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RESEARCH ARTICLE

Segmentation of Brain Tumor using Multiple Threshold Technique

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ABSTRACT

Radiology use medical imaging techniques to comprehend the structure and physiological functions of the body in both healthy and diseased subjects. A non-invasive method for viewing internal body structures can be performed by using magnetic resonance imaging (MRI). MRI characterizes soft tissue more accurately than other imaging methods like CT. In the current study, space-occupying lesions are visualized using MRI imaging. Slices of MRI data are used to analyze lesions. Single slice analysis is inappropriate to determine the lesion's size and volume. Hence, the MRI sequence is used to segment the lesions. Following segmentation, we view the MRI 2D image in 3D to look for lesions, or aberrant tissue, in the brain. The lesion is then visualized by performing clipping. This research suggests segmenting brain tumors automatically and even provides a 3D visualization for a more thorough study. Here, a space-occupying lesion is segmented from a T2 weighted Flair sequence of MR images in DICOM format, and by employing the segmented volume, 3D rendering and clipping are made possible.

Keywords: DICOM format, Magnetic resonance imaging, Space occupying lesion, Segmentation, Volume rendering

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INTRODUCTION

The radiographic examination is one of the most crucial diagnostic tools in medical practice. The care of patients is significantly impacted by medical imaging. They are crucial in the diagnosis and care of patients. Clinically diagnosing and treating patients with brain disorders typically involves a thorough examination of medical images. X-ray, computerized tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET) scans are the most often utilized imaging modalities. The identification and evaluation of brain space occupying lesions (SOL) are considerably improved by the technical advancement of CT and MRI, the use of contrast material in the imaging of brain tumors, as well as the introduction of novel imaging techniques.

When a brain space-occupying lesion is clinically suspected, a radiologic evaluation is necessary to highlight the lesion's exact location, size, and surrounding structures. Due to the physics involved in each modality, they have a particular role in the radiologic evaluation of the lesion. According to the conventional theory of the development of malignant tissue, any descendent of the founder cell is capable of forming a new mass once the tumor has acquired the capacity to spread. The emphasis is on early diagnosis and the requirement to eradicate all tumor cells in order to stop the recurrence.

Because of its great spatial resolution, non-invasive nature, and excellent contrast for soft tissues, MRI is a good tool for studying the brain. The MRI modality is more beneficial since it offers specific information on the tumor's kind, location, and size. Due to this, MRI is the preferred imaging method for use in diagnostic procedures, surgery, and monitoring therapeutic results.[1] When the number of patients increases, automated detection methods have a significant role in diagnosis and treatment planning since they have improved the understanding of normal and pathological examination for medical research.

The tumor region can be split and shown in 3D for better neurosurgical planning, making moving about in the structure possible. The MRI T1 and T2 relaxation durations can differ. Images from T1 and T2 have varying intensities, and each has a unique meaning. The term "spin to spin relaxation" refers to T2. Water has a long T2 and appears bright in T2 weighted MRI, but fat has a short T2 and appears black. T2

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weighted MRI sequences show SOLs to be bright. The use of T2-weighted imaging in functional MRI is appropriate for detecting tissue edema.[2] The most common cause of SOL of the brain is cancer, although it can also be brought on by other pathologies such an abscess or a hematoma. SOL are visualized using segmentation and 3D volume rendering of the brain MRI sequence.

The technique of dividing a digital image into several regions is known as image segmentation. The analysis of anatomical structures, including bones, blood vessels, tissue types, and diseased regions, can be done using image segmentation, which is widely used in the field of medical imaging.

Image segmentation is mainly used to identify boundaries and objects in images. It involves giving each pixel in an image a label so that pixels with the same label have similar properties. An image segmentation process yields either a group of segments that collectively cover the full image or a set of contours that are taken from the image. All of the pixels in a region are analogous to one another for some attribute or computed property like color, intensity, or texture.

The lesion is examined on a single slice of the MRI data. A single slice cannot adequately examine the volume and extent of the lesion, nor can the precise location of the lesion in the brain be seen. Deriving from the MRI sequence, the lesions are segmented. A suitable segmentation technique will be used to retrieve the lesion from the MRI sequence from pre-processed images. Binary images will be the result of the segmentation techniques.

The standard radiological investigation could be made easier with the use of three-dimensional (3D) volume visualization. A 2D series of images provides enough details to make the essential inference. The use of all the available 2D data to build an appropriate depiction in 3D has many benefits and enables accurate diagnosis.

Surface rendering and volume rendering are two methods for 3D visualization. Surface representations like triangular patches or polygonal meshes are used in surface rendering to represent 3D objects. These algorithms share the common issue of categorizing data in binary terms; either a surface passes through the current voxel or it does not.

The internal structures of the 3D models can be observed by volume rendering, which is utilized to address the drawbacks of surface rendering.[3] There are several different types of segmentation techniques to segment a tumor from an MRI of the brain. The choice of method depends on the application area because no such algorithms consistently deliver excellent results for all MRI types of brain images. Thresholding-based segmentation, region-growing-based segmentation, K-means clustering algorithm, and morphology-based segmentation are some segmentation techniques available.[4,5]

LITERATURE SURVEY

Ming *et al.*,[6] suggested an algorithm to identify the presence of a brain tumor in MR images using the k-means clustering technique. Hossam *et al.*[7] have labeled related components using k-means clustering. With the aid of the object rendering process in 2D slices, clustering is accomplished, and a 3D patch is subsequently produced. Vasuda *et al.*[8] developed a method for employing fuzzy clustering to detect tumors in MR images. This algorithm employs the fuzzy C-means technique. However, its main flaw is the length of time needed for computation.

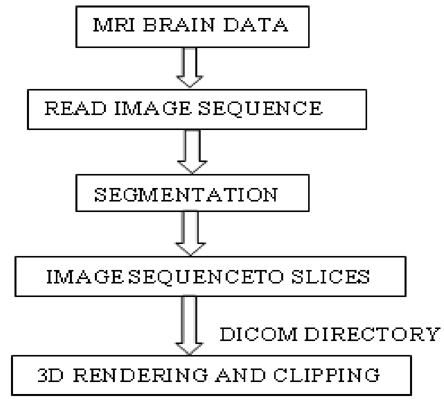

Figure 1: Flow chart of proposed methodology

In order to acquire the binary image, which is necessary for all types of segmentation, thresholding techniques can be helpful. It makes the assumption that images are made up of regions with various grayscale ranges. The desired classes are separated by a threshold intensity value, which is determined using a thresholding technique.[4] Nandish *et al.*,[3] developed a method for the segmentation of space-occupying lesions and the segmented MRI sequence is then used for volume rendering. Planes are clipped during volume rendering to identify and locate the lesions occupying space.

The threshold technique used for segmentation converts images to binary by choosing a threshold value from an image histogram. The current work uses the Otsu approach, one of many segmentation strategies based on thresholding. Otsu is a technique for global thresholding. In this method,[5] the within-class, between-class, and total variance are used to calculate the threshold operation, which is observed as the division of an image's pixels into two classes, objects and background, at grey level t.

The current work employs an image processing approach to separate brain lesions that occupy space and a visualization tool to show the separated lesions.

MATERIALS AND METHODS

Software platforms used in the present work include Insight Toolkit, visualization Toolkit and DICOM Viewer shows the flowchart of proposed method.

MRI Brain Data

T2 weighted brain MRI sequence are acquired and used to analyze. In T2 weighted MRI, water has long T2 and appears bright and fat has short T2 and appears dark. SOL appear bright in T2 weighted MRI sequence.

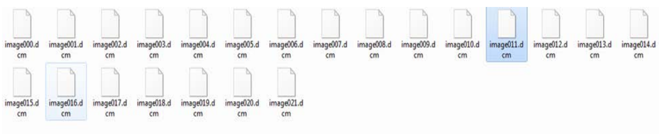

Figure 2: MRI input images

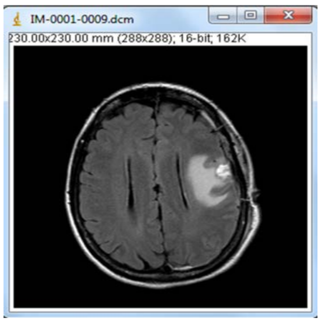

Figure 3: Axial section of Brain MRI image

Read Image Sequence

MRI data have multiple slices, and it is taken at specific slice thicknesses and distance between the corresponding slices. All slices of MRI is read as a sequence and made into the analyzed form that is .hdr file which is represented in 3 dimensions. The analyzed format images contain two files, header file (.hdr) and image file (.img). The image file has the data in binary form, and the header file has information about the voxel and its directions. Analyze is a format for multi-dimensional voxel data. This file is given as an input to the segmentation step.

Segmentation

Segmentation of the brain images is carried out mainly for the purpose of volumetric measurements and visualization. The segmentation method proposed in this work is based on Otsu algorithm. Otsu multiple threshold segmentation technique is used to automatically perform clustering-based image thresholding. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that intra-class variance is minimal, or equivalently the inter-class variance is maximal.

Algorithm

- Compute histogram and probabilities of each intensity level
- Set up initial value for class probability ωi(0) and mean μi(0)
- Step through all possible thresholds t = 1… maximum intensity
- Update ωi and μi
- Compute variance σ_b^2(t)
  Desired threshold corresponds to the maximum σ_b^2(t)
- The class probabilities and class means are computed iteratively to obtain desired outcome.

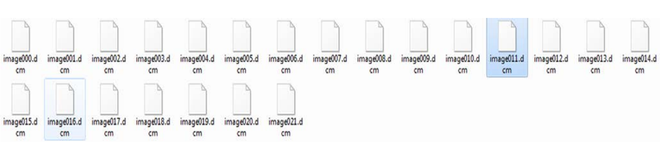

Figure 4: Folder consisting of segmented MRI images

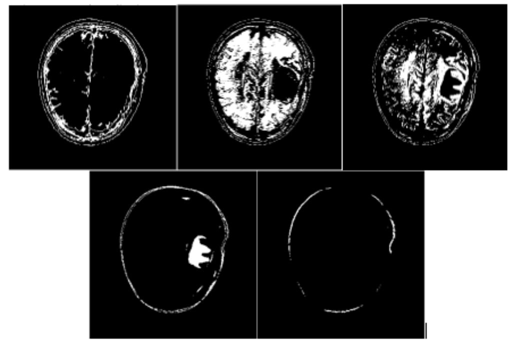

Figure 5: Resultant of Otsu Multiple Threshold Technique, first row shows results for Threshold value 1 (Left), 2 (Middle), 3 (Right), second row shows for Threshold value 4(Left) and 5 (Right).

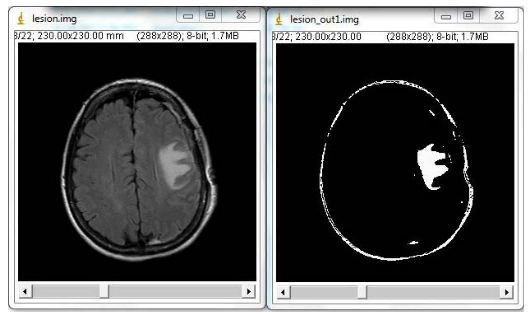

Figure 6: Input image to the segmentation process and its resultant output

Image Sequence to Slices

After segmenting the analyze file, data should be used for 3D volume rendering. Output file is generated as a sequence of binary images. All slices from sequence should be separated as an individual image file and store all the image files in to a directory. The directory containing the binary images is given as input to the volume rendering algorithm.

Volume Rendering and Clipping

Three-dimensional (3D) volume rendering has the potential to simplify standard radiological studies. Volume rendering can be done by an optical method using volume ray casting. Ray cast mapper is used to render the surface from volume data. Fixed point volume ray cast mapper is used instead of volume ray cast because it handles all the multi-component data and uses fixed-point computations and space hopping for high performance. Clipping the planes of the 3D model allow the user to look at the interior of the structure and analyze it. Clipping also helps determine the depth and other measurements of the space-occupying lesions in the brain.

RESULTS AND DISCUSSION

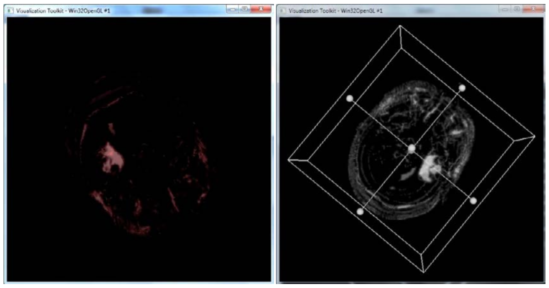

Figure 7: Volume rendering of MRI segmented data (left) and volume rendering with Maximum Intensity Projection and Depth peeling

The results obtained for MRI input sequence and the corresponding segmented MRI images are described in this section.

Figure 1 shows the flowchart of proposed method.

Figure 2 shows the sequence of MRI input images.

Figure 3 shows a specific input image- The axial section of the Brain MRI.

Figure 4 shows the segmented MRI images.

output images obtained after applying the Otsu multiple Thresholding technique to a single slice of MRI image are shown in Figure 5.

Figure 5 shows the result of Otsu multiple threshold technique for various thresholds.

Figure 6 shows the input to the segmentation process and the corresponding resultant output image obtained after being processed.

From the analysis of the result, a suitable output image where the lesion of interest is highlighted is obtained in the fourth level of the segmentation process, and this image is used for further 3D rendering. Figure 7 shows the volume rendering of the segmented MRI brain data.

Figure 7 depict the volume rendering of MRI segmented data (left) and volume rendering with maximum intensity projection and depth peeling. This indicates that 3D volume rendering has the potential to simplify standard radiological study and helps in accurate diagnosis.

CONCLUSION

Segmentation of the brain and rendering the 3D model has become significantly important in research and clinical diagnosis in the present day. The proposed methodology allows us to segment the space-occupying lesions, and the segmented MRI sequence is used for volume rendering. Also, while volume rendering, planes can be clipped to analyze and locate the space-occupying lesions.

Segmentation is performed using Otsu multiple threshold techniques, converting the image to binary by selecting number of threshold value. A respective number of outputs are generated for multiple threshold values. The required resultant of Otsu multiple thresholding is selected to perform volume rendering. In the proposed work, MRI T2 sequence is used. MRI study involves different protocols depending on the findings. So the developed segmentation can be implemented for different MRI sequences like spoiled gradient recalled echo (SPGR), fluid-attenuated inversion recovery (FLAIR), turbo spin echo (TSE), diffusion-weighted imaging (DWI) etc. In the future, the proposed work can be extended to make the measurements of the lesions, perilesional edema and other parameters which can be used in the clinical diagnosis and treatment planning.

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