Lecture 5
Fourth stage

Medical Imaging Processing II

Image Segmentation- I

By

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Segmentation is a process in which an image is divided into several sub regions based on a specific feature in order to pick up a region of interest. Segmentation process has enormous applications in the medical field. In the field of research and development much work has been done to overcome the problems faced by the segmentation process and yet there is a need of more effective and efficient work.

1. Purpose of Medical Image Segmentation

In the process of segmentation of a medical image, the details required by the segmentation process are highly dependent on clinical application of the problem. The purpose of segmentation is to improve the process of visualization to handle the detection process more effectively and efficiently. Other reasons of medical image segmentation can be seen in Fig. (1).

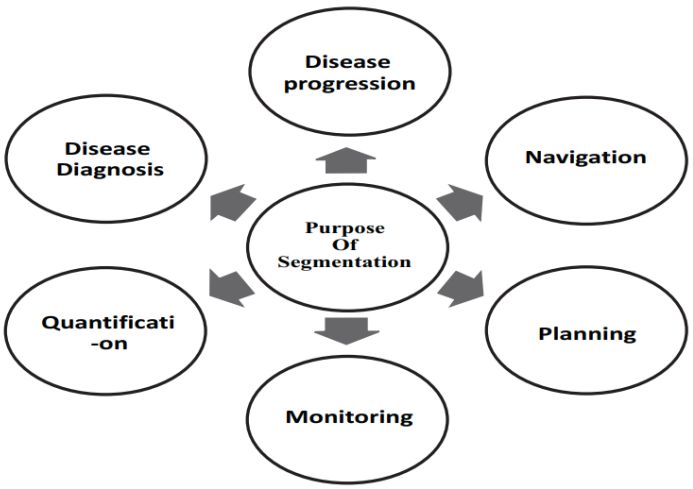


Fig. (1). Purpose of segmentation

2. Basic Principles of Segmentation

The process of segmentation is carried out on the basis of two central principles. These principles as shown in Fig. (2) are classified on the basis of features that contain texture, intensity, sharpness of edges and all the significant features in this context.

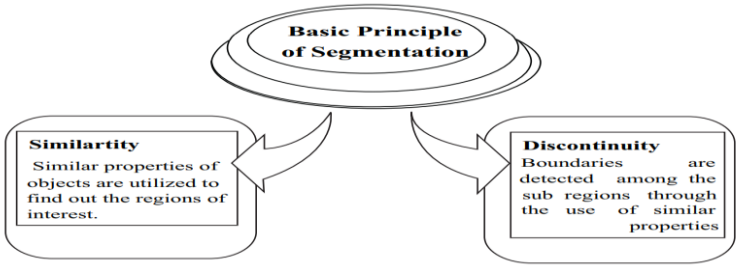


Fig. (2). Basic principles of segmentation.

3. Problems in Medical Image Segmentation

Segmentation of medical image faces many problems because of which the quality of segmentation process gets affected. These problems can be analyzed

- Noise
- Un uniform intensity
- partial volume averaging
- Lack of diverse features

The problem of uncertainty arises when there is noise in the image which makes the classification of image difficult. The reason is that intensity values of pixels are amended because of noise in the image. This alteration in the intensity values of pixels disturbs uniformity in the intensity range of image. Noise can be in the image because of motion in the picture, blurring effect and lack of diverse features etc. The problem of partial volume averaging causes the issue of inconsistency in the intensity values of image pixels. So in order to handle this uncertainty in the medical diagnosis systems image segmentation is playing a vital role.

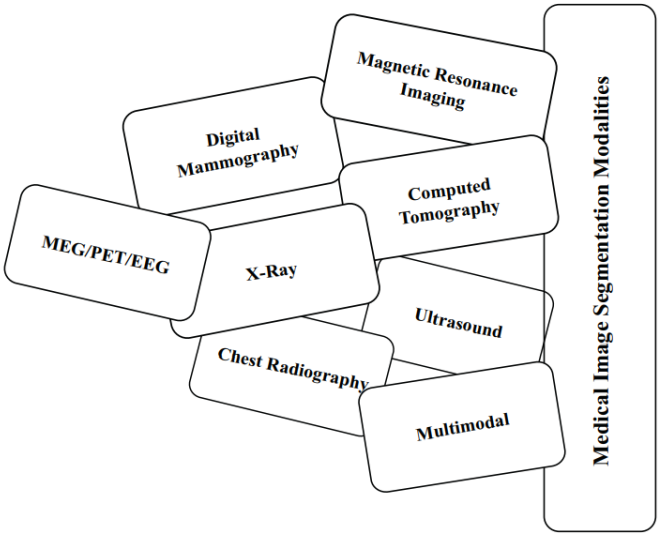
4. AI Techniques and Medical Image Segmentation

There is a need of automatic problem detection in the domain of medical image segmentation when the rate of making mistakes by the humans is increasing rapidly. AI is a field that is closely related and has many applications in the prospect of medical image segmentation. There are different reasons for using AI in medical image segmentation. These include:

- AI helps to analyze and classify data automatically using AI tools
- AI approaches are helpful for storage purpose
- AI techniques make it easier to retrieve data from a given medical image.
- AI provides an optimal way out to analyze the information in order to solve a problem.
- AI helps out in making effective decision in the field of medical image segmentation.

5. Modalities of Medical Image Segmentation

Segmentation process has many applications in the medical field. There are different medical modalities which are handled through the segmentation process. These modalities can be seen in Fig. (4). These modalities are discussed in the prospect of reconstruction.



5.1MRI

If we analyze the applications of segmentation in the medical field we can say that most work is carried out on the MRI brain images. The reason is that these images contain high signal to noise ratio which requires enhancement and segmentation of image to find out the region of interest. Another issue regarding these images is that they contain a variety of resolution because of which segmenting the image with required level of contrast is a great problem. The main applications is this regard are extracting volume of brain, segmenting different issues in matter of grey, white cerebro spinal liquid and to outline precise brain formations.

5.2 CT

Segmentation process has many applications in the analysis of computed tomography images. The main use of segmentation process in this regard is in the analysis of bones, thoracic scans, and segmentation of heart, stomach, brain and liver images and demarcation of abdominal aortic aneurysms. The contrast and resolution of these images is not as good as MRI images. Variety of methods is applicable in the segmentation process of CT images. These methods will be discussed later in this paper.

5.3 Ultrasound

Ultrasound images are usually with high rate of imperfection which makes it difficult to segment out the region of interest accurately. This reason caused many methods inapplicable for the segmentation of ultrasound images. Regardless of this issue some work still has been done in this regard. In most of the cases manual segmentation is done but these images are also used for the estimation of motion involved together with identifying pathology by means of textural classifiers .

5.4 Multimodal

In this case different modalities are used simultaneously to discover a problem. The information provided by different modalities is utilized to segment out a specific region of interest. The problem with this modality is that it is not always possible to gather multimodal data. Another issue in this regard is that they mostly require alignment process.

5.5Digital Mammography

Detection of different tumors is basically carried out in the segmentation of digital mammography. Most common
methods utilized for the mammography segmentation are variations in the process of thresholding.

5.6 Chest Radiography

In chest radiography, radiograph is projected to analyze or diagnose predicament of the chest area and its structure. The main problems under chest infection analysis are categorized as ABCDEF where each letter represents a different problem.

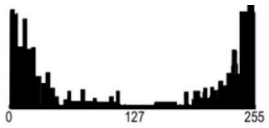
6. Thresholding

Thresholding is one of the most common methods used for image segmentation. The reason is that it is the most effective way when we want to analyze the foreground context by eliminating the image background. The basic working of this method is dependent on the intensity values of pixels in the image. The foreground image in this case is classified by comparing it through a threshold value with the background image that classifies it as a foreground image if there is a difference in the intensity values. Additional operations are needed to eliminate noise factor from the image and to acquire more effective results in the process of segmentation. In this case image is first converted into a binary image and then a defined threshold value is used which separates the different regions of image.

7. Simple thresholding

The most common image property to threshold is pixel grey level: $g(x,y) = 0$ if $f(x,y) < T$ and $g(x,y) = 1$ if $f(x,y) \geq T$, where T is the threshold. Using two thresholds, $T_1 < T_1$, a range of grey levels related to region 1 can be defined: $g(x,y) = 0$ if $f(x,y) < T_1$ OR $f(x,y) > T_2$ and $g(x,y) = 1$ if $T_1 \leq f(x,y) \leq T_2$.

Greyscale image "Boat"

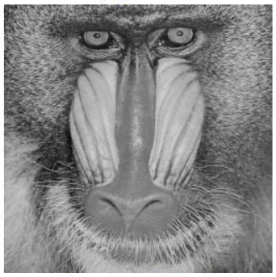


Its grey level histogram

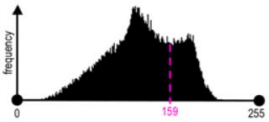
Binary regions for $T = 26$

Binary regions for $T = 133$

Binary regions for $T = 235$



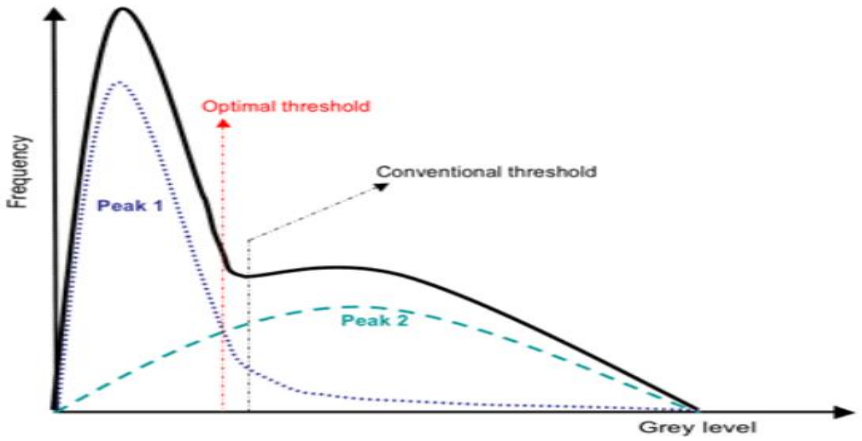
Greyscale image "Baboon"



Its grey level histogram

Binary regions for $T = 159$

A general approach to thresholding is based on assumption that images are *multimodal*, that is, different objects of interest relate to distinct peaks (or modes) of the 1D signal histogram. The thresholds have to optimally separate these peaks in spite of typical overlaps between the signal ranges corresponding to individual peaks. A threshold in the valley between two overlapping peaks separates their main bodies but inevitably detects or rejects falsely some pixels with intermediate signals. The optimal threshold that minimises the expected numbers of false detections and rejections may not coincide with the lowest point in the valley between two overlapping peaks:



Adaptive thresholding

Since the threshold separates the background from the object, the adaptive separation may take account of empirical probability

distributions of object (e.g. dark) and background (bright) pixels. Such a threshold has to equalise two kinds of expected errors: of assigning a background pixel to the object and of assigning an object pixel to the background. More complex adaptive thresholding techniques use a spatially varying threshold to compensate for local spatial context effects (such a spatially varying threshold can be thought as a background normalisation).

A simple iterative adaptation of the threshold is based on successive refinement of the estimated peak positions. It assumes that

(i) each peak coincides with the mean grey level for all pixels that relate to that peak and

(ii) the pixel probability decreases monotonically on the absolute difference between the pixel and peak values both for an object and background peak. The classification of the object and background pixels is done at each iteration j by using the threshold Tj found at previous iteration. Thus, at iteration j, each grey level f(x,y) is assigned first to the object or background class (region) if $f(x,y) \leq Tj$ or $f(x,y) > Tj$, respectively. Then, the new threshold, $Tj+1 = 0.5(\mu j,ob + \mu j,bg)$ where $\mu j,ob$ and $\mu j,bg$ denote the mean grey level at iteration j for the found object and background pixels, respectively:

References

- Muhammad Sharif, Afifa Masood, Mussarat Yasmin and Mudassar Raza A Survey on Medical Image Segmentation Saleha Masood, 2015, issue 11, pages 3-14 volume 3
- https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/topic3.htm