

Digital Image Processing based Detection of Brain Abnormality for Alzheimer's disease

Dr. PSJ Kumar¹, Mr. Anirban Saha²

¹(Professor and Head, Department of CSE, JIS College of Engineering, Kolkata, India)

²(PG Scholar, Department of CSE, JIS College of Engineering, Kolkata, India)

ABSTRACT : Digital medical imaging is highly expensive and complex due to the requirement of proprietary software and expert personnel. This paper introduces a user friendly general and visualization program specially designed in software called MATLAB for detection of brain disorder called Alzheimer's disease as early as possible. This application will provide quantitative and clinical analysis of digital medical images i.e. MRI scans of brain. Very tiny and minute structural difference of brain may gradually & slowly results in major disorder of brain which may cause Alzheimer's disease. Here the primary focus is given for detection & diagnosis of Alzheimer's disease which will be implemented by using bi-cubic interpolation technique.

Keywords - Alzheimer disease, Brain imaging, Color image segmentation, Image registration

I. INTRODUCTION

Brain is the most complex organ of our human body and is the center of our nervous system. Any abnormal behavior and functioning of brain may lead to the total collapse of entire body functionalities. One such brain abnormality may result in Alzheimer's disease. This paper introduces a simple user friendly GUI based application for detection of Alzheimer's disease by processing images of brain by taking MRI scanned images of brain as input data source, and analyzing its morphological abnormalities for the diagnosis.

II. REVIEW OF LITERATURE

Most common form of abnormality of brain is the deformation of cerebral [1, 2] cortex due to shrinking of brain. The sulci i.e. the spaces in folds of brain are grossly enlarged resulting to Alzheimer's disease [3, 4]. In this paper, the primary and main objective is the identification of cerebral cortex region of the brain & the measurement of the cavity area in the folds of brain also called sulci by using a software developed in MATLAB which uses a bi-cubic interpolation for more accurate result than the result may obtained by bi-linear interpolation or nearest neighbor interpolation [5].

III. ALZHEIMER'S DISEASE

Alzheimer's disease is a neurological disorder in which the death of brain cells causes memory loss and cognitive decline. A neurodegenerative type of dementia, the disease starts mild and gets progressively worse. Like all types of dementia, Alzheimer's is caused by brain cell death. It is a neurodegenerative disease, which means there is progressive brain cell death that happens over a course of

time. The total brain size shrinks with Alzheimer's, the tissue has progressively fewer nerve cells and connections. The structure of our brain changes as we get older just like rest of our body structure. Ageing results in slower thinking & occasional problems of remembering certain things. But serious memory loss, confusions & other major vital changes in the way our brain works are not related to normal ageing but may be signs of cell failures of our brain [6]. Brain consists of billions of nerve cells interconnected among them. In Alzheimer's disease like any other kinds of dementia [7], increasing number of brain cells gets deteriorates & thus die out.

The Alzheimer's Association says in its early onset information that it can sometimes be "a long and frustrating process" to get this diagnosis confirmed since doctors do not expect to find Alzheimer's in younger people. Some things are more commonly associated with Alzheimer's disease - not seen so often in people without the disorder. These factors may therefore have some direct connection. Some are preventable or modifiable factors (for example, reducing the risk of diabetes or heart disease may in turn cut the risk of dementia. If researcher's gain more understanding of the risk factors, or scientifically prove any "cause" relationships for Alzheimer's, this could help to find ways to prevent it or develop treatments. For the younger age groups, doctors will look for other dementia causes first. Fig.1 shows the gradual increase of number of people having Alzheimer's disease. While they cannot be seen or tested in the living brain affected by Alzheimer's disease, postmortem/autopsy will always show tiny inclusions in the nerve tissue, called plaques and tangles. Plaques are found between the dying cells in the brain - from the build-up of a protein called beta-amyloid and tangles are within the brain neurons - from a disintegration of another protein, called tau.

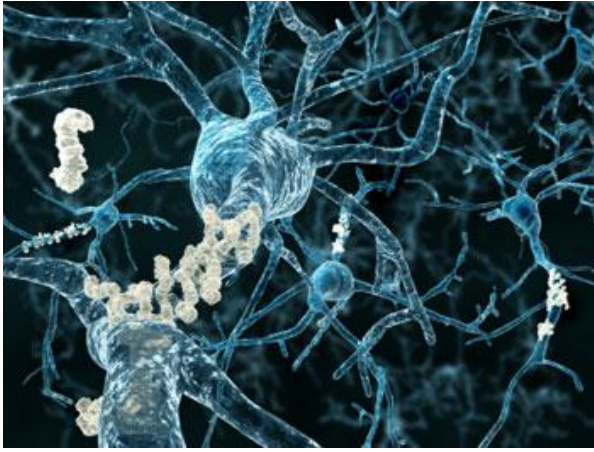


Fig.1 Neurons in the brain. In Alzheimer's, there are microscopic 'Plaques' and 'Tangles' between and within brain cells.

IV. BRAIN IMAGING TECHNIQUE

It requires special models to transform the signals that are being recorded or captured at the surface of human scalp into an image format. Brain imaging techniques allow doctors and researchers to view activity or problems within the human brain, without invasive neurosurgery. There are a number of accepted, safe imaging techniques in use today in research facilities and hospitals throughout the world. Magnetic resonance imaging is used in radiology to see or visualize the organization of internal structures and functioning of body parts. It is better than computed tomography scan as it provides much more contrast between the different soft tissues of our body.

4.1 Magnetic Resonance Imaging

Functional magnetic resonance imaging (MRI) is a technique for measuring brain activity. It works by detecting the changes in blood oxygenation and flow that occur in response to neural activity – when a brain area is more active it consumes more oxygen and to meet this increased demand blood flow increases to the active area. MRI can be used to produce activation maps showing which parts of the brain are involved in a particular mental process.

4.2 Computed Tomography

Computed tomography (CT) scanning builds up a picture of the brain based on the differential absorption of X-rays. During a CT scan the subject lies on a table that slides in and out of a hollow, cylindrical apparatus. An x-ray source rides on a ring around the inside of the tube, with its beam aimed at the subjects head. After passing through the head, the beam is sampled by one of the many detectors that line the machine's circumference. Images made using x-rays depend on the absorption of the beam by the tissue it passes through. Bone and hard tissue absorb x-rays well, air and water absorb very little and soft tissue is somewhere in between. Thus, CT scans reveal the gross features of the brain but do not resolve its structure well.

4.3 Positron Emission Tomography

Positron Emission Tomography (PET) uses trace amounts of short-lived radioactive material to map functional processes in the brain. When the material undergoes radioactive decay a positron is emitted, which can be picked up by the detector. Areas of high radioactivity are associated with brain activity.

4.4 Electroencephalography

Electroencephalography (EEG) is the measurement of the electrical activity of the brain by recording from electrodes placed on the scalp. The resulting traces are known as an electroencephalogram (EEG) and represent an electrical signal from a large number of neurons. EEGs are frequently used in experimentation because the process is non-invasive to the research subject. The EEG is capable of detecting changes in electrical activity in the brain on a millisecond-level. It is one of the few techniques available that has such high temporal resolution.

4.5 Magnetoencephalography

Magnetoencephalography (MEG) is an imaging technique used to measure the magnetic fields produced by electrical activity in the brain via extremely sensitive devices known as SQUIDs. These measurements are commonly used in both research and clinical settings. There are many uses for the MEG, including assisting surgeons in localizing pathology, assisting researchers in determining the function of various parts of the brain, neurofeedback, and others.

4.6 Near Infrared Spectroscopy

Near infrared spectroscopy (NIRS) is an optical technique for measuring blood oxygenation in the brain. It works by shining light in the near infrared part of the spectrum (700-900nm) through the skull and detecting how much the reemerging light is attenuated. How much the light is attenuated depends on blood oxygenation and thus NIRS can provide an indirect measure of brain activity.

V. IMAGE REGISTRATION

Medical images are increasingly being used within healthcare for diagnosis, planning treatment, guiding treatment and monitoring disease progression. Within medical research they are used to investigate disease processes and understand normal development and ageing. A critical stage in this process is the alignment or registration of the images. The most widely used application of medical image registration is aligning tomographic images. That is aligning images that sample three-dimensional space with reasonably isotropic resolution. Furthermore, it is often assumed that between image acquisitions, the anatomical and pathological structures of interest do not deform or distort. This 'rigid body' assumption simplifies the registration process, but techniques that make this assumption have quite limited applicability. Many organs do deform substantially, for example with the cardiac or respiratory cycles or as a result of change in position. The brain within the skull is reasonably non-deformable provided the skull remains closed between imaging and that there is no substantial change in anatomy and pathology, such as growth in a lesion, between scans. In this paper, data has been acquired by sampling the same object at different time span and/or from different perspectives and may lie in different coordinate systems. Image registration is the process of transforming or changing the different datasets from different co-ordinate system to a single coordinate system [8]. It is necessary so that we can compare & integrate data that are obtained from different measurement.

5.1 Need for Image Registration

Imaging equipment is imperfect, so regardless of the organ being imaged, the rigid body assumption can be violated as a result of scanner-induced geometrical distortions that differ between images. Although the majority of the registration approaches reviewed here have been applied to the rigid body registration of head images acquired using tomographic modalities, there is now considerable research activity aimed at tackling the more challenging problems of aligning images that have different dimensionality, aligning images of organs that deform, aligning images from different subjects, or of aligning images in ways that can correct for scanner induced geometric distortion. This is quite a rapidly moving research field, so the work reviewed in these areas is more preliminary. For all types of image registration, the assessment of registration accuracy is very important. The required accuracy will vary between applications, but for all applications it is desirable to know both the expected accuracy of a technique and also the registration accuracy achieved on each individual set of images. For one type of registration algorithm, point-landmark registration, the error propagation is well understood. For other approaches, however, the algorithms themselves provide no useful indication of accuracy. The most promising approach to ensuring acceptable accuracy is visual assessment of the registered images before they are used for the desired clinical or research application.

5.2 Image Registration Methodology

There are many image registration methods, and they may be classified into following eight categories: image dimensionality, registration basis, geometrical transformation, degree of interaction, optimization procedure, modalities, subject, and object. "Image dimensionality" refers to the number of geometrical dimensions of the image spaces involved, which in medical applications are typically three-dimensional but sometimes two-dimensional. The "registration basis" is the aspect of the two views used to effect the registration. For example, the registration might be based on a given set of point pairs that are known to correspond or the basis might be a set of corresponding surface pairs. Other loci might be used as well, including lines or planes. In some cases, these correspondences are derived from objects that have been attached to the anatomy expressly to facilitate registration. Such objects include, for example, the stereotactic frame and point-like markers, each of which has components designed to be clearly visible in specific imaging modalities. Registration methods that are based on such attachments are termed "prospective" or "extrinsic" methods and are in contrast with the so-called "retrospective" or "intrinsic" methods, which rely on anatomic features only. Alternatively, there may be no known correspondences as input. The category, "geometrical transformation" is a combination of two of Maintz's categories, the "nature of transformation" and the "domain of transformation". It refers to the mathematical form of the geometrical mapping used to align points in one space with those in the other. "Degree of interaction" refers to the control exerted by a human operator over the registration algorithm. The

interaction may consist simply of the initialization of certain parameters, or it may involve adjustments throughout the registration process in response to visual assessment of the alignment or to other measures of intermediate registration success. The ideal situation is the fully automatic algorithm, which requires no interaction. "Optimization procedure" refers to the standard approach in algorithmic registration in which the quality of the registration is estimated continually during the registration procedure in terms of some function of the images and the mapping between them. The optimization procedure is the method, possibly including some degree of interaction, by which that function is maximized or minimized. The ideal situation here is a closed form solution which is guaranteed to produce the global extremum. The more common situation is that in which a global extremum is sought among many local ones by means of iterative search.

"Modalities" refers to the means by which the images to be registered are acquired. Registration methods designed for like modalities are typically distinct from those appropriate for differing modalities. Registration between like modalities, such as MR-MR, is called "intramodal" or "monomodal" registration; registration between differing modalities, such as MR-PET, is called "intermodal" or "multimodal" registration. "Subject" refers to patient involvement and comprises three subcategories: inpatient, outpatient, and atlas, the latter category comprising registrations between patients and atlases, which are they typically derived from patient images. "Object" refers to the particular region of anatomy to be registered (e.g., head, liver, vertebra).

VI. COLOR IMAGE SEGMENTATION

Image segmentation is the process of separating or grouping an image into different parts. These parts normally correspond to something that humans can easily separate and view as individual objects. Computers have no means of intelligently recognizing objects, and so many different methods have been developed in order to segment images. The segmentation process is based on various features found in the image. This might be color information that is used to create histograms, or information about the pixels that indicate edges or boundaries or texture information. The color image segmentation is also widely used in many multimedia applications, for example; in order to effectively scan large numbers of images and video data in digital libraries, they all need to be compiled directory, sorting and storage, the color and texture are two most important features of information retrieval based on its content in the images and video. Therefore, the color and texture segmentation often used for indexing and management of data; another example of multimedia applications is the dissemination of information in the network. Today, a large number of multimedia data streams sent on the Internet, However, due to the bandwidth limitations; we need to compress the data, and therefore it calls for image and video segmentation.

6.1 Region Based Techniques

Region based methods are based on continuity. These techniques divide the entire image into sub regions depending on some rules like all the pixels in

one region must have the same gray level. Region-based techniques rely on common patterns in intensity values within a cluster of neighboring pixels. The cluster is referred to as the region, and the goal of the segmentation algorithm is to group the regions according to their anatomical or functional roles.

6.2 Clustering Technique

Given an image this method splits them into K groups or clusters. The mean of each cluster is taken and then each point p is added to the cluster where the difference between the point and the mean is smallest. Since clustering works on hue estimates it is usually used in dividing a scene into different objects. The performance of clustering algorithm for image segmentation is highly sensitive to features used and types of objects in the image and hence generalization of this technique is difficult. Ali, Karmarkar and Dooley presented a new shape-based image segmentation algorithm called fuzzy clustering for image segmentation using generic shape information which integrates generic shape information into the Gustafson-Kessel clustering framework. Hence using the algorithm presented in can be used for many different object shapes and hence one framework can be used for different applications like medical imaging, security systems and any image processing application where arbitrary shaped object segmentation is required. But some clustering algorithms like K-means clustering doesn't guarantee continuous areas in the image, even if it does edges of these areas tend to be uneven, this is the major drawback which is overcome by split and merge technique.

6.3 Split and Merge Technique

There are two parts to this technique first the image is split depending on some criterion and then it is merged. The whole image is initially taken as a single region then some measure of internal similarity is computed using standard deviation. If too much variety occurs then the image is split into regions using thresholding. This is repeated until no more splits are further possible. Quadtree is a common data structure used for splitting. Then comes the merging phase, where two regions are merged if they are adjacent and similar. Merging is repeated until no more further merging is possible. The major advantage of this technique is guaranteed connected regions. Quad trees are widely used in Geographic information system. Kelkar D. and Gupta, S[3] have introduced an improved Quad tree method (IQM) for split and merge. In this improved method they have used three steps first splitting the image, second initializing neighbors list and the third step is merging splitted regions. They have divided the third step into two phases, in-house and final merge and have shown that this decomposition reduces problems involved in handling lengthy neighbor list during merging phase. The drawbacks of the split and merge technique are, the results depend on the position and orientation of the image, leads to blocky final segmentation and regular division leads to over segmentation by splitting. This drawback can be overcome by reducing number of regions by using Normalized cuts method.

VII. SYSTEM DESIGN

The problems in analysis of images include [10], transport of data, identification of boundary, volume estimation, 3D reconstruction, shape analysis, image overlay, etc which requires that investigators must have access to suitable methods of biomedical image analysis. Different cost function, minimization method, different sampling, editing & smoothing strategies are compared [11]. Internal consistency measurements were used to place limits on registration accuracy for MRI scan. All strategies were consistent to sub-voxel accuracy for intra subjects, intra-modality registration [12]. Estimated accuracy of registration of structured MRI scan images was in 75.5 μm to 149.5 μm range. The registration algorithm described here are very flexible & robust. The main emphasis is given to the color combination of some brain tissues [13]. The spaces in the sulci can be easily detected by their color combination. Based on the color intensity of that area and measured results, the hypothesis will be generated. Fig.2 shows cerebral cortex region with color stain.

Fig.2 Cerebral cortex with color stain

7.1 Formulation of Model

1. Read & zoom the image using Bi-cubic interpolation [14].
2. Manage all exceptions while loading the zoomed image.
3. Get the pixmap.
4. Extract cavity area of sulci.
5. Find the sum of all pixel values of 3 arrays (red, green, blue) from cropped area.
6. If values == 0 identify as black.
7. Put total identified pixel (that are black) into an array called as cavity_array.
8. Else put (non-black) pixels into an array called cortex_arr.
9. Compare the length of cavity & cortex array by using length function.
10. If (length of cavity array is more), then trace as abnormality.
11. Else it's normal in nature.
12. Set the graph of both cavity & cortex array using plot function.

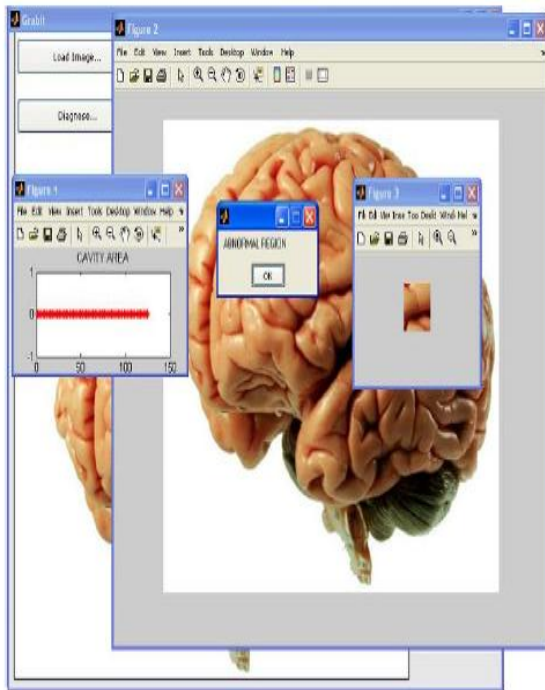


Fig.3 Abnormal area

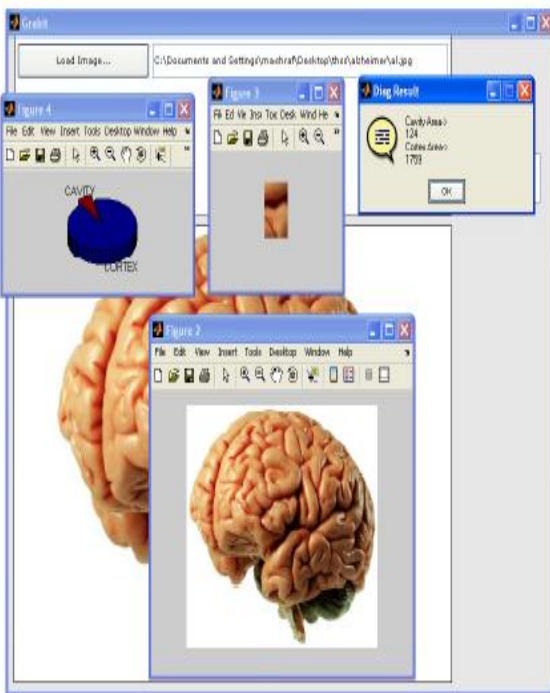


Fig.4 Measurement of abnormality

7.2 Conclusion

Due to heavy cost much of the medical imaging software tools are far from the reach of common man. In this paper, an attempt is made to develop a simple software tool using MATLAB to detect the structured abnormality of the brain tissues. The task has almost being fulfilled & provides a better enhancement of images which is achieved by implementing bicubic interpolation in place of bilinear interpolation to get a better result. But it still requires more

perfection. The highlight of this software tool is its simplicity coupled with user friendliness & keen observation of medical image at minute levels.

7.3 Future Enhancement

In this paper, measurement is based on color coding system. Measurement should be converted to some metric form so that the brain abnormality of Alzheimer's disease can be categorized as mild, moderate or severe.

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