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Simple Tool for Three-Dimensional Reconstruction of Coronal Hippocampus Slice Using Matlab

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Abstract. Information technology is developing very fast nowadays. In the medical field, one of which is the development of computer-aided diagnosis to strengthen the diagnosis. This paper will discuss the development of simple tools in measuring the volume of the coronal hippocampus slice due to MRI images. Based on this volume measurement, it will be used as the basis for the three-dimensional reconstruction of the hippocampus area. We emphasized 2-D analysis on the three slices of MRI images, both axial, sagittal, and coronal, in previous research. However, previous research results recommend that 3-D analysis will provide more information about the structure of the hippocampus and ventricles. Three-dimensional reconstruction is needed to add variables to measure the symptoms of Alzheimer's disease that we have done in previous studies. In this paper, we only discuss the three-dimensional analysis of the coronal slice. The results obtained indicate that the development of this simple Matlab-based tool can be used as a guideline for developing a better computer-aided diagnosis.

INTRODUCTION

Alzheimer's disease is a disease that affects many elderly patients, where the number is increasing every year.[1][2]. This condition is in contrast to the number of existing health services in developing countries such as Indonesia. This case happens because Alzheimer's is not a disease that has fatal consequences such as cancer, heart disease, kidney disease, etc. Alzheimer's diagnosis is carried out in several stages, one of which is the radiological examination to support the strengthening of the diagnosis. In radiology to support the diagnosis of Alzheimer's, usually using MRI to observe the hippocampus area. Alzheimer's disease will experience an abnormal condition in the hippocampus, which is a shrinkage according to the increase in the CDR (Critical Dementia Ratio) value in Alzheimer's sufferers [3]. With the rapid development of information technology, especially in digital image processing, the radiological image analysis process, which is usually manual, can use information technology, commonly known as Computer-Aided Diagnosis. The development of Computer-Aided Diagnosis itself has been very numerous, some of which are as follows. Taylor [4] evaluated the impact of computer-aided diagnosis, which is currently widely used, by asking a radiologist to perform a visual evaluation of medical images on the CADX system developed by them. Retter [5] developed and evaluated computer-aided diagnosis for breast cancer detection, including tissue movement in the breast, tissue segmentation, information extraction, and classification. Tiwari [6] has developed a Computer-Aided Diagnosis for the classification of brain tumors based on artificial neural networks. Cahan [7] has developed a Computer-Aided Diagnosis for the healthcare system that includes computerized diagnosis of various symptoms so that the system can provide some suggestions for the initial treatment of these symptoms. Zhu [8] has developed a Computer-Aided Diagnosis to classify pancreatic cancer tissue with normal tissue based on digital image processing. Chauhan [9] has developed a computer-aided diagnosis for tuberculosis based on texture extraction

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and segmentation of the chest area. Bajwa [10] has developed computer-aided diagnoses for skin diseases based on deep learning methods. Santiago [11] has developed computer-aided diagnoses for various types of scoliosis.

Our research has the ultimate goal of developing a computer-aided diagnosis to strengthen the diagnosis of Alzheimer's based on the severity of Alzheimer's according to the CDR scale [3] [12] [13] [14] [1] [15]. However, in this paper, we focus on developing a simple tool for calculating the coronal hippocampus slice volume to obtain a three-dimensional visualization of the hippocampus area.

METHODS

Data Acquisition

The physical data used in the experiment were MRI brain images obtained from OASIS (Open Access Series of Imaging Studies)[16][17][18][19][20]. Data is downloaded in a large capacity and a lot. The reading of the MRI data was performed on the MRIcro software. Then the software will convert the image into a new image file to be processed in MATLAB. Data clustering was carried out to make identification more accessible because the data contained in OASIS is still in random form, not yet structured. The grouping is done on the image is in the form of MRI images of the Alzheimer's brain with various ages, genders, and CDR levels.

System Design

After obtaining the data grouped as explained in the above sub-section, the next step is to do a system design. The stages of digital image processing that will be carried out include Brightness and Contrast Stretching. Then segmentation is done using the active contour method, then the image area is calculated. In order to identify the volume, each image that has been segmented and its area calculated will then be stored. So that in the final stage, the volume of the brain hippocampus MRI image will be identified. The design and program design will be tested and simulated with some data processed in the GUI (Guide User Interface) software that has been built. After showing the effectiveness, the GUI software will be applied to identify the volume of data on the MRI image of the Alzheimer's brain clustered based on age, gender, and CDR level. In this design, we used operating system Windows Seven Ultimate 64-bit, MRIcro, and Matlab R2013b

Three-Dimensional Reconstruction

In three-dimensional reconstruction, the most needed variable is the volume of the object to be reconstructed. In this experiment, the calculation of the volume of the coronal hippocampus slice was carried out after the area was localized. In this experiment, like our previous research [14] [21] [3] [13] [2] [12] [15] , we use active contour segmentation. Segmentation was carried out on all slices of the hippocampus to be reconstructed. In this experiment, the average number of slices per hippocampus is between 1-256 slices with an average thickness of 1 pixel. Volume calculation is done by adding up all the area of the slice in one intact hippocampus.

RESULTS AND DISCUSSIONS

In this experiment, the image used has a characteristic size of 208 x 176 pixels. A total of 416 MRI files of Alzheimer's brain consisting of CDR 0, CDR 1, CDR 2, and MRI images have not been identified. So that in this experiment, only 40 identified MRI images were used for system evaluation. The initial design of this research will use the direct MRI retrieval method by accessing files from the MRI images directly. However, we encountered problems accessing files with the extension ".hdr" into the MATLAB application. So we replaced this method with cutting images from each 2D MRI slice stored in the extension "*. Jpg, * .bmp, * .png. in this experiment, the image is stored with the extension "* .bmp. The 2D image accessing method is a reasonably efficient method because in the later stages of this experiment when the hippocampus image is separated from other images, it is still done manually by determining the hippocampus area's coordinates. The three-dimensional reconstruction program for the coronal hippocampus slice that has been designed is shown in Figure 1. In the created software, there are several stages, including insert image, contrast stretching, initial masking, active contour, calculate the volume and 3D visualization.

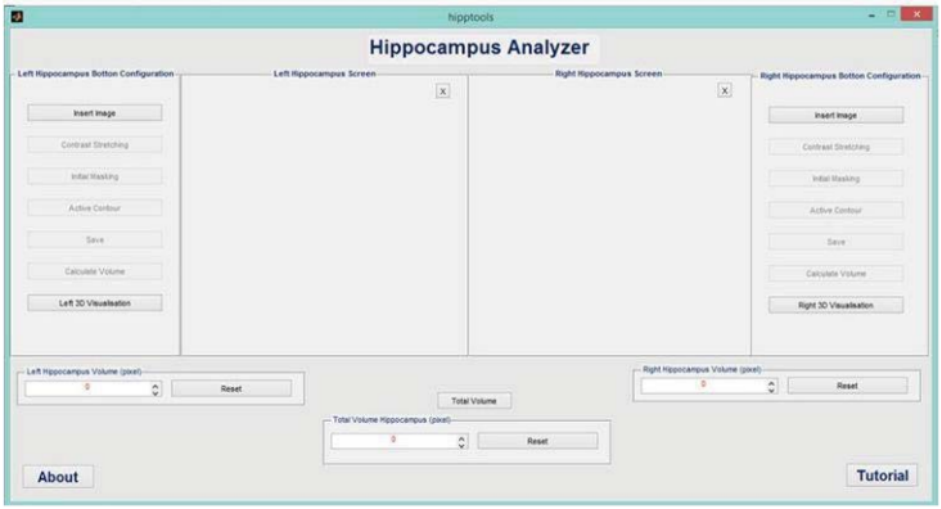

FIGURE 1. System home screen display

The stage of image retrieval is carried out sequentially from the first to the last slice. Each hippocampus coronal slice is stored in the same folder. This case is to make it easier to access the image that will be entered into the program. The function used to access the image is to use the *uigetfile* function, as shown in the source code below:

```
mainimage_lefthippo = 0;
axes(handles.viewer_left);
cla reset;

[filename,pathname] = uigetfile({
'*.bmp;*.jpg;*.png;*.tif;*.gif','file citra(*.bmp,*.jpg,*.tif,*.png,*.gif)';
'*.bmp','citra bitmap(*.bmp)';
'*.jpg','citra jpeg(*.jpg)';
'*.tif','citra tif(*.tif)';
'*.png','citra png(*.png)';
'*.gif','citra gif(*.gif)';
'*.*','semua file (*.*)'},...
'Buka Citra Hippocampus Kiri');

if ~isequal(filename,0)
    mainimage_lefthippo = imread(fullfile(pathname,filename));
    %visibles
    set(handles.viewer_left,'visible','on');
    axes(handles.viewer_left);
    imshow(mainimage_lefthippo);
else
    mainimage_lefthippo = 0;
    set(handles.viewer_left,'visible','off');
    return
end

handles.mainimage_lefthippo = mainimage_lefthippo;
```

When this function is executed, a search box for the image file's location will appear in the program. Image files that can be accessed by this function are only images with the extension ". * .Gif", "* .bmp", "* .tif", "* .png", and "* .gif". The program cannot execute files other than these extensions. Then the image file will be stored in a matrix which is then displayed in the viewer_left function. In the GUI, the process that occurs is as shown in Figure 2. The process of inserting an image is done by simply pressing the "Insert Image" push button on the GUI, then searching for the location of the image file we want to access. Then the image will be displayed on its GUI device.

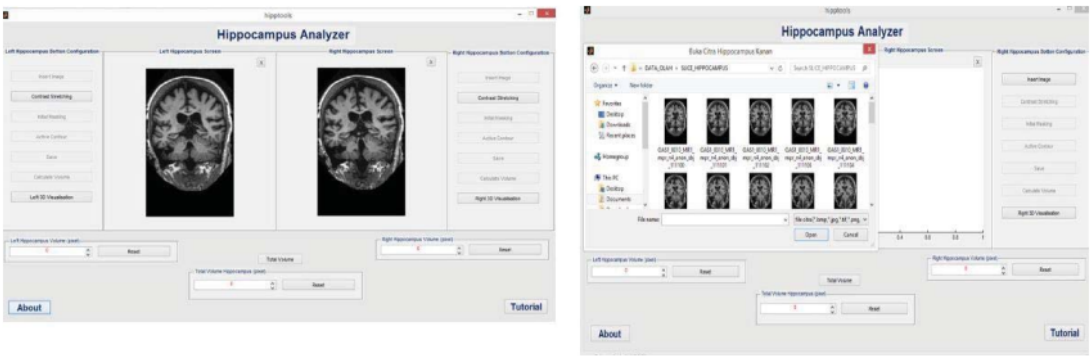

FIGURE 2. Display of Insert Image menu

The initial masking process in this experiment uses the *Roipoly* function in the MATLAB application. This function allows the user to perform MRI image segmentation interactively by following the contours of the hippocampus object, namely by creating dots around the hippocampus, where these points will ignore other areas around it. Figure 3 shows how the user creates contour points around the hippocampus to get the initial masking.

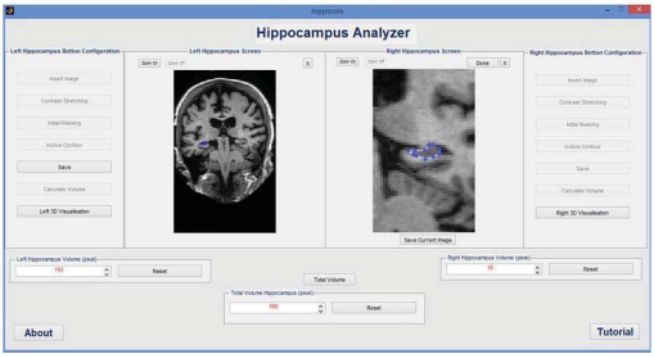

FIGURE 3. Initial masking process display

After the initial masking process is complete, the segmentation using the active contour method will be formed automatically by double-clicking the last point of the initial masking process. Figure 4 shows a menu display of the segmented hippocampus area.

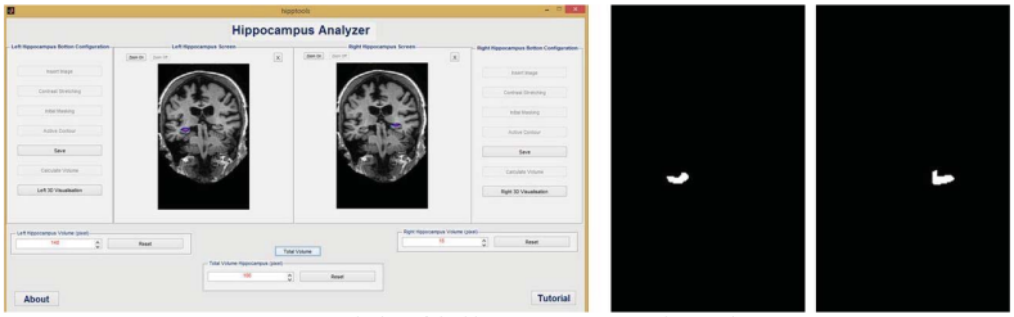

FIGURE 4. Display of the hippocampus segmentation result area

In calculating the volume of the hippocampus, the function used in the Matlab to do this addition is the sum function, with the details of sum (A, 1) the addition vertically and sum (A, 2) is the addition horizontally, and sum (A)

is the backward addition (z-axis). Using this algorithm to calculate the hippocampus volume for each coronal Alzheimer's MRI image is obtained. Figure 5 shows a view of the volume calculation and three-dimensional visualization.

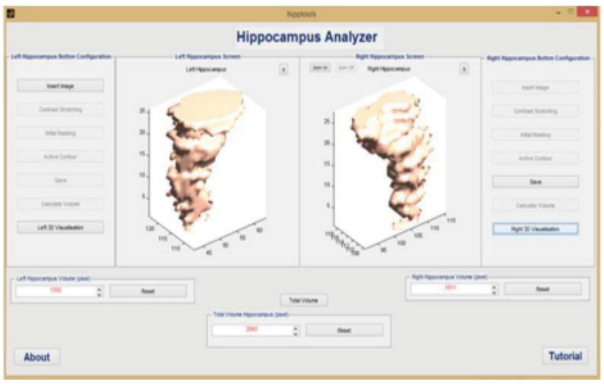

FIGURE 5. Display of volume calculation and 3D visualization

The results of implementing the MATLAB program made can be seen in the graph in Figure 6. The relationship between volume and CDR in the program's application shows that the average value for CDR 0 on the left hippocampus volume is 1973 pixels, the right-side hippocampus volume is 2055 pixels, and the total hippocampus volume is 4028 pixels. Then the average value for CDR 1 on the left hippocampus volume is 1252 pixels, the right hippocampus volume is 1253 pixels, and the total hippocampus volume is 2505 pixels. Meanwhile, the average value for CDR 2 on the left hippocampus volume is 731.5 pixels, the right hippocampus volume is 671 pixels, and the total hippocampus volume is 1402 pixels. It can be concluded that the volume of the left and right hippocampus of each hippocampus is not much different.

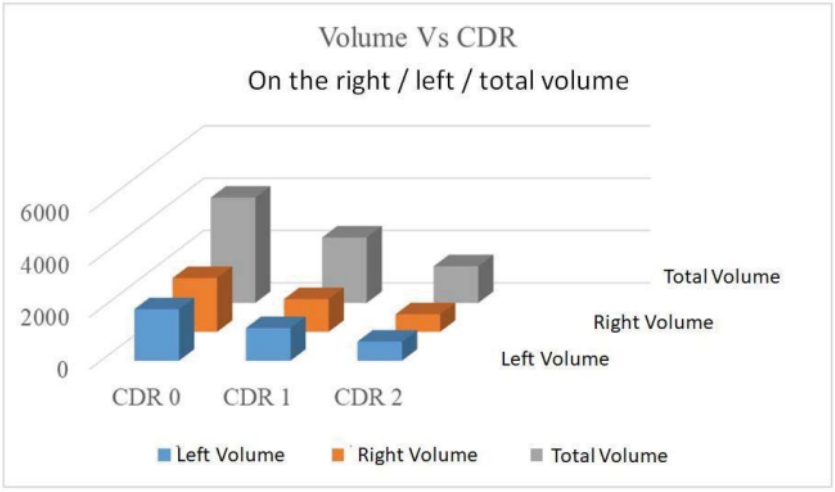

FIGURE 6. Graph of volume VS CDR

One of the performance measures in this tool developed with MATLAB is the execution time required to operate it. The relationship between CDR and operating time by the user results from the program's application showing that at CDR 0, the time used by the user is 74.1 minutes, then CDR 1 is 66.7 minutes, and CDR 2 is 53.5 minutes. This case shows that the lower the CDR value of an image, the longer it will calculate the volume. This case happens because the lower the CDR value, the greater the volume and the number of slices. Figure 7 shows this relationship.

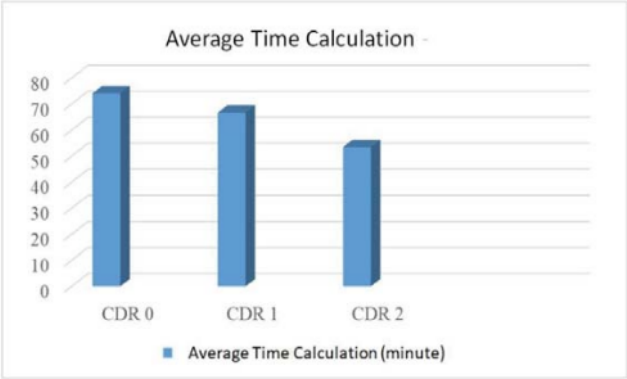

FIGURE 7. The graph of average time calculation

CONCLUSION

The design of a volume calculation and 3D visualization program using MATLAB, including the insert image stage, contrast stretching, initial masking, active contour, volume calculation, and 3D visualization, successfully calculates and visualizes coronal MRI image data the Alzheimer's hippocampus properly. This system could serve as a guideline for developing Computer-Aided Diagnosis for the next phase of Alzheimer's detection..

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