

MR Brain Volume Analysis Using BrainAssist™

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Abstract

In this paper we present a recently developed tool named BrainAssist, which can be used for the study and analysis of brain abnormalities like Focal Cortical Dysplasia (FCD), Heterotopia and Multiple Sclerosis (MS). For the analysis of FCD and Heterotopia we used T1 weighted MR images and for the analysis of Multiple Sclerosis we used Proton Density (PD) images. 52 patients were studied. Out of 52 cases 36 were affected with FCDs, 6 with MS lesions and 10 normal cases. Preoperative MR images were acquired on a 1.5-T scanner (Siemens Medical Systems, Germany). The acquired 3D MRI data set consist of approximately 120 T1 weighted coronal slices with flip angle 15°, matrix size 256 x 224, FOV 256, thickness 1.5 mm and pixel spacing 0.89 mm.

Keywords: BrainAssist, Brain Segmentation, Focal Cortical Dysplasia, Heterotopia, MR images, Multiple Sclerosis, Volume Calculation.

1. Introduction

BrainAssist is a recently developed comprehensive, user friendly, state-of-the-art medical image analysis tool used for the detection and analysis of Focal Cortical Dysplasia, Heterotopia and Multiple Sclerosis from T1 and PD weighted MR brain images. FCD lesions [1-3] are difficult to distinguish from non-lesional cortex and their delineation on MRI is a challenging task. Though sequences like FLAIR (fluid attenuated inversion recovery) can detect a large majority of these lesions, there are smaller lesions without signal changes that can easily go unnoticed by the naked eye. Although MRI has allowed the recognition of FCD in an increased number of patients, standard radiological evaluation fails to identify lesions in a large number of cases due to their subtlety and the complexity of the cortex convolution.

BrainAssist assists the radiologists and neurologists in identifying the lesions based on the characteristics of FCDs like increased cortical thickness, reduced demarcation of the gray-white matter junction and hyperdensity of gray and subcortical white matter [1-3]. The tool highlights the suspected FCD areas. Heterotopia is also characterized as a type of cortical dysplasia.

Heterotopia [4, 5] is a neurological disorder caused by clumps of grey matter being located in the wrong part of the brain. Sub-cortical focal heterotopia appears as islands of gray matter within the white matter. BrainAssist highlights the dislocated gray matter in the white matter. Multiple Sclerosis [6-9] is analyzed based its high intensity in the Proton Density (PD) MR image. For the analysis of FCDs and Heterotopia, T1 weighted MR images and for the analysis of Multiple Sclerosis, Proton Density (PD) images are used. The most carefully collected data from international surveys indicate that about 1 adult in 200 suffers from recurrent epilepsy. If we include infants who have suffered seizures caused by fever (usually a temporary problem) and adults who have only ever had one seizure, the figure rises to about 1 person in 80 [10]. Almost 25% of brain epilepsy is caused due to FCD. The survey indicates the importance of having automatic and perfect tools for FCD analysis.

This paper is organized as follows: Section 2 describes the pre-processing operations, such as, scalp removal & tissue segmentation. Analysis of FCD, Heterotopia and Multiple Sclerosis are explained in Sections 3,4 and 5 respectively. Section 6 deals with image saving options. Final conclusion and remarks are added in section 7.

2. Pre-Processing Operations

To find the Focal Cortical Dysplasia lesion areas with BrainAssist, we have to give T1 weighted MR volume (in DICOM format) as the input. The Graphical User Interface of BrainAssist is shown in Fig1. The upper panel shows input of the three different orthogonal views of volume data such as coronal, sagittal and transverse / axial view respectively. The lower panel shows output image of each and every process. If we click on the image in any one of the views, the other views will automatically synchronized with the corresponding position. The upper right most panel shows the histogram of the 3D volume image. The text boxes shown below the histogram is reserved for entering threshold values. These threshold values are used for gaussian curve fitting and brain tissue segmentation. The patient info panel displays the patient information like patient name, age, sex, ID, date of birth and image modality. The lower right most panel is devoted for showing volumetric information of brain.

2.1 Loading an Image

BrainAssist supports 2D and 3D DICOM files with extension of .dcm. To load the volume image we can use either File menu (File -> Open) or we can use Toolbar. BrainAssist displays the input data in three orthogonal views (Coronal, Sagittal & Transverse). While loading the volume data / image the patient's information are gathered from the header file and is displayed in the patient information area as

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shown in Fig.1 and the voxels are converted into 1 x 1 x 1 scaling space. Fig.2 (a) shows the *Browse for* open a file. Fig. 2 (b) shows the scaled version of T1 weighted MRI.

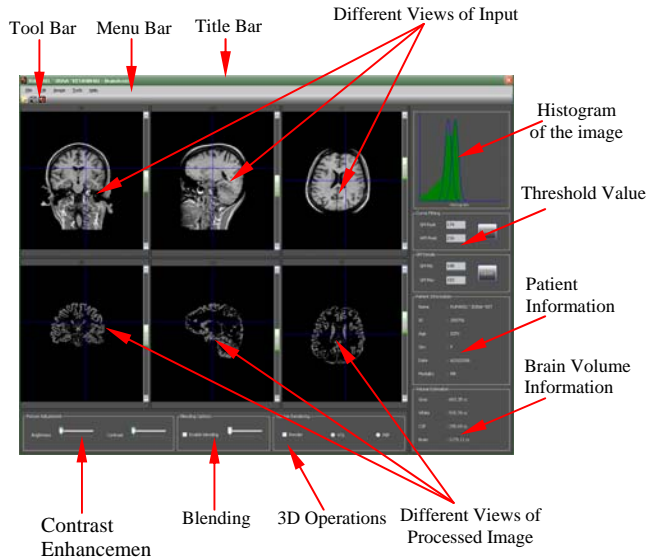


Figure 1: Graphical user Interface of BrainAssist

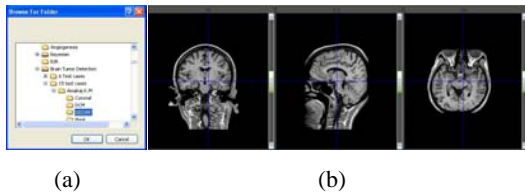


Figure: 2 (a) File open window, (b) Three different orthogonal view

2.2 Scalp Removal

BrainAssist supports fully automated scalp-stripping operation. The scalp removing operation consists of multi-stage procedure. For removing the scalp it's enough to press the scalp removal button in the Tool bar icon or Tool menu (Tool->Scalp Removal). Before FCD analysis we should remove the non-brain tissues, such as scalp (skin that covers the top of the head) and lipid areas from the MR T1 weighted images. The scalp removing operation is the combination of morphological operations and 3D connected component analysis. Fig.3 shows the scalp removed MRI volume image.

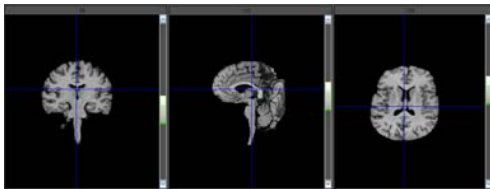


Figure 3: Scalp Removed Brain Volume

2.3 Cerebrum Segmentation

Removing cerebellum from scalp stripped brain image can reduce false negatives in automatic FCD analysis procedure. BrainAssist can remove cerebellum area from the scalp removed brain volume without any reference atlas

dataset. In existing tools, the cerebrum extraction is achieved by registering the image with brain atlas. But in BrainAssist, it is implemented based on statistical information of brain. Fig. 4 shows the cerebellum removed brain volume.

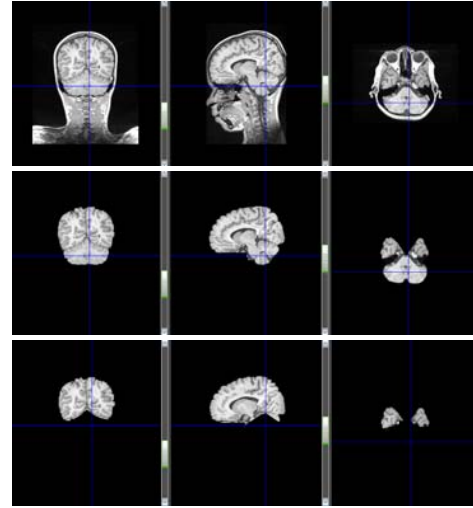


Figure: 4 (a) Original brain volume in different isometric view, (b) Scalp removed, (c) Cerebrum segmented from scalp removed brain volume

3. FCD Analysis

On T1-weighted Magnetic Resonance Imaging (MRI), FCD is generally characterized by variable degrees of cortical thickening, reduced demarcation of the gray-white matter junction and hyper-density of gray and sub-cortical white matter. FCDs are always classified as GrayMatter. So it's enough to keep GrayMatter area for FCD analysis.

3.1 GrayMatter Segmentation

The segmentation is done with fitting gaussian curve on the histogram of scalp removed volume. In the histogram we can see three peaks, the first peak corresponds to CSF, the middle peak corresponds to gray matter and the last peak correspond to white matter as shown in Fig.5.

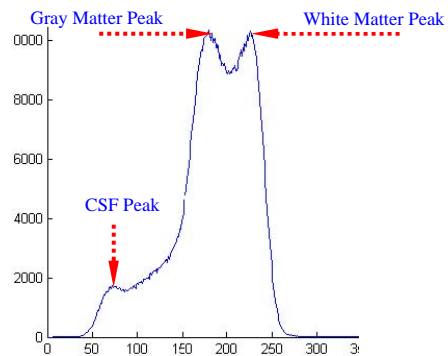


Figure: 5 Histogram of scalp removed image

For isolating gray matter click on the gray matter peak, and then click the text box named GM peak. Now, we can see the corresponding value appeared in the text box. After selecting of gray matter peak, click on the white mater

peak and repeat the earlier steps, the white matter peak value appear in the WM peak text box. After selecting booth peaks, click the *Draw button* to fit the Gaussian curve on the histogram. Fig.6 shows the two curves fitted on the histogram. Red curve corresponds to gray matter and green curve corresponds to the white matter. We can isolate the gray matter area by clicking the intersection of gray-white matter and other end of gray matter (starting end) in the curve. Now click the *submit* button, we can see the areas other than gray matter is subtracted from the brain image. Fig.7 shows the GrayMatter segmented image

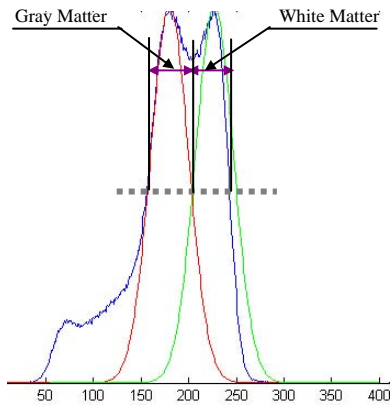


Figure: 6 Gaussian Curves fitted on the histogram

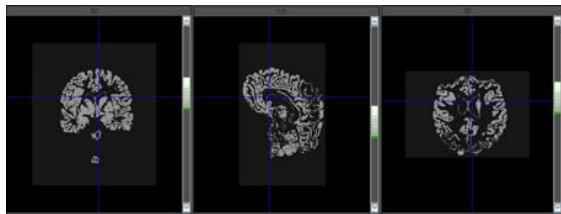


Figure: 7 Gray Matter Segmentation

After gray matter segmentation simply click on FCD analysis icon in the Tool bar or Tool menu (Tool -> FCD analysis) we can start the FCD analysis process. While running this process, it will automatically calculate the 3D thickness map and compute complex map. For easy visualization and analysis, the complex map is displayed using *hot* colormap. Fig.8 shows the complex map with *hot* colormap. The areas near to white color are suspected areas.

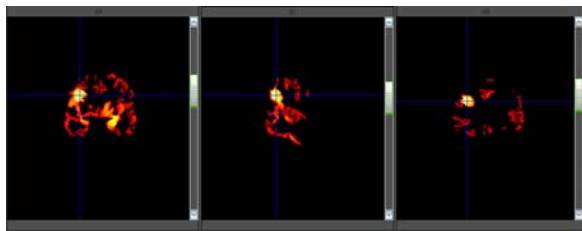


Figure: 8 Complex Map with Hot Color map

BrainAssist provides copious options for better analysis like, blending the complex map with original image. For activating the blending option, the blending check box

should be checked and by moving the slider bar we can change opacity of the original image. Fig.9 shows the super imposed image.

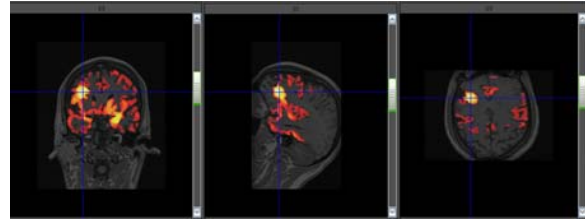


Figure: 9 Complex map Superimposed with Original Image

4. Heterotopia Analysis

Heterotopia appears as islands of gray matter within the white matter [4, 5], BrainAssist highlights the dislocated gray matter in the white matter. Heterotopia is characterized as a type of cortical dysplasia hence the procedure for analysis the heterotopia is same as the FCD analysis. First we have to remove the scalp by clicking scalp removal button. The nature of Heterotopia is dislocation of gray matter in the white mater. So, we have to separate gray matter alone by using scalp-removed histogram (explained in section 3.1). After gray matter segmentation, click on FCD analysis icon in the Tool bar or Tool menu (Tools -> FCD analysis). Fig.10 shows an example of Heterotopia diagnosis. The areas near to white color are suspected areas.

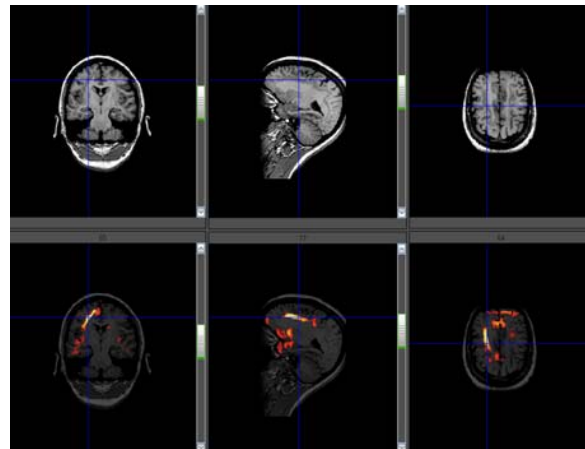


Figure: 10 Heterotopia Analyses

5. Multiple Sclerosis Analysis

Multiple Sclerosis (MS) Lesion is an inflammatory disease of the Central Nervous System (CNS). The pathology underlying this disorder is the formation of multiple demyelinated plaques. Lesions are typically widely disseminated in the central nervous system (CNS), with the predilection of well myelinated areas: the optic nerve, periventricular white matter, corpus callosum, cerebellum and cervical cord. In people affected by MS Lesion, patches of damage called plaques or lesions appear in seemingly random areas of the CNS white matter. MS lesion is characterized as a type of white matter lesion and it spreads more than one area. [6 - 9] So, MS lesion analysis is not very similar as FCD

analysis. First, we have to remove the scalp by clicking scalp removal button. For MS Lesion analysis its enough to search in high intensity area alone in MR Proton Density (PD) images. So, the high intensity area has to be first segmented from MR PD images. After high intensity segmentation by simply click on MS Lesions analysis icon in the Tool bar or Tool menu (Tool -> MS Lesions analysis) we can start the MS Lesion analysis process. Fig. 11. shows the complex map with *hot* colormap. The areas near to white color are suspected areas.

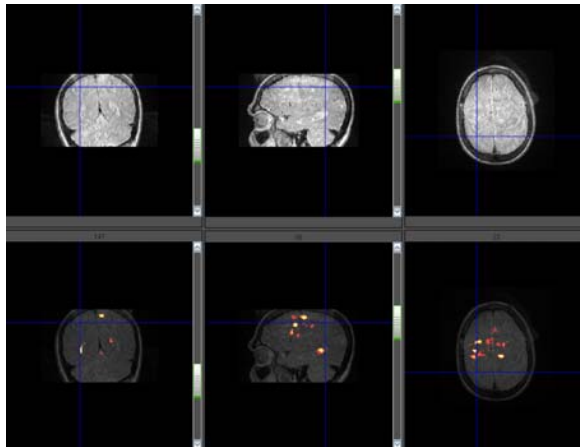





Figure: 11 Multiple Sclerosis Analysis

6. Image Saving Option

Brain Assist provides two different type of Image saving options, (i) single slice image saving option and (ii) Volume Image saving option. In single image saving option has two image formats (i) BMP image format and (ii) DICOM image format.

An image can be saved as DCM image format by selecting the Save As option under the File menu or to quick save an image, click  Save as DICOM image on the Standard Toolbar.

An image can be saved as BMP image format by selecting the Save As option under the File menu or to quick save an image, click  Save as Bmp image on the Standard Toolbar.

Volume image can be saved as DCM image format by selecting the Save As Volume... option under the File menu or to quick save volume image, click  Save as image volume on the Standard Toolbar.

7. Conclusion

In conclusion, BrainAssist is a comprehensive, user friendly, state-of-the-art medical image analysis tool. Scalp removal and Tissue classification is successfully achieved without any brain atlas. The tool assists Radiologists and other clinicians to effectively analyse MR Brain images.

8. Reference

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