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-RESEARCH ARTICLE-

Detection And 3D Modeling Of Brain Tumors Using Image Segmentation Methods And Volume Rendering

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Abstract

This paper is on detecting brain tumors using MRI images, and obtaining a 3D model of the detected tumor. With the developed software, image segmentation algorithms were applied to MRI images to separate tumor from healthy brain tissues. In the development phase, various image segmentation algorithms were tried, and high success rates were aimed. After obtaining an algorithm with a high success rate, a 3-dimensional image of the detected tumor will be generated using volume rendering. With this image, features of the tumor such as its location, shape and how it spreads in the brain can be observed.

Keywords:

Tumor, mri, image segmentation, volume rendering.

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Introduction

A brain tumor is an abnormal growth of cells inside the brain. Tumors are classified as benign or malignant. Tumors with cancer cells are called malignant. They may spread to other tissues, and sometimes to the other parts of the body. If there are no cancer cells the tumor is called benign, they usually do not spread to nearby tissues (Angulakshmi & Priya, 2018). There are over 120 brain, and central nervous system (CNS) tumor types which are different for everyone. They form in different areas, develop from different cell types, and may have different treatment options (Sudharani et al., 2016).

There are different types of imaging modalities, such as Ultrasound Imaging, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and X-RAY. But when analyzing the

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internal structure of the body, like the brain, MRI is the most efficient method for detection of the brain tumor (Samriti & Paramveer, 2016). Tumors can be detected from 2D MRI images. However, they will not give the exact information about the shape, and size of the tumor that has to be removed which makes the operation more complex (Narayanan & Yogesh, 2018).

It is possible to detect a brain tumor automatically using image segmentation methods. But, due to irregular noises, and the complex structure of the brain, this task becomes difficult. This means using intensity alone, which is one of the most important features to discriminate between different types of tissues, is insufficient when making segmentation (Dubey et al., 2010). Because of this, a large variety of segmentation algorithms have been developed.

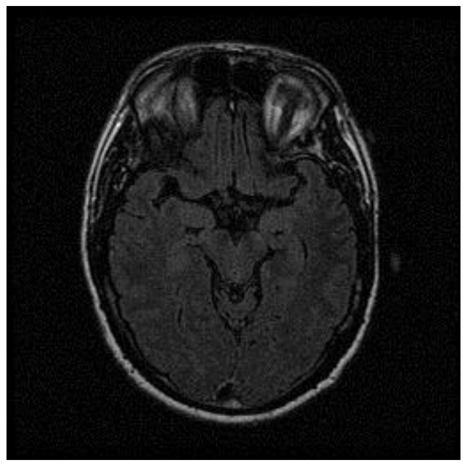

Figure 1. 2D MRI Image without tumor.

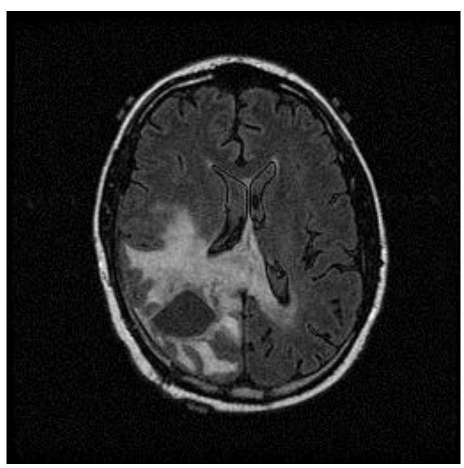

Figure 2. 2D MRI Image with tumor.

In the developed software some of these algorithms were used and modified to obtain an accurate segmentation. Then, volume rendering techniques were used to generate a 3D model. Volume rendering means displaying the 2D projection of a 3D dataset which is discretely sampled. In this study, these are the MRI slices. After combining image segmentation and volume rendering techniques a 3D model of the brain tumor is obtained (Gordillo et al., 2013).

Related Work

Methods for tumor detection can be divided into two general groups: with and without ANN (Artificial Neural Network). In this paper image segmentation algorithms without ANN were used.

The morphological examination is one of the methods used for tumor detection. The tumor is detected by examining the structure and shape (Gibbs et al, 1996). Another method used is the Robust Estimation method. With this method, both edema and tumor were detected with pixel density and geometric shape abnormalities (Prastawa et al., 2003).

Edge detection is an important technique used in image processing for detection and extraction of features. It is also used in image segmentation, which was used in some studies for marking the tumor area in the MRI image (Kumar, 2011); (Ananda & Thomas, 2012); (Banerjee et al., 2015). Later on, volume calculations were done besides detecting the tumor. If slice thickness, and pixel spacing attributes are known it is possible to calculate the volume of the tumor after detecting it by using the whole set of the MRI images.

In one of the studies performed in 3D, region growing technique was applied for detecting the tumor. Then the tumor was imaged using volume rendering, and the surface area, and volume of the tumor were also calculated (Sudharani et al., 2016). In (Mitra et al., 2017), FLAIR, T1C, and T2, which are different types of MRI images, were used together instead of using just one type of MRI image. A 3D image of the tumor was obtained by assigning the color values of these 3 different types of images to R, G, B values and, using them at the same time.

In order to increase the success of tumor detection, besides the improvements made in the image processing phase, preprocessing can be done to the images as in (Isselmou et al., 2016); (Kanmani & Pushparani, 2016) and (Toum et al., 2017). Algorithms such as median filter, histogram equalization, thresholding are very important because applying them at the preprocess stage greatly increase the success rate at the image processing phase.

In this paper, FLAIR MR images were used to develop the software with image segmentation algorithms without using artificial neural networks. Taken MRI images were processed automatically with the developed algorithms, and when the detection was completed for all of the slices, the tumor could be examined in 3D with the image obtained using volume rendering.

Material and Method

Datasets taken from the Cancer Imaging Archive website were used (“A growing archive of medical images of cancer”, n.d.). These are 2D FLAIR MRI slices of a couple of different patients. MRI slices of a patient are seen in Figure 3.

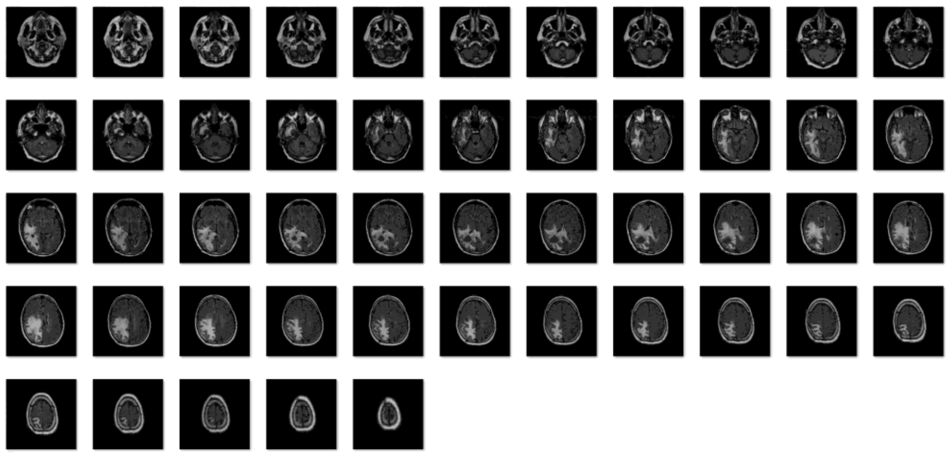

Figure 3. MRI slices of a patient.

The software was designed using C#, and OpenGL codes. The software takes MRI images as input. First, the noises in the images are cleared using thresholding since noises reduce image quality that makes detection even more complex. Red colored pixels in Figure 4. shows salt and pepper noise. Getting rid of them highly increases the image quality.

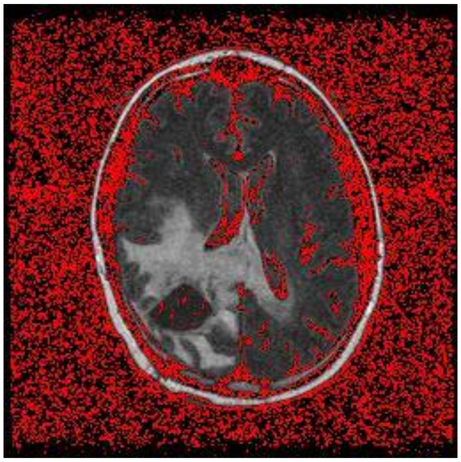

Figure 4. Salt and pepper noise.

To obtain a better image before tumor detection phase, histogram equalization and thresholding are also used. A histogram is a graph showing the numbers of color values in an image. Histogram equalization is also a method used to compensate for chromatic dispersion caused by the clustered color values of an image in a certain place. Thresholding is the display of only the desired color value range in the image.

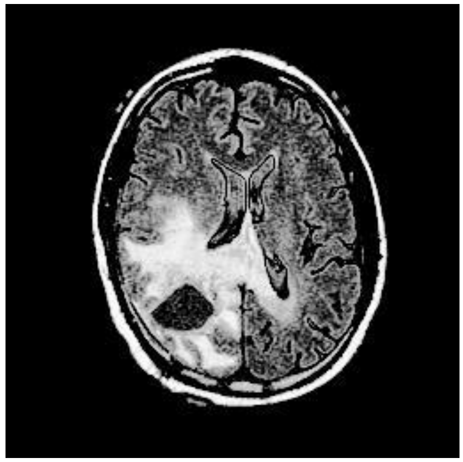

Figure 5. Image after histogram equalization.

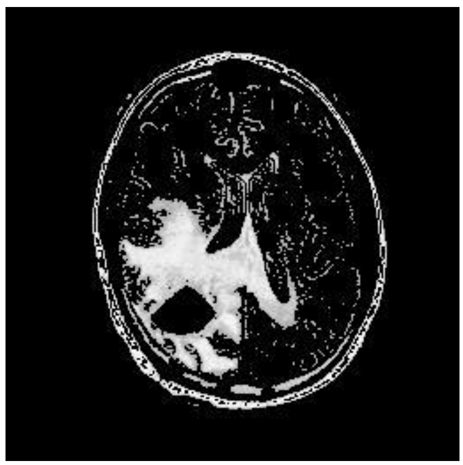

Figure 6. Image after thresholding.

After these methods are applied, additional filtering is done. Purpose of the additional filtering step is to clear more pixels which are not a part of the tumor. The decision for this is made by looking around every pixel to see if they are a part of a bigger object, and cleared if not. At the detection phase, radius based detection is applied. A certain radius around every pixel is checked and marked if full. Then the whole tumor is filled using the marked pixels. Once the image segmentation has been successfully accomplished for all of the slices, volume rendering is used to obtain the 3D model of the detected brain tumor. Volume rendering calculations are done according to the Regression Based Normal Estimation method. The 3D image is obtained by combining 2D MRI images that went through the image segmentation algorithms.

There must be a defined camera in the space to render the 2D projection of a 3D data set. Also, the opacity, and color of every voxel must be defined. Voxels are like pixels in a bitmap, but voxels represent values in three-dimensional space. RGBA (red, green, blue, alpha) transfer function is used to define the RGBA value for voxels which defines their opacity and color. In this transfer function R, G, B values define the color, and a value that defines the opacity. Figure 9 shows the block diagram of the process.

Figure 7. Image after additional filtering.

Figure 8. Detected tumor.

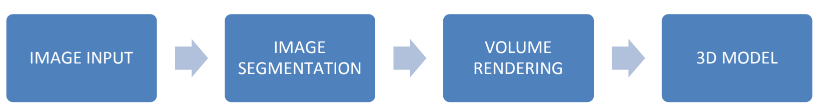

Figure 9. Block diagram of the process.

Results and Discussion

After completing all the steps, an output image was obtained. In this image, the detected tumor was marked with red. In the developed software all slices can be inspected by a scrollbar both when the slices are first loaded to the program and when the output images for all of the slices are obtained. Output images can also be saved for using them later. By combining marked images and the volume rendering, the 3D model of the tumor was reconstructed as seen in Figure 11. Saved output images can be loaded any time to inspect, and to get the 3D model.

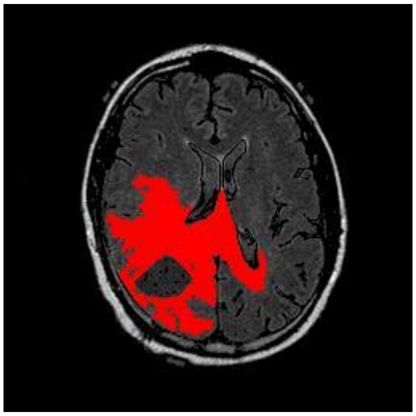

Figure 10. Output image.

Figure 11. 3D Model of the tumor.

Conclusion

Nowadays, brain tumor cases are quite frequent. Brain tumors are graded from the first grade to the fourth grade, from low to high according to the risk they carry. Therefore, the sooner the tumor is detected and intervened, the better the treatment will be. But, if we have more information about the tumor location, size, and how it spreads inside the brain, the success rate of the operation will be greatly increased and the risk will be minimized. The developed software reconstructs the 3D shape of a detected tumor. It allows getting more information about the tumor in a short period of time.

This research is still in progress. The software needs more improvements to detect tumors better. Tumor detection with higher accuracy, and a better 3D model that allows us to determine the tumor location, shape and how it spreads in the brain is aimed.

Acknowledgements

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