected pixels. Each pixel in the region is similar due to some property such as color and texture.

Nan Li et al. (2013), Author have proposed an image clustering method called fuzzy C-means with edge and local information(FELICM), which decreases the edge degradation by adding the weights of pixels within local neighbor windows. They had used the canny edge detection for edge extraction, adaptive threshold values. It had been shown that the proposed method could be directly applied without using the filters. This approach has delivered the better results with respect to fuzzy c means clustering method and mean shift approach. The experiments show that the proposed FELICM method is insensitive to the isolated regions and more accurate edges than FLICM.

Monika Xess et al. (2013), This paper presented an overall search over the topic clustering based color image segmentation and novel approaches to FCM algorithm. This paper described two techniques namely K-means clustering and fuzzy c-means (FCM) clustering for better segmentation results. The benefits of Spatial Fuzzy C-means (SFCM) which overcomes the limitation of conventional FCM towards noisy image have been discussed. Thresholding by Fuzzy C-means (THFCM) approach solves the problem of existing method to determine a threshold for excellent segmentation.

Amrita Mohanty et al. (2013), This paper had described the analysis of color images using cluster based segmentation techniques. It has discussed the various segmentation techniques like thresholding, edge-based detection, region based detection and clustering. The main illustration is based upon the color image segmentation using k-means, fuzzy c-means and clustering and corresponding results have been compared.

R.Ravindraih et al. (2013), This is a survey paper which as represented the various image segmentation algorithms based on fuzzy clustering. It had described the use of image segmentation with the medical image processing. It had covered different types of fuzzy c-means algorithms like fcm, improved fcm, bias corrected fuzzy c-means and their corresponding use to the image segmentation.

Hamed Shamsi et al (2012), This paper illustrated that the traditional way to segment the MR images is the fuzzy c-means (fcm) clustering algorithm. This method is basically sensitive to noise. So to overcome the traditional method a new modified fuzzy c-means clustering with spatial information for image segmentation was proposed. The proposed method used the spatial information for the better results as compared to fcm. The results proved that the proposed method was more robust to noise than the standard fcm algorithm.

Santanu Bhowmik et al (2012), This paper basically represented the survey on clustering based image segmentation. It described the various clustering techniques to achieve image segmentation. Clustering is done based on different attributes of an image such as size, color, texture etc. This paper covered the types of clustering such as log-based clustering, hierarchical clustering. It had described the segmentation in relevant to various image processing techniques.

S. Krinidis et al. (2010), Author had proposed algorithm named fuzzy local information C-means (FLICM) which can remove the shortcomings of the already known fuzzy c-means algorithms. It used fuzzy local information like spatial and gray level which guarantees noise sensitiveness and robustness to noisy images.

Y. Tarabalka et al (2009), Author had introduced a new spectral-spatial classification scheme for the hype spectral images which combines the results obtained by the pixel wise support vector machine classification and the segmentation map obtained by partitioned clustering. The proposed schemes perform well for the recognition of images having large spatial structures.

Li et al. (2012), Author has suggested new approach to lessen over-segmentation using both pre and post processing for watershed segmentation. A new watershed segmentation process that combines pre-processing of the image and post-processing of image objects to produce the final segmentation results. In the initial stage of the watershed transform, this not only generates a gradient image fromthe original image. It also presents the texture gradient. The texture gradient can be obtained by a gray-level co-occurrence matrix.

3. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware Requirements

- 20 GB HDD or Onwards
- 3 GB RAM or Onwards
- P-V Processor or Onwards

Software Requirements

- Windows OS 7 or Onwards
- MATLAB 2013 or Onwards

3. CONCLUSIONS

In this research work we explained limitations of performing manual analysis of anatomical structures such as right atrium, left atrium, right ventricle and left ventricle and then calculate its length, area, stroke volume, diameter, fractional shortening, and ejection fraction from input echocardiography image. We discussed that manual analysis of echo image resulted into the dependency of having special resource to analyze the echocardiography image accurately in order detect the heart cavities. Any false analysis from image leads to incorrect diagnosis and hence it is required to have specialized expert operator. Therefore, we introduced novel technique in this research for the analysis of echo images based on computer aided diagnosis (CAD) using image processing.

REFERENCES

[1] Aditi Roy, Shamik Sural, et. al., "A Hierarchical Approach for Content-Based Echocardiogram Video Indexing and Retrieval", ACM, ICCCS'11 February 12-14, 2011.

[2] M. Airouche, L. Bentabet, and m Zelmat, "Image Segmentation using Active Contour Model and Level Set Method Applied to Detect Oil Spills", Proc. of World Congress on Engineering (WCE 2009), Jul 1-3, 2009.

[3] Alberto Amato, Vincenzo Di Lecce, "Edge Detection Techniques in Image retrieval: The Semantic meaning of Edge", 4th EURASIP, Conf. on Video/Image Prpcessing and Multimedia Communications, 2-5 July 2003.

[4] Alison Noble J, "Ultrasound Image Segmentation: A Survey", IEEE Transactions on Medical Imaging, Vol. 25, No. 8, pp. 987-1010, August 2006.

[5] Echocardiography – Normal Examination and Echocardiographic Examinations, 2/e, by Bonita Anderson, MGA Graphics, Australia, May, 2007.

[6] Andrea Vattani, "k-means Requires Exponentially Many Iterations Even in the Plan", SCG'09, Proceedings of the 25th annual symposium on Computational geometry, ACM, Jun 2009.

[7] Andrew Trolsen, "Pro C# with .NET 3.0", 2007, APress, New York, USA.

[8] Ariel Fuxman, et al, "Improving Classification Accuracy Using Automatically Extracted Training Data", KDD'09, June 28–July 1, 2009, Paris, France, 2009.

[9] Aristidis Likasa, Nikos Vlassisb, Jakob J. Verbeekb, "The global k-means clustering algorithm", Journal: Pattern Recognition - PR , vol. 36, no. 2, pp. 451-461, 2003.

[10] Arnold W. M. Smeulders, "Content-based Image Retrieval at the end of the Yearly Years", IEEE Transactions on Pattern Analysis and machine Intelligence, Vol 22, No 12, pp. 1349–1380, Dec 2000.