A Review: Haemorrhage Intracranial Segmentation in Ct Brain Images

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Abstract

This paper presents haemorrhage intracranial segmentation in CT brain images using different techniques and a combination of techniques like thresholding, region growing, watershed and clustering methods. MRI and CT scan are common imaging techniques used for the evaluation of brain hemorrhages. Number of researches has been done on MRI brain segmentation. On the other hand, research on segmenting CT brain images is not so vast. Image segmentation is the first and an important step towards image analysis. The segmentation methods performance is compared in terms of percentage of correct classification, computation time and other factors.

1. Introduction

Due to increased stress and the additional pressure on human body, our body is deteriorating with time. As the medicinal area is advancing, so are the diseases. The problems like brain stroke (a brain attack cutting off vital supplies of blood and oxygen to the brain) are not new but the increase in number is definitely alarming and as brain is the most important and delicate part of the human body, new ways for detecting and curing such detecting and curing such diseases are being explored in medical field. Brain hemorrhage is a type of stroke. Hemorrhagic strokes are the ones which result from rupture of a blood vessel or an abnormal vascular structure.

Generally, the hemorrhages inside the skull happens abruptly. It can result from physical trauma or nontraumatic causes. Physical trauma also called injury, is a physiological wound caused by an external source. In other words it is a physical wound or injury, such as a fracture or blow. On the other hand, nontraumatic causes are such as hypertension leading to spontaneous bleeding into brain tissues [3]. A quick brain damage can be the result of brain hemorrhage. A pressure is put on the brain and it is deprived of oxygen because of accumulation of blood. Moreover, the functions controlled by cells of brain are interrupted. Bleeding occuring within the skull is basically called as intracranial hemorrhage. In diagnosis physical symptoms are checked and a CT scan of the brain can be done. Further MRI can also be performed. Besides these some other tests also exist like Cerebrospinal fluid exam. Some tests involve checking for irregularly formed arteries or veins. A brain disease like hemorrhage is a medical emergency and hence it is necessary to evaluate the reasons responsible for bleeding. By this appropriate treatment of patient is possible. Damage to brain can be minimized by prompt medical treatment, hence improving a patient's chances of recovery. In some critical situations, surgery may be necessary. The brain picture is mainly taken by Magnetic resonance imaging (MRI) and Computed tomography (CT) scan. CT scan results are fast and thus valuable during immediate diagnosis requirement. In some cases for e.g. when patients are hooked with drips then also CT scan can be done unlike some other scanning methods. A CT scan discloses hemorrhages in many cases thus providing exact information to neurologist, necessary for deciding whether emergency treatment is required. Sometimes people assume, as MRI is better so it should be preferred. But, it is not always the right fact. Actually the requirement of scan varies for different diseases. For brain, MRI completes in about 30-45 minutes while 5-10 minutes may be taken by CT scan. So, in time taken by MRI a severe hemorrhage could kill a patient. Further, CT scan involves easy evaluation of abnormalities sometimes inspite of MRI, like in acute hemorrhage cases. On the other hand, an MRI easily detects small or subtle lesions. Radiation dose is high in CT scans in comparison to other diagnostic tests. This is a problem when patient has to go through repeated ct scan but not when patient has to go through scan once. This can increase risk of cancer. MRI does not involve X-rays like CT but uses magnetic power. Therefore, MRI can be safer than CT for a patient that has to go through multiple scan sessions. In acute head injury cases, MRI is not often used. The doctor may want an MRI after the acute phase has passed. MRI scan has some drawbacks, inspite of the fact that it gives better image details than CT. The time taken by MRI is having a long duration. Further, CT scanner is easily available in most hospitals but such may not be a case for MRI scanner. It is not suitable for patients with metallic implants. MRI scans create problems in case of confused or fidgety patients. It can be concluded that each type of scan has different importance for evaluation of different diseases. The definitive tool for accurate diagnosis of an intracranial hemorrhage is CT scan i.e. computed tomography as shown in figure 1. Typically computed tomography scanning of head is used to detect infarction, tumors, calcifications, hemorrhage and bone trauma. Head CT is the mainstay of diagnosis in ICH [2]. Acute bleeding appears hyperdense (whiter) on a CT, relative to the surrounding tissues as shown in figure1 [10].

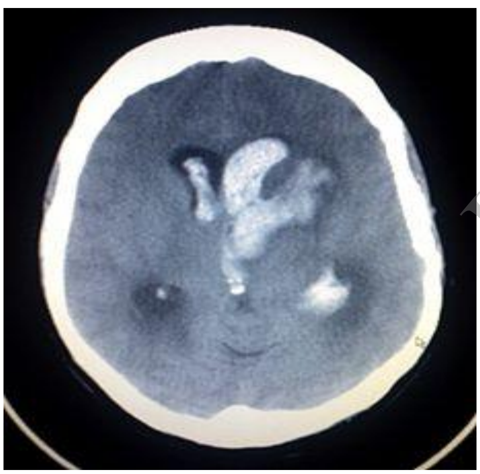

Fig1. CT scan of a spontaneous intracranial hemorrhage

Image segmentation is the process of partitioning an image into different segments. These segments often correspond to different tissue classes, organs, pathologies, or other biologically relevant structures in medical imaging. In medical image analysis, one fundamental problem is image segmentation which identifies the boundaries of objects such as organs or abnormal regions like tumors in images. Due to noise, low contrast and other imaging ambiguities medical image segmentation becomes difficult [1]. It is possible with the segmentation results to have shape analysis, detecting volume change, and making a precise radiation therapy treatment plan. In image processing, image segmentation techniques are considered a critical operation because further process steps have to rely on the segmentation results. For segmentation two principal ways exists i.e. manual segmentation which is done with the help of medical experts. The medical experts manually mark potions to be segmented with mouse. Another way is to perform automatic segmentation with the help of algorithms.

2. Available segmentation techniques

Unlike the vast literature in brain segmentation from MRI data, research on segmenting brain from CT images is sparse. Mostly different techniques are used jointly with one another to solve different problems in segmentation. Some of these techniques are discussed below.

a. Thresholding technique

Thresholding techniques have a central position in image segmentation. It includes local techniques and global techniques. The local techniques are related to local properties of the pixels. Further these are also related to pixels neighbourhoods. The global techniques uses globally obtained information for segmentation. The examples are like with the help of image histogram and global texture properties. Beside these, there are also split-merge and growing techniques. A thresholded image is defined as:

$$g(x,y)= \begin{cases} 1 \text{ if } f(x,y)>T \\ 0 \text{ if } f(x,y)\leq T \end{cases}$$

The gray levels of pixels belonging to the object are different from the gray levels of the pixels belonging to the background in many applications of image processing. Therefore, thresholding becomes a simple but effective tool to separate objects from the background. Thresholding operation outputs a binary image whose one state will indicate the foreground objects while the complementary state will correspond to the background. On the basis of an application, the foreground can be represented by gray-level 0 i.e. black and the background by the highest luminance i.e. 255 in 8-bit images, or conversely the foreground by white and the background by black. It is one of the important approaches to image segmentation. Often an image histogram is used to determine the best setting for the threshold [9]. W.

Mimi Diyana W. Zaki et al. [5] presented MLSA approach to segment intracranial brain hemorrhage ct scan images. In order to segment brain structure in ct images to detect hemorrhage, comparison of Multi-level Local Segmentation Approach (MLSA) with different techniques is done. MLSA helped to automate the segmentation process and resulted in average Percentage of Correct Classification of 97.1% and computational time of 0.17 seconds. Basically the use of automated multi-level Otsu segmentation helped to achieve good results.

b. Region growing technique

Region growing method is region based image segmentation. It involves the selection of initial seed points therefore also a pixel-based image segmentation method. This method examines neighbouring pixels of initial seed points and then determines whether the pixel neighbours should be added to the region. Basically it involves to start from some pixels (seeds) representing distinct image regions and to grow them, until they cover the entire image. Hence, a seed must be planted for each region that needs to be extracted. A. Bardera et al. [7] presented a semi-automated method for brain hematoma and edema segmentation and volume measurement using ct imaging. In this method a combination of region growing and level set approach is used. The level set approach requires propagation function. The results are almost similar to those which can be taken by manual segmentation technique. Therefore, this technique gives good results. 4 minutes of processing time is obtained in comparison with manual segmentation 10 mins time. In future work modification is there with focus on use of the method on a larger set of images. V. SĂCELEANU et al. [6] presented techniques to segment hemorrhage and calculation of its volume from both CT and MR images. Semiautomatic detection techniques like region growing, GVF snake and watershed are surveyed. The author observed which one of these provides fast and as per requirement results. By the comparison of these methods to manual segmentation, it is observed that interest areas are better shown by GVF. Watershed stood as second and third position is acquired by region growing algorithm. Future work includes further developments to combine GVF and Region Growing algorithm and to study the results with some other methods. Due to it speed of segmentation should be more fast.

c. Clustering techniques

Clustering algorithms does the same function like classifier methods without the use of training data. Therefore, these are unsupervised methods. In order to avoid drawback of lack of training data, clustering methods uses iterations. In other words, such methods train themselves using the available data. Figure2. shows three clusters representing results of cluster analysis [11].

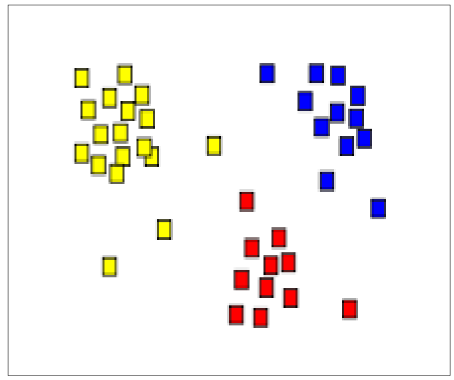

Fig2. Coloring of squares into three clusters representing results of cluster analysis

Some typical cluster models include:
1. Connectivity models: Example is hierarchical clustering that builds models based on distance connectivity.
2. Centroid models: Example for these models includes the k-means algorithm which represents each cluster by a single mean vector.
3. Distribution models: In this, modelling of clusters is done using statistical distributions like multivariate normal distributions . K-means algorithm, fuzzy c-means algorithm and expectation-maximization algorithm are most common. Tong Hau Lee et al. [8] proposed a technique which includes various unsupervised clustering techniques to have satisfactory segmentation results on CT images. Images of abnormalities, cerebrospinal fluid and brain matter are set to be obtained as target. K-means and FCM methods are together implemented firstly. Further a decision tree is used. It is observed in results that used method gives efficient results.

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3. Conclusion

Different techniques like thresholding, region growing and clustering techniques for CT brain image segmentation are reviewed in this paper. The proposed multilevel segmentation approach (MLSA) provides average PCC of 97.1% and average computation time of 0.17 seconds. The MLSA approach gives satisfactory results. This method is also compared to watershed and EM method and gives best result among them as shown in table 1 [5].

Table1. Comparison of computation time and percentage of correct classification of proposed MLSA, watershed segmentation and EM method

Methods	Average computational time (s)	Average PCC
Proposed MLSA	0.17	0.971
Watershed	1.15	0.678
EM	7.26	0.866

Another method combines region growing and level set method to segment brain. Volume measurement is also done. This technique gives processing time of 4 minutes for each study. Other techniques presented are region growing, watershed and GVF snake in which GVF gives best areas of interest. Watershed segmentation is less efficient than GVF. Further, region growing algorithm has the worst results among the other two. Other technique is unsupervised clustering to segment CT brain images. In this a combination of k-means and fuzzy c- means is implemented. These are also implemented individually. The results are shown in table 2 [8]. The experimental results show that combination of k-means and FCM is efficient for segmentation.

Table2. Results of the classification of the abnormal regions

Method	Precision	Recall
k-means	94.69%	87.70%
FCM	90.98%	81.97%
k-means & FCM	94.07%	90.07%

It can be concluded that measurement of hemorrhage volume using CT scan is an important factor. Practically it is usually performed by manual segmentation. Manual segmentation is time consuming and also operator dependent. So, there is a need of automated techniques which can be implemented with less processing time and with more accuracy.

4. Future scope

A combination of techniques when used rather than using a single technique gives better segmentation results. In future work, use of unsupervised clustering techniques in combination with some other segmentation techniques can be done for segmentation and hemorrhage area calculation.

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