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An Effective Image Processing Technique for Finding Brain Tumor Volume

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Abstract: Brain, the control center of the body controls it by receiving, interpreting and directing the sensory information throughout the body. Any disease in brain may lead to total collapse of entire function of the body. Tumor is one of the major disorders that affect the brain. It is a life threatening disease which poses a number of challenges to both medical and engineering technologists. The early diagnosis of brain tumor significantly increases the life span and improves the quality of life. In this study, a novel approach is proposed for the diagnosis of brain tumor in MRI images with the help of computer aided system. This method adopts a three-step approach to remove the skull, segmenting tumor and to calculate it's volume; in the first step an improved systematic application of morphological reconstruction operations is done for the brain image and a thresholding based technique is used to extract the brain tissues inside the skull and in the second step histogram thresholding is applied for tumor segmentation. In the final step tumor volume is calculated. The results are compared with Fuzzy C-Means and K-Means techniques to prove the superiority of the proposed method over the existing ones.

Key words: T1 weighted MRI images of brain, skull stripping, morphological operations, histogram thresholding, volume calculation

INTRODUCTION

The human brain (Gilat, 2008) is the center of the human nervous system. The higher functions of body like vision, hearing, speech, fine controls of movements, posture balance, etc. are controlled by brain (Poonam and Pruthi, 2013). A brain tumor is an abnormal growth of tissue in the brain. Unlike other tumors, brain tumors spread by local extension and rarely metastasize (spread) outside the brain. There are two types of brain tumors: primary brain tumor and secondary brain tumor (Adesina, 2010).

Primary tumor: The primary tumor cell is a tumor growing at the anatomical site where tumor progression began and proceeded to yield a cancerous mass.

Secondary tumor: Secondary brain tumors are tumors caused from cancer that originates in another parts of the body. The secondary tumors are not the same as primary brain tumors.

Brain tumors can occur at any age. The exact cause of brain tumors is not clear. The symptoms of brain tumors depend on their size and type and its location. Different location of tumor causes different functioning disorders (Jayaraman *et al*., 2010).

The most common symptoms of brain tumor include headache in early mornings, tingling in the arms or legs, seizures, balance and walking problems, changes in speech, vision or hearing, memory loss, etc. Brain tumors can develop at any age but are most common in children between the ages of 3-12 and in adults aged 55-65. Primary brain cancer is the second most common cause of cancer death between birth and age of 34 and the fourth most common cause of cancer death in men aged 35-54. The National Cancer Institute estimates there will be about 23,000 new cases of brain cancer diagnosed in 2012 (www.webmd.com). Even >400000 persons per year in the world (based on the World Health Organization (WHO) estimates) are suffering from this disorder (Joshi *et al*., 2010).

Early diagnosis of brain tumor is the important role for implementing the treatment planning. Diagnosis of brain tumor is a challenging task due to the tumor characterization in images such as size, shape, location and intensities and can only be performed by professional neuro radiologists. In the recent past several research works addressed the problems on early diagnosis and treatment of brain tumor with the help of various image processing techniques.

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Sivaramakrishnan and Karnan (2013) carried a research on detection of brain tumor using Fuzzy C-Means clustering and histogram techniques. Dhanalakshmi and Kanimozhi (2013) investigates an automatic brain tumor detection using K-Means clustering.

MATERIALS AND METHODS

A novel method is proposed in this study for brain tumor segmentation and its volume calculation. The computer aided system does it with various image processing techniques like morphological operations, histogram thresholding segmentation and volume calculation. Figure 1 shows the steps involved in the proposed method.

Image acquisition and preprocessing: MRI scan images of brain are acquired. These scanned images are either color or gray-scale images. If it is a color image that image is converted into gray-scale image. Preprocessing is done for improving the quality of optical vision. Skull stripping is the preprocessing step done here. It is the process of segmenting brain tissues from non-brain tissues in the whole-head magnetic resonance images. Skull is stripped by morphological operations like erosion which is followed by opening by reconstruction. Then dilation is carried out and opening closing by reconstruction is followed. Finally Otsu's thresholding is done to obtain skull removed brain (Ramesh *et al*., 2014). Figure 2 shows the acquired brain MRI image and the preprocessed brain MRI image.

Image thresholding: Thresholding is the simplest method of image segmentation. From the grayscale image, thresholding can be used to create binary images. Initially the threshold value is selected from histogram. To differentiate the pixels (ROI) from the rest, a threshold is chosen and that value is compared with each and every pixel value of brain image. If the threshold value is lower than pixel value of the image then retain that pixel in the image (i.e. will remain as it is). If the threshold value is greater than pixel value of an image then that pixel is removed from the image. After thresholding we get binary image and it has only two values binary '0' (0); binary value '1(255). The pixel values which are greater than the threshold value are set to binary '1' (255), remaining are set as binary '0'(0). The output image obtained is tumor with dark background.

Segmentation by thresholding: Morphological operations like erosion, opening closing by reconstruction is performed to segment the tumor in brain image. The erosion operator takes two pieces of data as inputs. The first is the skull stripped image which is to be eroded and second is a set of co-ordinate points known as structuring element. After that filling and region closing through morphological operation is applied to that eroded image. This operation fills the small holes and gaps in a single

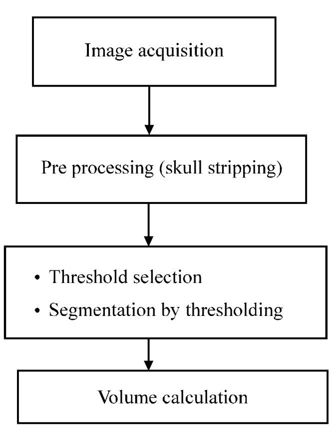

Fig. 1: Flow chart of proposed method

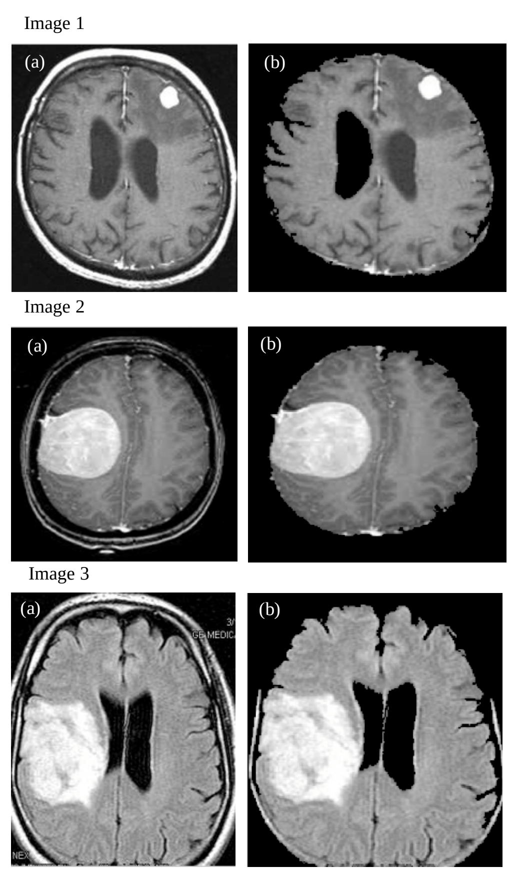

Fig. 2: Images 1-3: a) acquired brain MRI image and b) preprocessed brain image

pixel object. Closing protects coarse structures by closing small gaps and rounding off concave corners. Figure 3 shows the segmented tumor in brain MRI image.

Classification-volume calculation: The segmented tumor is the region of interest, the volume of which is to be found. The number of pixels in this region is obtained to find the volume of tumor. For the manually cropped tumor images, the images are first converted to binary ones and then the volume is found.

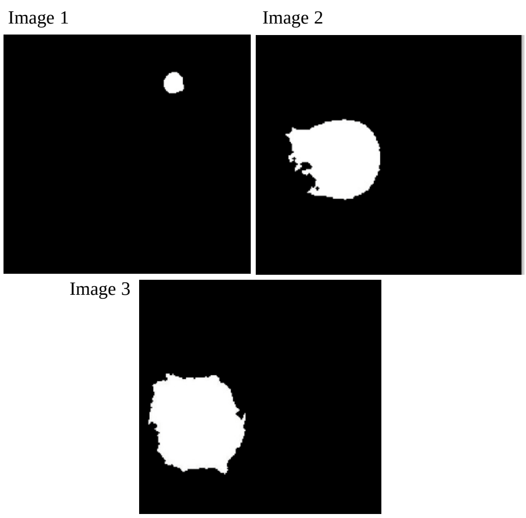

Fig. 3: Segmented tumor images

RESULTS AND DISCUSSION

The proposed method is applied on the selected T1 weighted images. The results are obtained as shown in Fig. 4 and Table 1. Figure 4 shows the volume of tumors.

Initially MRI images are acquired; pre processing is done to remove the skull in the images. Morphological operations are done to segment the brain tissues from the non-brain tissues. Histogram thresholding is then carried out to segment the tumor portion in brain image. Finally, tumor volume is calculated to find the size of the tumor.

The MRI images of tumor affected brain taken are subjected to FCM, K-Means, histogram thresholding and manual cropping techniques for segmenting the tumor.

Table 1: The volume of tumors

Images	Segmented FCM	Tumor K-Means	Images thresholding	Volume of manually cropped brain tumor images
1	3731	10920	212	397
2	3625	10956	2993	3768
3	8155	23643	4499	6834

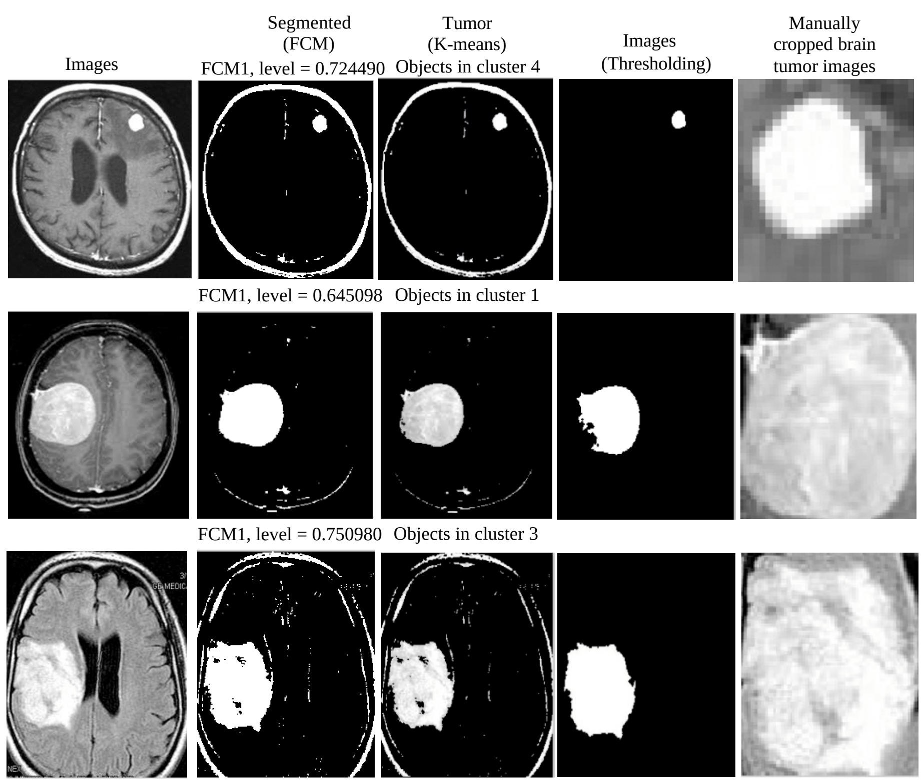

Fig. 4: The experimental results of proposed method

Then, the tumor volume is calculated. The results given in Table 1 show that histogram based thresholding technique applied to brain tissues after removing the skull are more accurate than FCM, K-Means techniques.

This method is simple and efficient, involves only few steps. The run time is lower when compared to other methods like FCM, K-Means.

CONCLUSION

In this study, a computer aided method is proposed for the volume of brain tumor using various image processing techniques. This method is applicable only for T1 weighted MRI images. The method should be modified suitably that it could be applied to T2 weighted MRI images also.

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