DETERMINING THE LOCATION AND SIZE OF THE BRAIN TUMOR WITH 3D SLICER

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Abstract

Cancer is the leading cause of death in both developed and developing countries. Brain and other central nervous system (CNS) tumors are among the most fatal cancers and account for substantial morbidity and mortality in the United States. Brain tumors account for 85% to 90% of all primary central nervous system (CNS) tumors. Worldwide, an estimated 308,102 people were diagnosed with a primary brain or spinal cord tumor in 2020. Detection of brain tumors on MR images is a time-consuming and laborious task performed by radiologists and doctors. Efforts have been made to develop automated systems to assist physicians in tumor detection and diagnosis and treatment planning. Our aim here is to make the tumor tissue easier to detect by labeling and thresholding the brain MR image.

Brain Tumor and MRI

Tumor is a tissue formed in a place where it should not be in our body or the uncontrolled growth of any tissue. Although not every tumor is lethal, there is an exceptional case of brain tissue in brain tumors. Benign tumors are formed by the unwanted growth of the brain's own cells while the malignant brain tumors are often the result of the spread of cancerous cells from other parts of the body. Since the brain tumor has the potential to hamper the functions of body functions,and although not all brain tumors are lethal, they must be kept under control and intervened correctly.

The issue of how brain tumors are understood is very important and it affects the success in both diagnosis and treatment. Biopsy can be difficult, risky and time-consuming with known methods to obtain information about the lesions in the brain. In the evaluation of brain tissue and its diseases, the imaging method that comes to the forefront is the Magnetic Resonance Imaging (MRI). MRI provides a rough idea about the type of brain tumor, and then it is clearly understood whether there is a brain tumor with the pathology laboratory examination. While it is possible to obtain information about the anatomical and structural state of the brain with standard MR imaging, it is also possible to obtain information about the metabolic, biochemical and hemodynamic structure of the brain with new technologies. Technological developments provide great convenience in diagnosis and identification of pathologies. With advanced MR imaging methods such as Diffusion MR, DTI MR, Functional MR, Perfusion MR and MR spectroscopy, the extent, type, metabolic-biochemical structure of the tumor, the areas and pathways that allow speech, vision and movement can be evaluated.

In routine brain examinations, T1 and T2-weighted images are obtained in the axial, coronal and sagittal planes. The images we base our study on are the axial, sagittal and coronal planes of the MR image of the brain.

Location and Size Detection of Brain Tumor Using 3D Slicer

3D Slicer is a free open-source software application for medical image computing. It is similar to a radiology workstation as a clinical research tool and supports versatile visualizations, provides advanced functionality such as automated segmentation and registration for a variety of application domains. The software platform is being used in this research for the better analysis, , visualization (including volumizing) of MRI images. 3D Slicer is frequently and extensibility used used by researchers today because of its powerful plug-in capabilities to add algorithms and applications. The following steps are followed in our project:

Step 1- Data Addition: DICOM MRI images are uploaded to the application. For the experiment the available datasets in the application are used

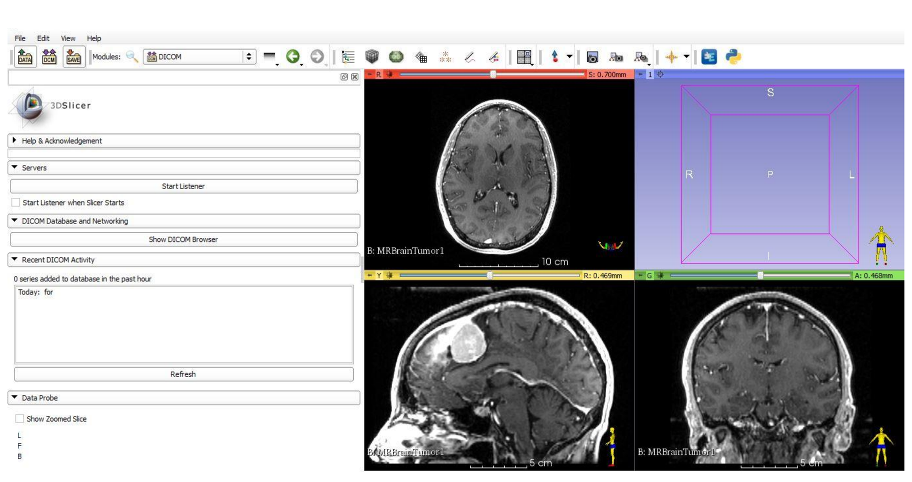

FIgure 2. Step 1: Data Addition

Step 2- Volume Rendering and Cropping: The region of interest (ROI) is selected and volume of these parts is created. The regions other than the selected volumes are rendered invisible.

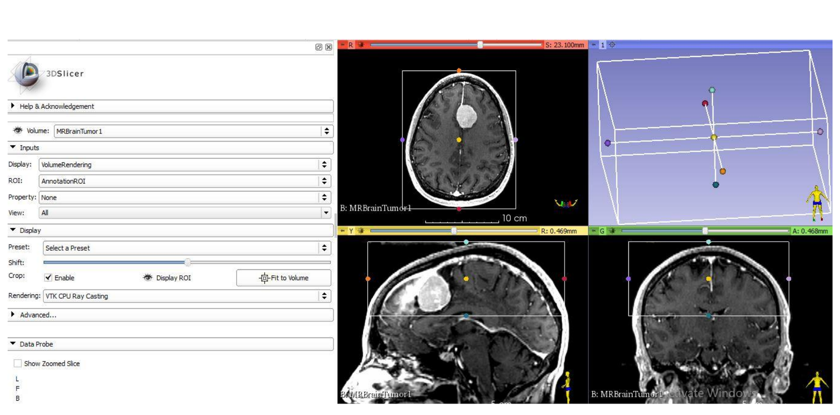

FIgure 3. Step 2 (a): Volume Rendering

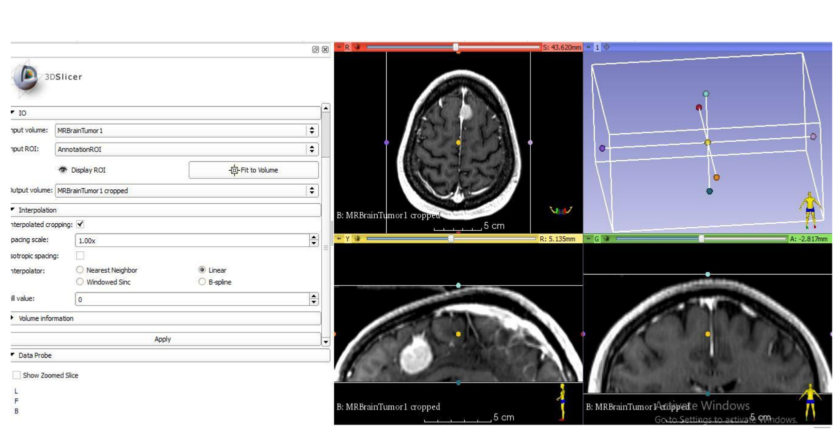

FIgure 4. Step 2(b) Cropping Operation

Human Brain

The brain, which is one of the most complex and large organs in our body, consists of over 100 billion nerves. It communicates with many connection points called synapses in the nerves. There are multiple specialized regions in the brain that work together. The cortex is the part where voluntary movements and thinking begin.The brain stem, where basic functions such as sleep and breathing are kept under control, is located between the spinal cord and the other part of the brain. The basal ganglia, the structure at the center of the brain, coordinates messages between the brain and other regions. The cerebellum is responsible for balance and coordination. The brain consists of several lobes in terms of structure.

The frontal lobe is responsible for motor functions and decision making, the parietal lobe controls handwriting, problem solving, body position, the temporal lobe is responsible for hearing and memory, and the occipital lobe controls the visual processing system of the brain.

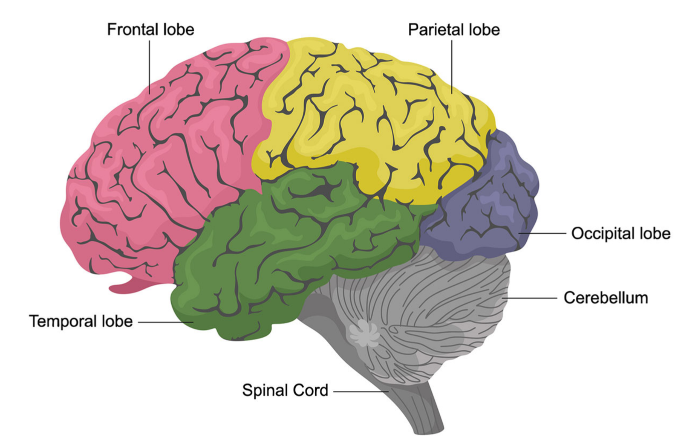

Figure 1. Anatomy of the Brain

Step 3- Labeling the ROI: Labeling the region of interest gives important information about the brain based on the structure of the brain. In our application, we are labeling two parts; the first is the tumor area, and the other is the entire Central Nervous System (CNS), which is outside the tumor area. While labeling the tumor region, green color from the GenericAnatomyColors is selected. The remaining region CNS is labeled in the yellow color. The minimum and maximum threshold values (Threshold Range) for the regions we have labeled are specified

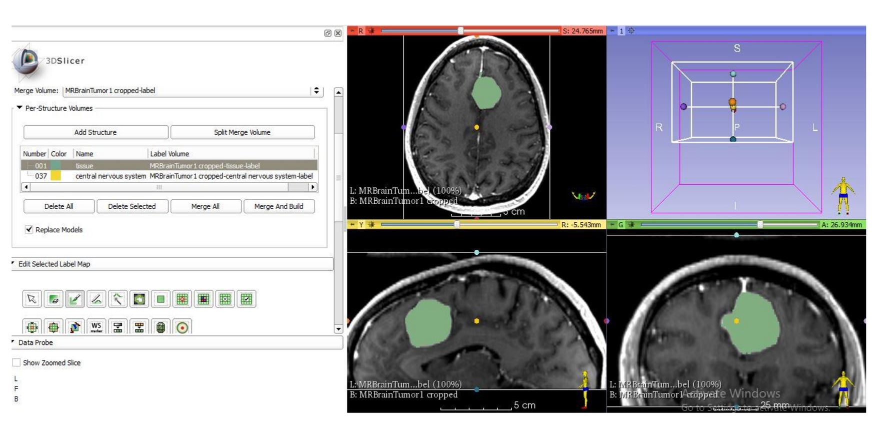

Figure 5.Step 3 (a): Labeling the Tumor

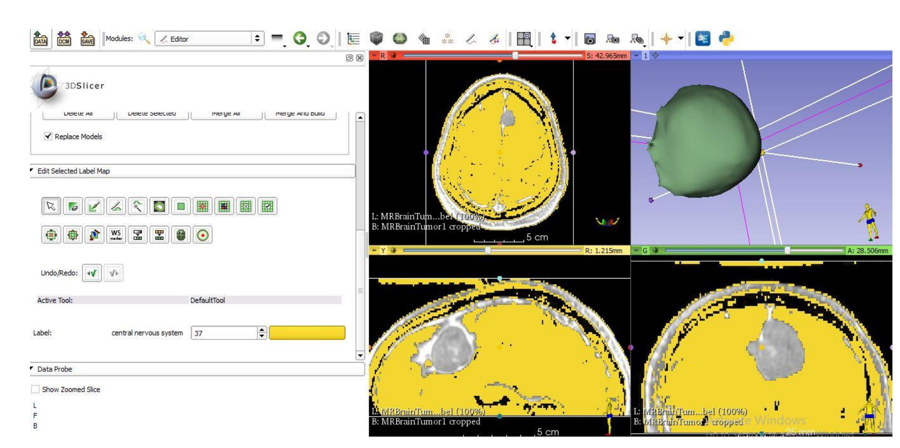

Figure 6. Step 3 (b): Labeling the CNS

Step 4- Model Creation: The model of the regions labeled are processed separately. While performing these operations, Laplacian image filtering operation is used. A 3D data is obtained from the segmented images based on the cross-sectional images. This outcome of this step can give health personnel volume information about the tumor area and the remaining area.To resolve the problem of the the CNS region surrounding the tumor area preventing the tumor from being seen, the permeability of the CNS region is increased making tumor region clearly visible.

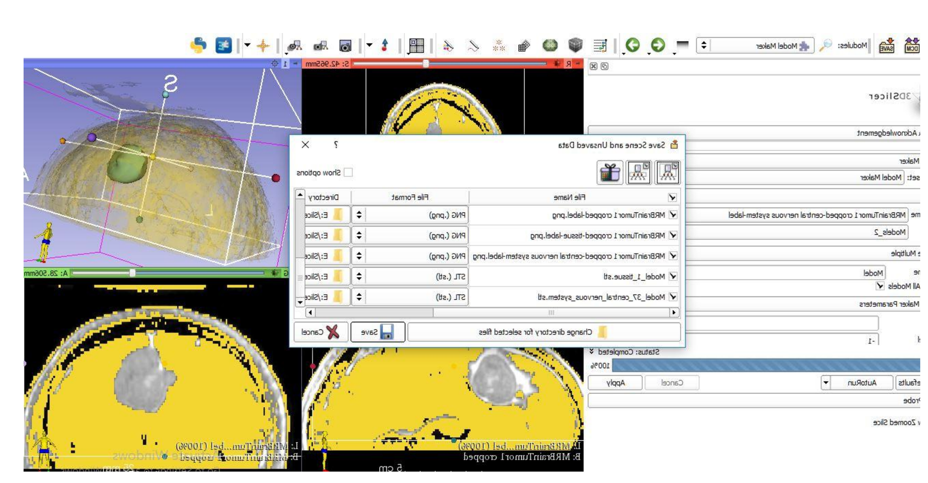

Figure 7. Step 4: Obtaining a 3D Model of Tumor and CNS

Step 5- Results and 3D Printing: The three-dimensional version of the pure tumor and the brain are obtained in the STL (.stl) format. This format is used for saving designs used in the stereolithography process and includes a 3D master design for the creation of various other prototypes. this way, a three-dimensional image of the brain is obtained. The obtained 3D image can be provided a concrete structure with the 3D Printer and can provide us information about parameters such as the volume and weight of the tumor.

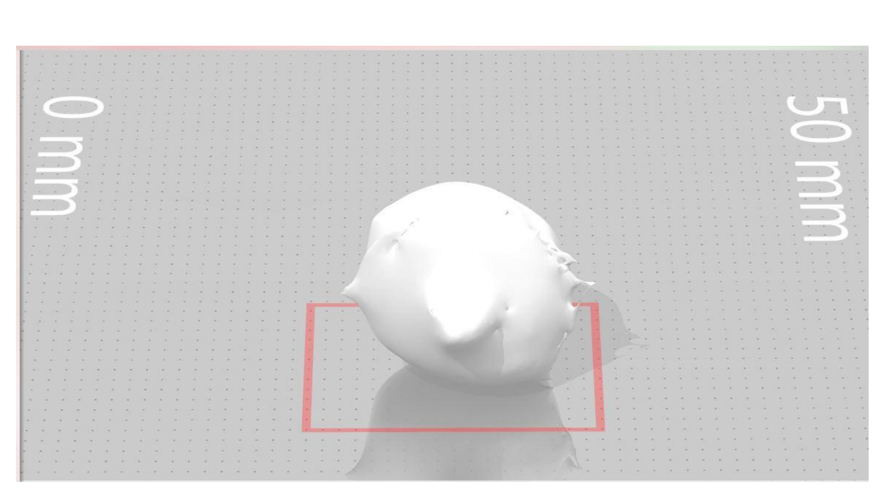

Figure 8. Step 5(a): 3D version of Brain Tumor ready for printing

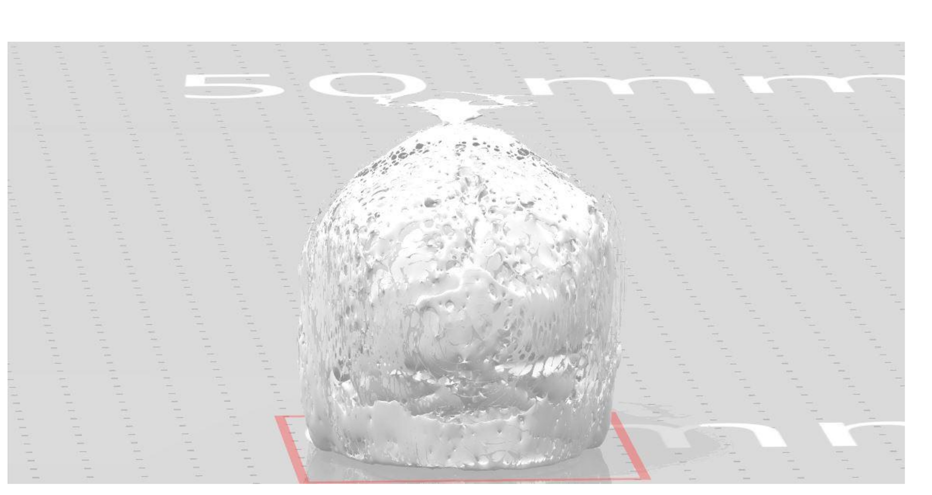

Figure 8. Step 5(b): 3D version of Brain ready for printing

Conclusion

This approach provides a promising approach to understand the size and location of the tumor. With the availability of raw MRI datasets, this process can be tested in understanding its application in a wide range of medical imaging applications. However, the results till date, shows that the steps followed can provide us visible outcomes in the experiment and a possibility of its further growth for future applications.

References

1. A. Fedorov et al. / Magnetic Resonance Imaging 30 (2012) 1323–1341
2. CA CANCER J CLIN 2021;71:381–406
3. Yu et al, Cancer Data Science and Computational Medicine