Image Processing Technique for Brain Abnormality Detection

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Abstract

Medical imaging is expensive and very much sophisticated because of proprietary software and expert personalities. This paper introduces an inexpensive, user friendly general-purpose image processing tool and visualization program specifically designed in MATLAB to detect much of the brain disorders as early as possible. The application provides clinical and quantitative analysis of medical images. Minute structural difference of brain gradually results in major disorders such as schizophrenia, Epilepsy, inherited speech and language disorder, Alzheimer's dementia etc. Here the main focusing is given to diagnose the disease related to the brain and its psychic nature (Alzheimer's disease).

Keywords: Alzheimer, Bilinear Interpolation, Brain Imaging, Cerebral Cortex, Image Registration, Neuroinformatics.

1. INTRODUCTION

The human brain [1] is the center of the human nervous system and is the most complex organ in any creature on earth. Any abnormality in brain leads to the total collapse of entire vital functions of the body [2]. This paper introduces a concept of simple user friendly GUI application to process an image of brain and analyze its morphological abnormalities.

2. PROBLEM DEFINITION

Typical abnormality of brain is the shrinking of its cerebral cortex (as shown in *Figure 1*). The spaces in the folds of the brain (the sulci) are grossly enlarged. This type of abnormality leads to Alzheimer's disease. Here the major objective is to identify the cerebral cortex region of brain and measure the cavity area in the sulci (*Figure 2*) using software.

Currently, Brain MRI images could be checked for abnormality using more recent techniques [3], [4], [5].

Goyal et al. [3] showed a technique for automatic detection of some types of brain abnormalities, along with techniques for tumor segmentation in MRI sequences. They presented an automated and clinically-tested method for detection of brain abnormalities and tumor-edema segmentation using MRI sequences. Their method follows a Radiologist's approach to the brain diagnosis using multiple MRI sequences instead of any prior models or training phases. Their procedure consists of the following steps:

i. Pre-processing of the MRI sequences, T2, T1, and T1 post-contrast (enhanced) for size standardization, contrast equalization and division into active cells.

ii. Identification of the T2 MRI sequence as normal or abnormal by exploiting the vertical symmetry of the brain.

iii. Determination of the region of abnormality using its hyper-intense nature.

iv. Separation of tumor from edema using the T1 and its post-contrast (enhanced) sequences.

v. Estimation of the volume of tumor found and generation of an anatomical differential of the possible disorders.

Lashkari [4] introduced an automatic brain tumor detection method to increase the accuracy and yield, and decrease the diagnosis time. The goal in his work was to classify the tissues into two classes: normal and abnormal. *MR* images that were used in his work were images from normal and abnormal brain tissues. He tried to give clear description from brain tissues using *Zernike* Moments, Geometric Moment Invariants, energy, entropy, contrast and some other statistic features such as mean, median, variance, correlation between corresponding points, and values of maximum and minimum intensity. He used a feature selection method to reduce the feature space as well. His method used neural networks to do that classification. The purpose was to classify the brain tissues into normal and abnormal classes automatically; which saves the radiologist time, and increases accuracy and yield of diagnosis.

Reddy et al. [5] showed an improvement to fuzzy clustering means (FCM). They introduced an earlier spatial constraint into FCM algorithm, in which the spatial information is encoded through mutual influences of neighboring positions. To detect the abnormalities of Brain MRI images, they used a new spatial FCM, and compared the results with k-means and FCM techniques.

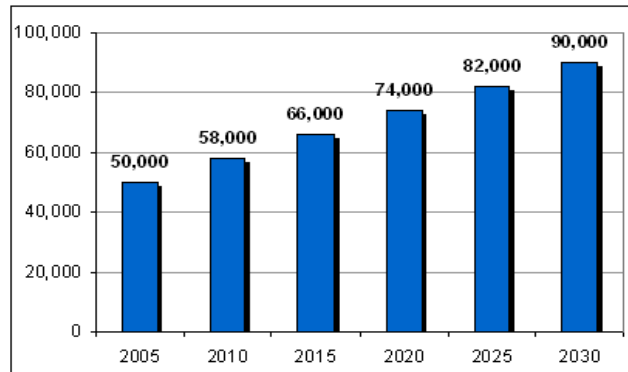
FIGURE 1:
Cerebral Cortex.

FIGURE2:
Sulci.

3. PROJECT GOALS

A. Alzheimer- The Brain Disorder: Just like the rest of our bodies, our brains change as we age. Most of us notice some slowed thinking and occasional problems remembering certain things. However, serious memory loss, confusion and other major changes in the way our minds work are not a normal part of aging [6]. These may be the signs of brain cells failure [7].

The brain has 100 billion nerve cells (neurons). Each nerve cell communicates with many others to form network. Nerve cell networks have special jobs. Some are involved in thinking, learning and remembering. Others help us see, hear and smell. Still others tell our muscles when to move. In Alzheimer's disease, as in other types of dementia, increasing numbers of brain cells deteriorate and die [6]. *Figure 3* shows the gradual increase of Alzheimer's diseased people.

FIGURE 3: Alzheimer's Patients' Census.

B. Brain imaging methods: Functional imaging of electric brain activity requires specific models to transform the signals recorded at the surface of the human head into an image [8]. Two categories of model are available: 1) single-time-point and 2) spatio-temporal methods. The instantaneous methods rely only on few voltage differences measured at one sampling point. To create a spatial image from this limited information, they require strict assumptions that rarely conform to the underlying physiology. Spatio-temporal models create two kinds of images: first, a spatial image of discrete equivalent multiple dipoles or regional sources, and second, an image of source current waveforms that reflect the temporal dynamics of the brain activity in circumscribed areas. The accuracy of the spatial image is model dependent and limited, but it can be validated from the spatio-temporal data by the "regional source imaging" technique, introduced here. The source waveforms are linear combinations of the scalp waveforms, and thus, specific derivations which image local brain activities at a macroscopic level.

Brain source imaging of somatosensory evoked potentials revealed temporally overlapping activities from the brainstem, thalamus, and from multiple sources in the region of the contralateral somatosensory projection areas.

MRI (Magnetic Resonance Imaging): Magnetic Resonance Imaging (MRI), or nuclear magnetic resonance imaging (NMRI), is primarily a medical imaging technique most commonly used in radiology to visualize the internal structure and function of the body. MRI provides much greater contrast between the different soft tissues of the body than computed tomography (CT) does, making it especially useful in neurological (brain), musculoskeletal, cardiovascular, and oncological (cancer) imaging. Unlike CT, it uses no ionizing radiation, but uses a powerful magnetic field to align the nuclear magnetization of (usually) hydrogen atoms in water in the body. Radio frequency (RF) fields are used to systematically alter the alignment of this magnetization, causing the hydrogen nuclei to produce a rotating magnetic field detectable by the scanner. This signal can be manipulated by additional magnetic fields to build up enough information to construct an image of the body.

Magnetic Resonance Imaging is a relatively new technology. The first MR image was published in 1973 and the first study performed on a human took place on July 3, 1977. By comparison, the first human X-ray image was taken in 1895.

Magnetic Resonance Imaging was developed from knowledge gained in the study of nuclear magnetic resonance [8]. In its early years the technique was referred to as nuclear magnetic resonance imaging (NMRI). However, as the word nuclear was associated in the public mind with ionizing radiation exposure it is generally now referred to simply as MRI. Scientists still use the term NMRI when discussing non-medical devices operating on the same principles. The term Magnetic Resonance Tomography (MRT) is also sometimes used.

Functional MRI: Functional MRI or functional Magnetic Resonance Imaging (fMRI) is a type of specialized MRI scan. It measures the haemodynamic response related to neural activity in the brain or spinal cord of humans or other animals. It is one of the most recently developed forms of neuroimaging. Since the early 1990s, fMRI has come to dominate the brain mapping field due to its low invasiveness, lack of radiation exposure, and relatively wide availability.

Positron Emission Tomography (PET): Positron emission tomography (PET) is a nuclear medicine imaging technique which produces a three-dimensional image or picture of functional processes in the body. The system detects pairs of gamma rays emitted indirectly by a positron-emitting radionuclide (tracer), which is introduced into the body on a biologically active molecule. Images of tracer concentration in 3-dimensional space within the body are then reconstructed by computer analysis. In modern scanners, this reconstruction is often accomplished with the aid of a CT X-ray scan performed on the patient during the same session, in the same machine.

If the biologically active molecule chosen for PET is FDG, an analogue of glucose, the concentrations of tracer imaged then give tissue metabolic activity, in terms of regional glucose uptake. Although use of this tracer results in the most common type of PET scan, other tracer molecules are used in PET to image the tissue concentration of many other types of molecules of interest.

C. Image Registration: In this project, sets of data acquired by sampling the same scene or object at different times, or from different perspectives, will be in different coordinate systems. Image registration is the process of transforming the different sets of data into one coordinate system. [9] Registration is necessary in order to be able to compare or integrate the data obtained from different measurements.

Medical image registration (for data of the same patient taken at different points in time) often additionally involves elastic (also known as nonrigid) registration to cope with deformation of the subject (due to breathing, anatomical changes, and so forth). Nonrigid registration of medical images can also be used to register a patient's data to an anatomical atlas, such as the Talairach atlas for neuroimaging.

Image registration is the process of overlaying two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors. It geometrically aligns two images—the reference and sensed images. The present differences between images are introduced due to different imaging conditions. Image registration [10] is a crucial step in all image analysis tasks in which the final information is gained from the combination of various data sources like in image fusion, change detection, and multichannel image restoration. Typically, registration is required in remote sensing (multispectral classification, environmental monitoring, change detection, image mosaicing, weather forecasting, creating super-resolution images, integrating information into geographic information systems (GIS)), in medicine (combining computer tomography (CT) and NMR data to obtain more complete information about the patient, monitoring tumor growth, treatment verification, comparison of the patient's data with anatomical atlases), in cartography (map updating), and in computer vision (target localization, automatic quality control), to name a few. During the last decades, image acquisition devices have undergone rapid development and growing amount and diversity of obtained images invoked the research on automatic image registration.

D. Image registration methodology: Image registration, as it was mentioned above, is widely used in remote sensing, medical imaging, computer vision etc. In general, its applications can be divided into four main groups according to the manner of the image acquisition [9]:

1. Different viewpoints (multi-view analysis). Images of the same scene are acquired from different viewpoints. The aim is to gain larger a 2D view or a 3D representation of the scanned

scene. Examples of applications: Remote sensing—mosaicing of images of the surveyed area. Computer vision—shape recovery (shape from stereo).

2. Different times (multi-temporal analysis). Images of the same scene are acquired at different times, often on regular basis, and possibly under different conditions. The aim is to find and evaluate changes in the scene which appeared between the consecutive image acquisitions. Examples of applications: Remote sensing—monitoring of global land usage, landscape planning. Computer vision— automatic change detection for security monitoring, motion tracking. Medical imaging— monitoring of the healing therapy, monitoring of the tumor evolution.

3. Images of the same scene are acquired by different sensors. The aim is to integrate the information obtained from different source streams to gain more complex and detailed scene representation. Examples of applications: Remote sensing—fusion of information from sensors with different characteristics like panchromatic images, offering better spatial resolution, color/multispectral images with better spectral resolution, or radar images independent of cloud cover and solar illumination. Medical imaging—combination of sensors recording the anatomical body structure like magnetic resonance image (MRI), ultrasound or CT with sensors monitoring functional and metabolic body activities like positron emission tomography (PET), single photon emission computed tomography (SPECT) or magnetic resonance spectroscopy (MRS). Results can be applied, for instance, in radiotherapy and nuclear medicine.

4. Scene to model registration. Images of a scene and a model of the scene are registered. The model can be a computer representation of the scene, for instance maps or digital elevation models (DEM) in GIS, another scene with similar content (another patient), 'average' specimen, etc. The aim is to localize the acquired image in the scene/model and/or to compare them. Examples of applications: Remote sensing—registration of aerial or satellite data into maps or other GIS layers. Computer vision—target template matching with real-time images, automatic quality inspection. Medical imaging— comparison of the patient's image with digital anatomical atlases specimen classification.

Due to the diversity of images to be registered and due to various types of degradations it is impossible to design a universal method applicable to all registration tasks. Every method should take into account not only the assumed type of geometric deformation between the images but also radiometric deformations and noise corruption, required registration accuracy and application-dependent data characteristics. Nevertheless, the majority of the registration methods consist of the following four steps (closed-boundary regions, edges, contours, line intersections, corners, etc.) are manually or, preferably, automatically detected. For further processing, these features can be represented by their point representatives (centers of gravity, line endings, distinctive points), which are called control points (CPs) in the literature. Feature matching. In this step, the correspondence between the features detected in the sensed image and those detected in the reference image is established. Various feature descriptors and similarity measures along with spatial relationships among the features are used for that purpose. Transform model estimation. The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated. The parameters of the mapping functions are computed by means of the established feature correspondence.   Image resampling and transformation. The sensed image is transformed by means of the mapping functions. Image values in non-integer coordinates are computed by the appropriate interpolation technique. The implementation of each registration step has its typical problems. First, we have to decide what kind of features is appropriate for the given task. The features should be distinctive objects, which are frequently spread over the images and which are easily detectable. Usually, the physical interpretability of the features is demanded. The detected feature sets in the reference and sensed images must have enough common elements, even in situations when the images do not cover exactly the same scene or when there are object occlusions or other unexpected changes. The detection methods should have good localization accuracy and should not be sensitive to the assumed image degradation. In an ideal case, the algorithm should be able to detect the same

features in all projections of the scene regardless of the particular image deformation. In the feature matching step, problems could be caused by an incorrect feature.

E. Mathematics of Image Registration: Given two images of the same object (possibly at different times, from different distances or angles or points of view, with distortion from a lens or other intervening medium, or using different imaging technologies), one would like to find a mapping that identifies points of one image with points in the other. An ideal mapping should have various features: in particular, it should be relatively smooth, and the data should fit the mapping well. (Criteria such as these can of course be made more precise using appropriate mathematical and statistical language.) Since an "ideal" mapping may be computationally infeasible (or may not even exist) the goal is to develop mathematical algorithms to find a mapping of a given specified type (e.g., definable by Bézier transformations) and which is as close to ideal as various practical limitations admit.

F. Defining Project Goals: Fundamental problems in the analysis of functional and structural imaging data include data transport, boundary identification (including manual tracing, edge detection, and tissue segmentation), volume estimation, three-dimensional reconstruction and display, surface and volume rendering, shape analysis, and image overlay. These problems require that research investigators have access to suitable methods of image analysis, implemented on a set of software programs, in order to conduct neuroimaging research.

Different cost functions, different minimization methods, and various sampling, smoothing, and editing strategies were compared. Internal consistency measures were used to place limits on registration accuracy for MRI data, and absolute accuracy was measured using a brain phantom for PET data. All strategies were consistent with subvoxel accuracy for intrasubject, intramodality registration. Estimated accuracy of registration of structural MRI images was in the 75 to 150 μm range. Sparse data sampling strategies reduced registration times to minutes with only modest loss of accuracy.

The registration algorithm described is a robust and flexible tool that can be used to address a variety of image registration problems. Registration strategies can be tailored to meet different needs by optimizing tradeoffs between speed and accuracy. The main emphasis is given to the color combination of some brain tissues. ***The spaces in the folds of the brain (the sulci) can be easily detected by their color combination. Color intensity of that area will be measured; based on that measurement results, hypothesis will be generated. Cavity in cerebral cortex region stained in PET image is shown in figure 4.***
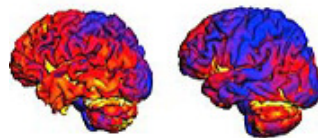
FIGURE 4: Cerebral Cortex with Color Stain
(PET Image).

4. MODEL FORMULATION

1. Read and zoom the image using Bilinear Interpolation [11]
   im1(1+(i-1)*fac,1+(j-1)*fac,:)=im(i,j,:)
    Where im1 is the image array and fac is the zooming factor
    im1 (i, j, :) =b1+b2*dx+b3*dy+b4*dx*dy
    Where b1, b2, b3, b4 bilinear interpolation constants and dx,dy   localized pixels

2. Manage all Exceptions while loading the zoomed image: ExceptionHandling
    (Try Catch statement [12]).

3. Get the pixmap (Identified as 3D array of image in MATLAB [12]).

4. Extract cavity area of sulci (Apply imcrop function [12]).

5. Find the sum of each pixel value of three arrays; (RED+GREEN+BLUE) from cropped area

6. If value= =0 identify as black.

7. Put total identified pixels (black) into an array called as cavity array.

8. Else put those pixels (not black) into an array called as cortex array.

9. Compare the length of both cavity and cortex arrays (Apply length function).

10. If (length of cavity array is more), then trace as abnormality in the figure.

11. Else normal nature.

12. Set the graph of both cavity and cortex arrays (Apply plot function).

5. TESTED RESULTS USING MATLAB
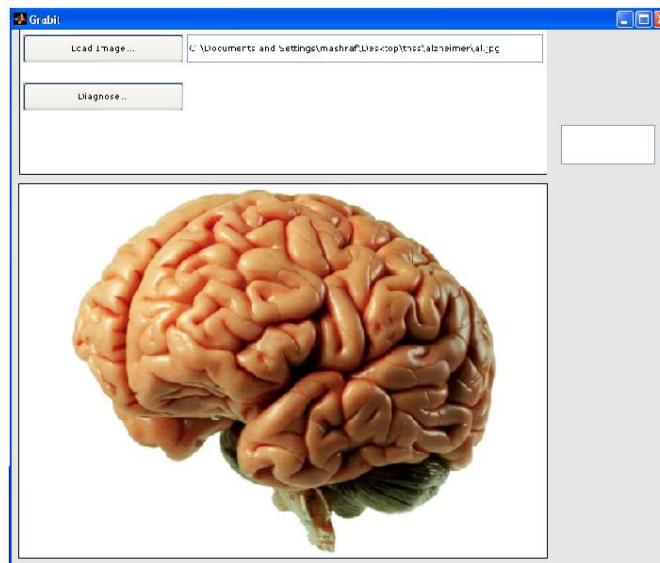
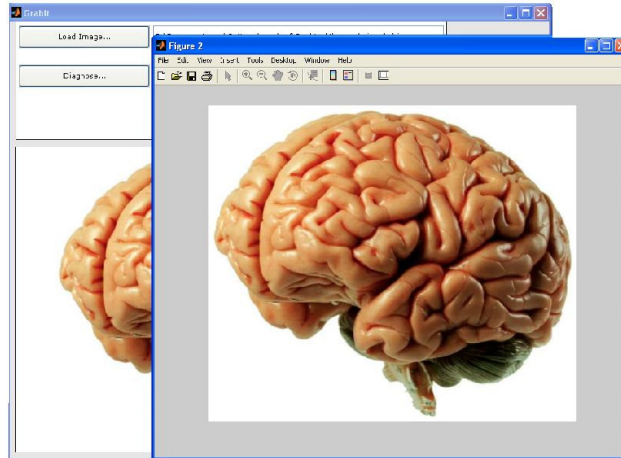

FIGURE 5: Simulated Image First Load.
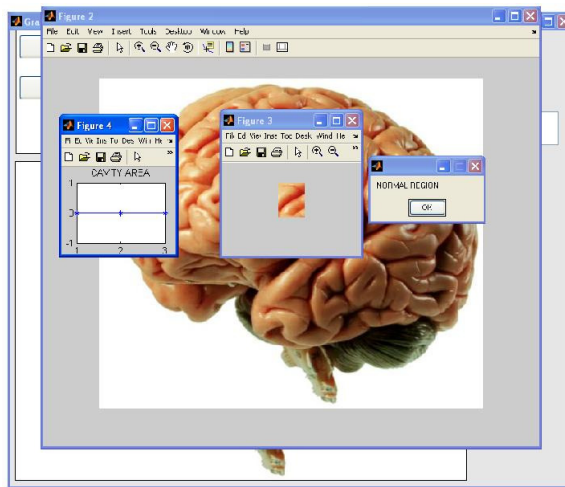
FIGURE 6: Image in Zoom.
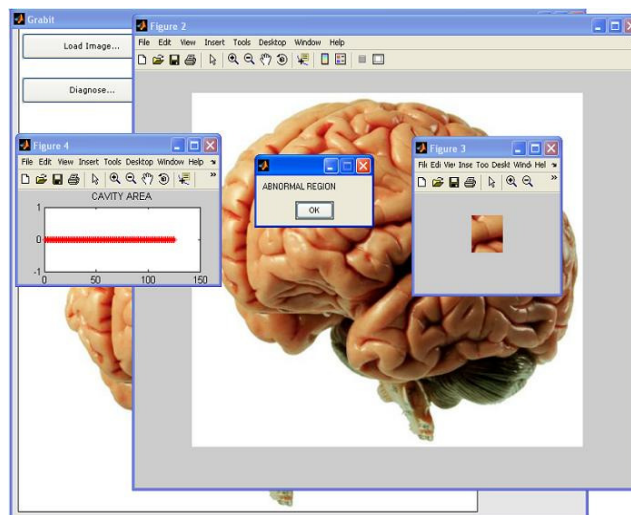

FIGURE 7: Normal Area.
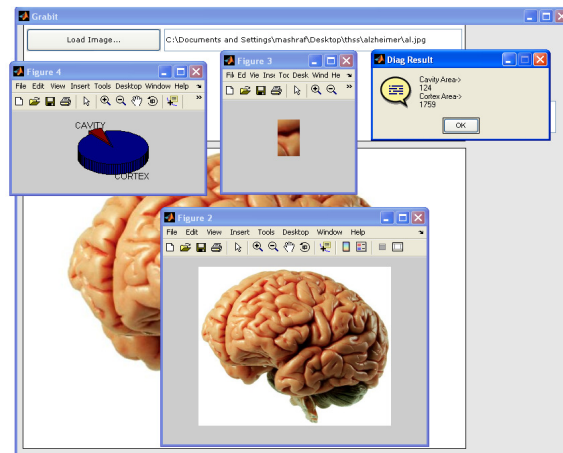

FIGURE 8: Abnormal Area.

FIGURE 9: Measure of Abnormality.

6. SCOPE OF STUDY

The scope of this study can open an emerging trend in the field of computer and medical science; a new branch of science called Neuroinformatics, it may deal all the issues of neuroscience and computer science.

Neuroinformatics is a research field that encompasses the organization of neuroscience data and application of computational models and analytical tools. These areas of research are important for the integration and analysis of increasingly fine grain experimental data and for improving existing theories about nervous system and brain function. Neuroinformatics provides tools, creates databases and the possibilities for interoperability between and among databases, models, networks technologies and models for the clinical and research purposes in the neuroscience community and other fields.

Neuroinformatics stands at the intersection of neuroscience and information science. Other sciences, like genomics, have proved the effectiveness of data sharing through databases and by applying theoretical and computational models for solving complex problems in the field. Through Neuroinformatics facilities, researchers can share their data and contribute to other disciplines using available tools for the analysis and integration of data. Researchers can also more easily quantitatively confirm their working theories by means of computational modeling. Additionally, Neuroinformatics fosters more collaborative   research of which one aim is to provide better possibilities to study the brain at multiple levels of brain structure. There are three main directions where Neuroinformatics has to be applied:

  a. The development of tools and databases for management and sharing of neuroscience data at all levels of analysis,

  b. The development of tools for analyzing and modeling,

  c. The development of computational models of the nervous system and neural processes.

In the recent decade; as vast amounts of diverse data about the brain were gathered by many research groups, the problem of how to integrate the data from thousands of publications in order to enable efficient tools for further research; was raised. The biological and neuroscience data are highly interconnected and complex, and by itself represents a great challenge for scientists.

Combining informatics research and brain research provides benefits for both fields of science. On one hand, informatics facilitates brain data processing and data handling, by providing new electronic and software technologies for arranging databases, modeling and communication in brain research. On the other hand, enhanced discoveries in the field of neuroscience will invoke the development of new methods in information technologies.

7. CONCLUSION

Due to high cost and requirement of professionalism much of medical imaging softwares are far from common man. Here the attempt was develop simple software in MATLAB to detect the structural abnormality of brain. The task almost fulfilled but it requires much perfection. The highlight of this software is simplicity, user friendliness and keen observation of the image at minute level.

8. FUTURE RESEARCH

In this research the measurement of cavity area is totally based on the color coding system. This measurement should be converted into some metric form. After that the abnormality can be categorized as mild, moderate and severe.

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