Survey on Different Methods of Image Segmentation

Sreeji C, Vineetha G R, Amina Beevi A, Nasseena N

Department of Computer Science and Engineering
Sree Buddha College of Engineering,Pattoor
mail2sree1@gmail.com
chachu.gr@gmail.com
amilalu@gmail.com
nasseena.n@gmail.com

***Abstract*— Medical image segmentation place a crucial role in different medical imaging applications. Image segmentation is a process of partitioning a digital image into multiple segments. Segmentation makes the image into something, which are easier to analyse. Segmentation is needed in diagnosis, surgery planning and other medical applications. Current segmentation approaches are reviewed and reveals its advantages and disadvantages. Different segmentation methods are thresholding, region growing, clustering, artificial neural networks, deformable models, Markov random field models, deformable models, multi-agent system approach, wavelet segmentation and image segmentation using EIS.**

Keywords— Medical imaging, image processing, magnetic resonance imaging, image segmentation, computed tomography.

I. Introduction

Medical imaging is a part of biological imaging and it incorporates with radiology, microscopy, microphotography, nuclear medicine etc. medical imaging is a technique which helps the doctors to see the internal parts of the human body, helps in easy diagnosis of diseases. Medical imaging techniques available today are magnetic resonance imaging (MRI), computed tomography (CT), digital mammography and other imaging modalities.

For some applications we cannot process the whole image directly for the reason that it is inefficient and unpractical. So different image segmentation methods are needed. Image segmentation plays a vital role in biomedical imaging applications. Image segmentation is a process of partitioning a digital image into multiple segments to change the representation of the image into something that is easier to analyse. This segmentation is mainly done of one of two basic properties of intensity values. The properties are discontinuity and similarity. Similarity (homogeneity) in images is to partition an image into regions that are similar according to a set of predefined criteria in images. Homogeneity refers to the uniformity (similarity) of images. Discontinuity property can be stated as partition of an image is based upon sharp changes in intensity. The similarity of pixels mainly deals with the homogeneity of intensity in the image. Most of the existing segmentation methods rely on the segmentation of homogeneous images. The segmented images are visually different, homogenous and meaningful with respect to some properties. Methods for performing image segmentation vary depending on the application, imaging modality and some other applications. Selection of appropriate method to a segmentation problem is a difficult task.

Segmentation techniques can be stated as the methods that are used for extracting and representing the information from an image. The accuracy of segmentation is determined by the essential success or failure of computerized analysis procedure. A set of segments that collectively cover the entire image, or a set of contours extracted from the image is the result of image segmentation. Each of the pixels in a region are similar with respect to some characteristics or computed property such as color, intensity or texture. When applied to a stack of images, typical in medical imaging, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like marching cubes. There are so many applications for image segmentation .The main practical applications include content based image retrieval, Machine vision, Medical Imaging, Object detection, Pedestrian detection, Face detection, Brake light detection, Locate objects in satellite images, Recognition Tasks, Iris recognition, Traffic control systems. The main applications of medical imaging are Locate tumors and other pathologies, Measure tissue volumes, Diagnosis & study of anatomical structure.

This paper provides an overview of methods used for medical image segmentation. Methods and its applications that are appeared in recent literature are briefly described. We refer most commonly used modalities for imaging anatomy: magnetic resonance imaging (MRI), X-ray computed tomography (CT), ultrasound etc. most of the techniques described can be applicable to other imaging modalities.

II. BACKGROUND

In this section we define the terminology that is used through out this review.

A. Definitions

An image is a collection of measurements in two-dimensional (2D) or three-dimensional (3D) space.

Image segmentation is defined as the partitiong of an image into non-overlapping, constituent regions which are homogeneous with respect to some characteristics such as intensity or texture.

Labelling is the process of assigning a meaningful label to each region or class and is performed separately from segmentation.

B. Dimensionality

Dimensionality refers to whether segmentation is performed on a two-dimensional image or a three-dimensional image.

III. METHODS

This section describes several common approaches that have appeared in the recent literatures on medical image segmentation. Each method describes the overview of how it is implemented and also its advantages and disadvantages. Each technique is described separately, different methods can be used together to solve a particular problem [5][6].

Different segmentation methods described in this paper are thresholding approaches, region growing approaches, clustering approaches, deformable models, Markov random field models, multi-agent system approach, wavelet segmentation, image segmentation using EIS.

A. Thresholding

This is the simplest method of image segmentation. Tresholding is used to create binary image based on intensity of the image. This method attempts to find an intensity called threshold. This technique to partition an input image into two or more pixel value by comparing with the predefined threshold value T [1].

Let I(i,j) be an image,

$$I(i,j) = \begin{cases} 0 & p(i,j) < T \\ 1 & P(i,j) \geq T \end{cases}$$

Where p(i,j) refers to the pixel value at position (i,j). thresholding can be either locally or globally. Global thresholding partitions the image into two based on the above equation. In local thresholding image is divided into sub images and thresholding properties are derived from the local properties of its pixels.

The disadvantages of this methods are difficulty in finding the threshold value, in its simplest form two classes are generated and it cannot be applied to multiple channel images, thresholding does not take into account the spatial characteristics of the image. This causes it is sensitive to noise and intensity inhomogenity, which can occur in magnetic resonance images. Corrupt the histogram of the image, cause the separation more difficult [1].

B. Region Growing

Region growing is a widely used segmentation technique. Region of an image is connected based on some criteria. These criteria can be intensity information or edges in the image. Region based segmentation is partitioning of an image into similar areas of connected pixels based on some criteria [7].

This technique requires a seed point selected by the operator and extracts the pixels connected to the initial seed with the same intensity value. Te problems of discontinuous edges and no segmentation of objects without edges are eliminated.

Its main disadvantage is that manual interaction is needed to obtain the seed point. A seed must be planted for each region to be extracted. This method can be sensitive to noise, so the extracted region may have holes or it may be disconnected.

C. Clustering

This method is termed as unsupervised method because it does not use the training data. Clustering method train themselves using the available data.

Tree commonly used clustering algorithms are K-means clustering, fuzzy e-means algorithm and expectation-minimization (EM) algorithm. K-means clustering algorithm clusters data by iteratively computing a mean intensity for each class and segmenting the image by classifying each pixel in the class with closest mean. Fuzzy e-means algorithm allows soft segmentation based on fuzzy set theory. The EM algorithm uses the clustering principle; here data follows a Gaussian mixture model. Clustering method requires an initial segmentation. It do not directly incorporate spatial modelling. So it is sensitive to noise and intensity inhomogenities.

D. Deformable Models

These are physically motivated, model-based techniques for delineating region boundaries using closed parametric curves or surfaces that deform under the influence of internal or external influences [2]. A closed curve or surface must be placed near the desired boundary and then allowed to undergo an iterative relaxation process. This help to delineate an object boundary in an image. Internal forces are found from with in the curve or surface to keep it smooth through out the deformation. External forces are usually computed from the image to derive the curve or surface towards the desired feature of interest.

The main advantage of this method is their ability to directly generate closed parametric curve or surfaces from images and their incorporation of a smoothness constraint that provides robustness to noise and spurious edges [11].

Disadvantage of this model is that it requires manual interaction to place an initial model and select appropriate parameters.

E. Markov Random Field Models

Markov Random field Models (MRF) itself is not a segmentation method but a statistical model which can be used within segmentation methods. Here specifies the spatial interaction between nearby pixels. These interactions provide a mechanism for modeling a variety of image properties. In medical imaging they are typically used to take into account the fact that most pixels belong to the same class as their neighboring pixels [4].

MRF incorporated into clustering segmentation algorithm such as K-means algorithm. The segmentation is then obtained by maximizing the posteriori probability of the segmentation given the image data using iterative method such as iterated conditional models or simulated annealing.

The disadvantage of MRF models is the proper selection of parameters of controlling the strength of spatial interactions. Here loss of important structural details occurs. This method also require computationally intensive algorithm. Despite these difficulties, MRF are widely used not only to model segmentation classes, but also to model intensity inhomogenities that can occur in magnetic resonance images.

F. Multi-agent system approach

This method uses the properties of agent in a multi-agent environment. The agent can use its properties to perform segmentation over time. Segmenting images with high complexity is possible due to the automatic nature of the agent. The goal of the agent is to find out appropriate label for each pixel in image. Moderator agent creates and initializes the agent with in image. The agent takes the image and applies some values. The input image is divided into sub images and each agent works on each sub image and tries to mark each pixel as a specific region by means of priori-knowledge. The local agent marks each cell of sub image separately. Moderator agent checks the outcome of all agents' work to produce final segmented image [12].

The main use of this method is to segment medical images simultaneously with different regions of interest. This method is automatic and user interaction is not needed for segmenting the image. Advantage of this method is that segmenting image into more than two regions in a parallel way.

G. Wavelet segmentation

A mathematical tool for hierarchically decomposing functions in the frequency domain by preserving the spatial domain is the wavelet. For many advanced techniques of multi-dimensional signal processing and its applications Image segmentation is an essential step. Since their introduction [3], wavelets are used in applications such as computer graphics, image compression, digital image processing, and feature detection. By the use of wavelets, an image pyramid can be produced which is used for representing the entropy levels for each frequency.

The technique of wavelet transform is used for features extraction associated with individual image pixels. The Haar transform has been applied as a basic tool used in the wavelet transform for the image decomposition and feature extraction. The mathematical analysis of Haar transform is used as a tool for image compression and image pixels features extraction using decomposition and reconstruction matrices. This method is described for the description of the whole system enabling perfect image reconstruction. Wavelets are mainly functions generated from a single function by its operations dilations and translations. Haar transform is the simplest compression process of this type. Image Segmentation Using Wavelet Transform have the following subsections for describing this algorithm. The subsections are Image Features Extraction, Pixel Differences, Circular Averaging Filtering, Thresholding and Skeletonizing. The wavelet transform offers great design flexibility. Basis selection, spatial-frequency tiling, and various wavelet threshold strategies can be optimized for best adaptation to a processing application, data characteristics and feature of interest. To enable real time processing capability fast implementation of wavelet transforms using a filter-bank framework is used. Multi-resolution representation is one of the most important features of wavelet transform [14].

H. Image segmentation using EIS

Enhanced intelligent scissors (EIS) is used in the segmentation of medical images. In this method a boundary is formed around the region of interest based on a sequence of user selected points [8].

A phase based representation of the image is extracted as the external local cost using a robust interactive complex wavelet phase moment estimation scheme. The boundary extraction problem between two user-selected points is treated as an active contour problem and formulated as a HMM. A novel approach of solving the formulated HMM is based on internal and external local costs.

This method is highly robust to contrast non-uniformities and noise through the use of an external local cost based on complex wavelet phase coherence moments. A high level of segmentation accuracy can be achieved for medical images through this method.

IV. MODALITIES

This section describes the application of segmentation to various medical imaging modalities.

A. *Magnetic resonance Imaging (MRI)*

Magnetic resonance imaging is a medical imaging technique help to create the detailed structure of the human body. It uses non-ionizing frequency signals to acquire its images and is best suited for soft tissues. The image an resolution produced by MRI is quite detailed and can detect tiny changes of structures within the body. It will help in easy detection of diseases. MRI provides god contrast between different soft tissues. Many different pulse sequences exist for acquiring MR images. MRI is used for disease detection through out the body. In the head, traema to the brain can be seen as bleeding or swelling. Other abnormalities often found include brain aneurysms, stroke, tumors of the brain as well as tumors or inflammation of spline.

B. *Computed Tomography (CT)*

Computed tomography allows for 3-D imaging at resolutions equal to or better than MRI. It provides contrast between soft tissues but not as good as in MRI. Segmentation in CT has also been applied to thoracic scans using statistical clustering, a combination of region growing operations as well as sophisticated methods such as Markov random field and deformable models. CT images are also used in brain segmentation.

C. *Digital Mammography*

This method is typically performed for localization of tumors or other indicators of pathology. Mammogram is initially segmented into candidate region which are then labelled as suspicious or normal. In another approach the image is first processed to detect for the presence of pathology and segmentation is performed as a final step to determine precise location. Most common segmentation techniques used in mammography are thresholding and its variations. Extensions of region growing methods are also used.

D. *Ultrasound*

Ultrasound is a cyclic sound pressure. Ultrasound scan is a painless test that uses sound waves to create images of organs and structures inside human body. You lie on a coach and an operator places a probe on your skin over the part of your body to be examined. The probe is a bit. Lubricating jelly is put on your skin so that the probe makes good contact with the body. The probe is connected by a wire to the ultrasound machine, which is linked to a monitor. Pulses of ultrasound are sending from the probe through the skin into your body. The echoes are detected by the probe and are send down the wire to the ultrasound machine. They are displayed as a picture on the monitor. The picture is constantly updated so te scan show movement as well as structure. Ultrasound scan takes 15-45 minutes, depending on which part of the body is being examined. It is used in many situations.

V. CONCLUSION

We have looked different segmentation techniques. Segmentation has number of applications in medical imaging field. Future works in medical image segmentation are needed for improving the accuracy, precision, computational speed of segmentation methods and for reducing the manual interaction. Segmentation methods are particularly valuable in areas such as computer integrated surgery; here visualization of the anatomy is an essential component.

REFERENCES

[1] P.K. Sahoo, S. Soltani, and A.K.C.Wong. A survey of thresholding techniques. *Comput. Vis. Graph. Im. Proc.*, 41:233–260, 1988.

[2] G.B. Aboutanos and B.M. Dawant. Automatic brain segmentation and validation: image-based versus L.K. Arata, A.P. Dhawan, J.P. Broderick, M.F. Gaskil-Shipley, A.V. Levy, and Nora D. Volkow. Threedimensional atlas-based deformable models. In *Medical Imaging, SPIE Proc.*, volume 3034, pages 299–310, 1997.

[3] E.A. Ashton, M.J. Berg, K.J. Parker, J. Weisberg, C.W. Chen, and L. Ketonen. Segmentation and feature extraction techniques, with applications to MRI head studies. *Mag. Res. Med.*, 33:670–677, 1995.

[4] S.M. Choi, J.E. Lee, J. Kim, and M.H. Kim. Volumetric objection reconstruction using the 3D-MRF model-based segmentation. *IEEE T. Med. Imag.*, 16:887–892, 1997.

[5] Dzung L Pham, Chenyang Xu, Jerry L Prince, A survey of current methods in medical image segmentation.

[6] Tranos Zuva, Oludayo O Olugbara, Sunday O Ojo and Seleman M Ngwira, Image segmentation, Available techniques, and open issues, 2011.

[7] FREIXENET, J., MUNOZ, X., RABA, D., MARTI, J.& CUFI, X. 2002. Yet Another Survey on Image Segmentation: Region and Boundary Information Integration. Springer:408 - 422.

[8] Akshaya Mishra, Alexander Wong, Wen Zhang, Dzvid Clausi, Paul Fieguth, Improved interactive segmentation using enhanced intelligent scissors (EIS)

[9] Xiaolei Huang , Computer science and engineering department, Lehigh university, Medical image segmentation.

[10] Gavriil Tsech penakis, El-Baz, Acharya , Mirmehedi, Multimodality-the state-of the art, Medical image segmentation and registration methodologies, Deformable model-based image segmentation

[11] Yonggang Wang, Yun Zhu and Quiang Guo, Institute of image processing and pattern recognition Shanghai jiaotong University, Chaina, Medican image segmentation based on deformable models and its applications.

[12] Mahsa Chitsaz, Woo Chaw Seng, A multi-agent system approach for medical image segmentation. International conference on future computer and communication, 2009.

[13] H P Ng, S Huang, K W C foong P S Goh, W L Nowinski, department of diagnostic radiology, National university of Singapore, Medical image segmentation using watershed segmentstion with texture based region merging.

[14] Mallat, S. 1987. “A compact multiresolution representation: the wavelet model.” *Proc. IEEE Computer Society Workshop on Computer Vision,* IEEE Computer Society Press, Washington, D.C., p.2-7

[15] C. Florin, J. Williams, and N. Paragios, ‘Globally Optimal Active Contours, Sequential Monte Carlo and On-line Learning for Vessel Segmentation,’ *European Conf. on Computer Vision*, 2006.

[16] M. Kass, A. Witkin, and D. Terzopoulos, ‘Snakes: Active contour models,’ *Int’l Journal of ComputerVision*, 1:321-331, 1987.