

Computer aided tool for Early Detection of Alzheimer's Disease

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Abstract

Over recent years, medical imaging research has increased to its zenith that employs principles of engineering utilizing Artificial Intelligence techniques and image computing techniques to medical modalities to yield efficient healthcare solutions. Alzheimer's disease (AD) is a devastating condition that leads to significant memory loss due to neurodegeneration. Early identification of such conditions is significant to reduce the disease progression which subsequently improves the life of patients. MRI scan has been the best modality to visually diagnose the brain tissue state. Visual inspection by the radiologists has its limitations to accurately detect the amount of cell death happened. Moreover, such a volumetric analysis is of great importance to identify the progression rate of neurodegeneration of brain tissues over a period of time. Hence an automated system that provides a volume of neuronal death of individual brain tissues from MRI scan images helps to reduce time and effort of radiologists to diagnose the disease progression. This research aimed to develop such a system to accurately measure the pixel volume of brain tissues. The methodology included the image pre-processing steps followed by segmentation of brain tissues into Gray matter, White matter and Cerebrospinal fluid. The outcome of research is an application that automatically segments the brain tissues and obtain the pixel volume which has been successfully developed using digital image computing and unsupervised machine learning under Artificial Intelligence algorithms. The application helps the radiologists to input the MRI brain images and get the volume of each tissue from the inputted MRI DICOM brain images.

Keywords: *Artificial Intelligence, MRI DICOM, Alzheimer's disease, image pre-processing, brain tissues.*

Introduction

Artificial intelligence refers to systems or devices that simulate human intelligence to perform tasks. It is related to the ability to think highly of data analysis and aims to enhance human contributions, which makes it of great value. Artificial intelligence has entered the medical field as it is considered the new concept of diagnosis and treatment of diseases in a smart way according to the highest standards of technology. So, in our project, we want to combine artificial intelligence with one of the brain diseases called Alzheimer's. Neurodegenerative diseases such as Alzheimer's disease are characterized by loss of neurons in the brain which results in a progressive decline in memory (Subash et al., 2014). Alzheimer's. harms the human brain and the brain is considered as one of the most important and complex organs in the universe, the brain comprises of tissues namely Gray Matter, White Matter, and Cerebrospinal, People who suffer from this disease have atrophy or shrinkage in the brain as a result of the loss of these three tissues. Also, they are suffering from this disease experience a significant memory loss due to neuronal death. Even though there is no drug available to completely eradicate the disease, early detection of the disorder is very crucial. Accurate and automatic prediction of brain tissue volume from image scans is quite challenging. This research aims at developing software that quantifies the brain tissues automatically from MRI T1-weighted axial images to know how much tissue volume reduction has happened over a period of time. Visual inspection by the radiologists is a tedious and unreliable task to comprehend the severity of neuronal death. Hence automatic atrophy measurement of brain tissues would be useful for the physicians. Moreover, the availability of a system is advantageous for them where the doctors can input own dataset, and they can also comparative analysis of the volume of the tissues.

Literature Review

Somasundaram and Kalaiselvi (2011) talks about magnetic resonance imaging (MRI) and specifically about ways to remove non-brain areas that appear in the images of brain MRI such as the scalp, fat, and skull. The importance of these methods in the medical field is to increase the speed of identification of the disease and medical diagnosis of the patient, especially in diseases spread in the brain such as Alzheimer's and Dementia and other ailments. The method proposed by this article to extract the brain part of the MRI centred in two steps, the first step feature extraction which is to determine the brain area and boundaries in the MRI scan e second step the segmentation which is fragmented the MRI scan to extract the brain. This method has been applied to mad cow disease and its results have shown that it is a successful method because the brain has been extracted from MRI successfully, also been some other tests that have been extracted half of the brain because of the cerebral tissue in the state of the brain from growing and here we can say that this is a case of Alzheimer's disease. With this evidence we can say that the method is successful compared to other methods, this can be applied in an automatic system that processing the MRI images. The authors have written this article by applying their method through datasets obtained that compilation of a different source s Internet Brain Segmentation Repository (IBSR).

Nilakant et al. (2017) discusses a survey of advanced methods for segmentation the MRI image of the brain. This paper examines the complexities in the division algorithm and furthermore the difficulties in the division the brain MRI images. The division segmentation an analysis of the current literature that has additionally been talked about. The authors describe two types of segmentation methods: basic segmentation methods and advanced segmentation methods, and the methods divide into many types such as manual segmentation, thresholding, neural network methods and so on. Also, it points out the main use for each method and the segmentation region. This paper includes some segmentation algorithms as well such as Fuzzy C-Means, Hybrid Clustering, and Artificial Intelligence and the use of each one. The research concludes with each segmentation method has advantages and disadvantages and still, there is no algorithm that segment all brain part in the MRI images. In my opinion, what makes the article successful is that the authors have described all the segmentation methods in detail with defining its merits and demerits which make it a good reference for each researcher.

Lakshmi (2015) identified the image segmentations that offer volumetric quantification of cortical atrophy and consequently assist in the detection of many diseases such as Alzheimer's, schizophrenia and hydrocephalus. This paper deals with the comparison of segmentations outcomes by using /applying the k-means algorithm after skull erosion and by using BET (brain extraction tool). Also, this paper provides analysed the MRI brain image like T1-weighted, T2-weighted, Axial and coronal. Using denoising techniques, morphological operations & then find connected component labelling to implement non-brain part removal. Then applied the k-means clustering algorithm by using the brain extraction tool and manual method. The brain extraction tool is applied to take off the skull from an image. It comes from FSL's toolkit (external program). There are two kinds of methods for segmentation that have been discussed in this paper. First one includes the skull stripping by using BET and then applied k-means clustering algorithm, the second method is by removing noises of MRI by using wavelet denoising and then using morphological operations such as erosion and dilation to stripping the skull. This research found out that k means is the best algorithm, and it is faster than hierarchical clustering, but sometimes it does not work completely with non-globular clusters.

Methods

We developed a software that begins by scanning the MRI brain images followed by image pre-processing including image de-noising and skull/dura removal. The latter can be achieved by applying digital image computing techniques. The subsequent step involves segmenting the brain into three tissues utilizing Artificial Intelligence techniques based on the machine by using K-mean clustering algorithm learning. Finally, the volume of segmented tissues is measured, and this measure will help the doctors to the comparative analysis of the MRI brain of the patients. Our project will help the neurologist and radiologist doctors very much because sometimes the doctors cannot do a comparative analysis of the MRI effectively because of the slight change that happened so they will find some deficit to analysis and here comes the role of our project in solving this problem.

Results

An early identification of such disease is significant to reduce the disease progression which subsequently improves the lives of patients, and to understand this disease further, we have conducted an interview with a psychologist at the Sultan Qaboos University hospital and then we made and developed an automated system that provides a volume brain tissues of individual brain from MRI scan images which will help to reduce time and effort of doctors to diagnose the disease progression visually. The research involved preprocessing and segmentation. Preprocessing removes the brain skull. Skull stripped image segmentation is done into 3 tissues namely gray matter, white matter and cerebrospinal fluid. Finally, the volume of each tissue is calculated.

The proposed flowchart showing the used methods and result :

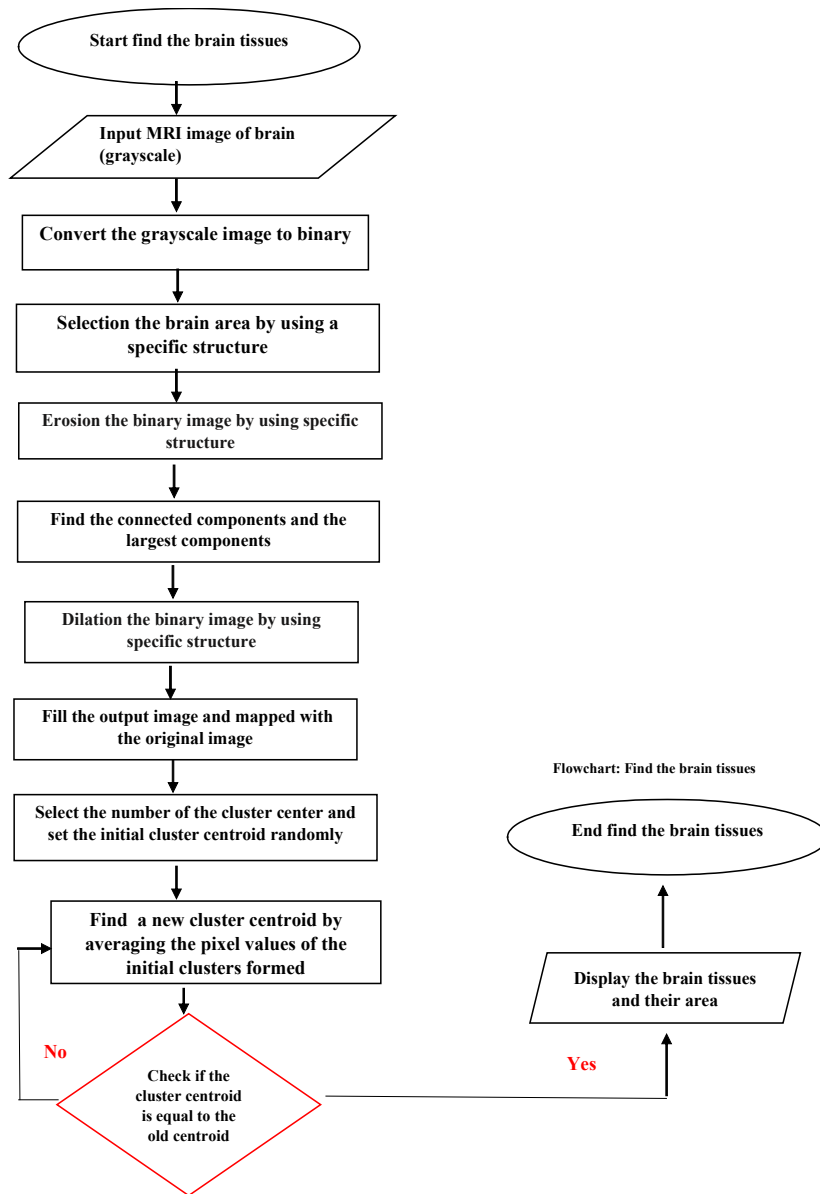


Figure 1: Find the Brain Tissues Flowchart

Discussion

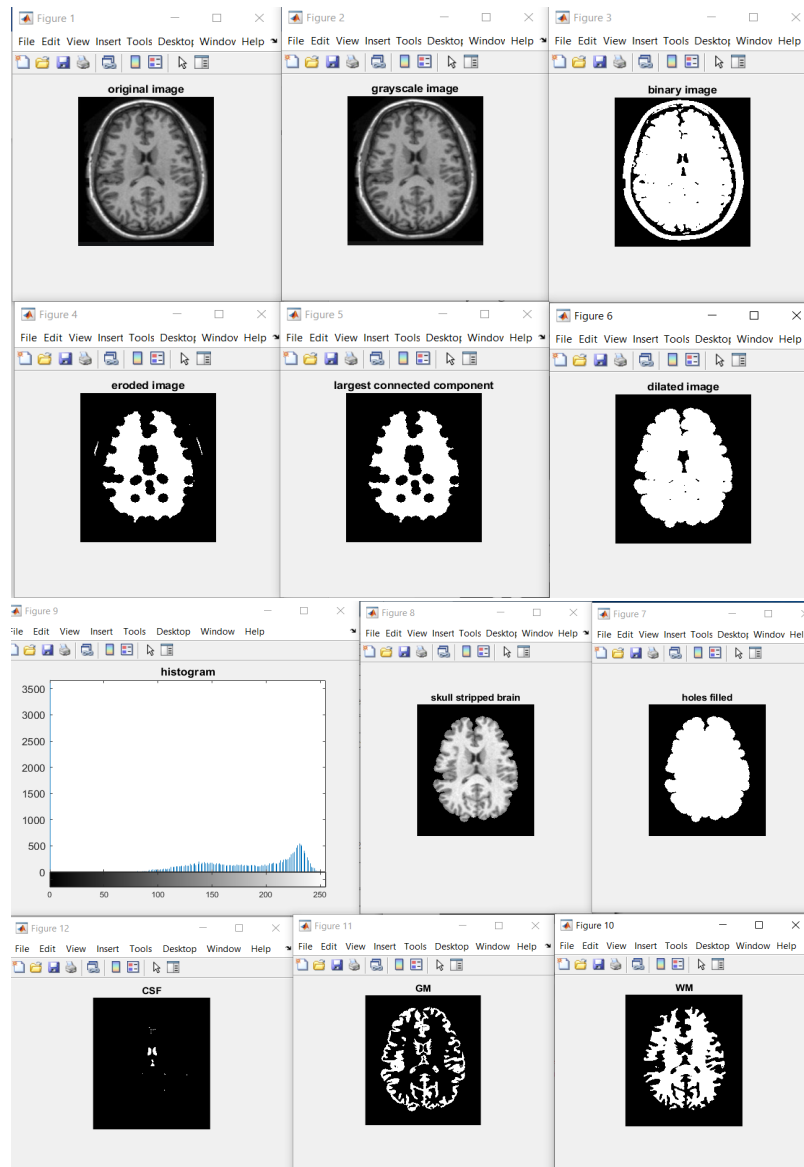


Figure 2: MRI processing steps

In the above window, we have use the Matlab program to do some segementation on brain MRI to generate the brain tissue and their volume (white matter, gray matter and cerebrospinal fluid) with the help of K-mean clustering algorithm.

[Figure 1] is shown an MRI scanning image for Alzheimer's patients. First step is removing the non-brain portion because the outer covering is not a tissue, for that we convert the image to grayscale [Figure2] then into binary [Figure 3] because we want to apply Erosion which can be applied only on the binary image and some space will be created while removing the non-brain portion, so we apply an appropriate structure element, and we define the size and the shape to probe the input image [Figure 4] is showing the eroded image. From the eroded image, we label the connected component and extract the largest connected component which is the brain [Figure 5] then we apply

Dilation to expand the image pixels by adding pixels to the boundaries of the brain image by using the same structure element that used in erosion [Figure 6]. After that, we fill the holes in the dilated image [Figure 7] and map it with the grayscale image to get the skull stripped brain [Figure 8].after those steps we start the K- mean clustering algorithm first step in this algorithm is to choose the centroid randomly then initialize the white matter, gray matter and cerebrospinal fluid matrixes after that, we start the loop to find which cluster it belongs to witch matrix then its will find the minimum value and new cluster centroid so the loop will check if the new centroid is equal to the old centroid until the centroid is finished after that the (white matter, gray matter and cerebrospinal fluid) [Figure10] [Figure 11] [Figure12], will display with their volume and we have used the histogram to clarify this more clearly [Figure 9]. And the volume of the segmented tissues is shown in the figure 3 below.

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Command Window
>> wm_area

wm_area =

    11554

>> gm_area

gm_area =

    6103

>> csf_area

csf_area =

    182

fx >> |
<
    
```

Figure 3: volume of the segmented tissues

Also, we build and develop a GUI in the MATLAB that shows the whole steps but, in the future, for doctors, it will just require to show three buttons which are input the image, the skull stripped image and the brain tissues with the measured volume. Here, we can input any brain MRI from the computer and go through the whole steps and get the volume of the three tissues.

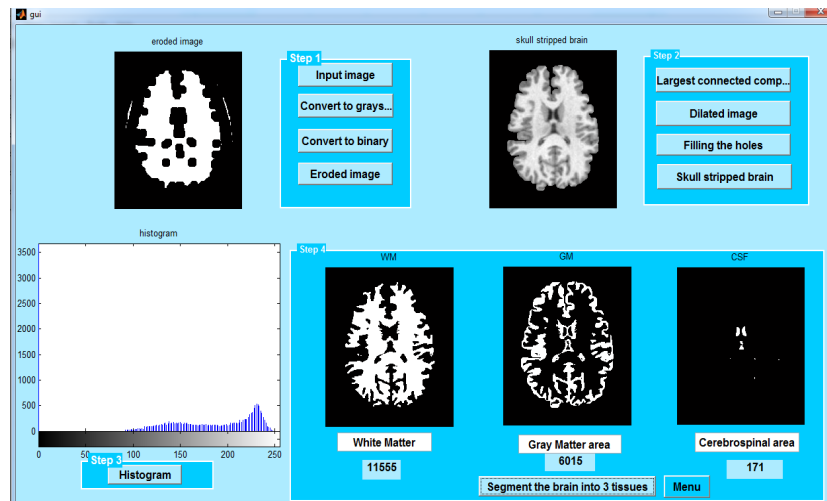


Figure 4: MRI processing steps with GUI

Conclusion

Throughout the period of work in the project, we get a lot of experience and knowledge. The most important experience we get is that we learned more about medical imaging, artificial intelligence techniques, and image computing techniques through reading and gathering the information from some research, books, articles and searching some websites. This project develops our capability in researching and grow with great knowledge in using MATLAB for image processing and applying a k-means clustering algorithm to segment the brain into three tissues. Moreover, we learned how to build a GUI (Graphic User Interface) in MATLAB to show our output and connect it with the database. On other hand, we struggled many times until we get the results because it was the first time for us to deal with image processing and artificial intelligence techniques but with the help of the online courses we took and the articles and books we read, all that make the understanding of the processing steps easier to learn and accomplish ours project.

This project will have a significant importance in the healthcare sector as it will help doctors to detect the brain loss easily for Alzheimer's patients from the application that we developed which will quantifies the brain tissues automatically from magnetic resonance imaging (MRI) images to know how much of volume reduction has happened over a period of time. Also, as this software will assist in reduce the time and efforts for radiologists in the hospitals of Sultanate of Oman.

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