Pattern Recognition in Brain FMRI for Agnosia

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ABSTRACT

Learning disability (LD) is a neurological disorder caused by a dysfunction of the central nervous system. There are 3 major groups of learning disability including dyscalculia, dysgraphia, and dyslexia. Dyslexics have difficulty with reading, writing, spelling, short term memory, personal organizational ability and spoken language. Nowadays, fMRI is widely used in studies of brain function, including reading and dyslexia, because fMRI is non−invasive, safe, and can be used repeatedly, which is suitable for studying humans, especially children.

The objective of this thesis is to develop software to analyze dyslexia brain fMRI images. The researcher used the Microsoft C sharp language to develop the software. Pattern recognition was used for classifying and calculating subjects' image data. Three-dimensional reconstruction was used for presenting an image. We used 9 subjects, consisting of 6 normal and 2 abnormal subjects. The software classified as a 5 subjects as normal and 3 as abnormal. The software sensitivity was 85.71%, specificity was 100%, and accuracy was 88.89%.

Keywords: FMRI, Agnosia, pattern recognition, neural network, Microsoft C sharp

1. INTRODUCTION

Learning disability (LD) is a neurological disorder that causes by the dysfunction of central nervous system (CNS) [1]. The characteristic of the learning disability are on academic and functional skills including writing, spelling, reading, calculating, and algorithm. There are 3 major groups of learning disability, e.g. dyscalculia, dysgraphia, and dyslexia. Dyslexia is the most common disorders of learning disability in children. There is 5-10% of population around the world who has the reading disability. The symptoms of this order are difficult in reading, writing, spelling, short term memory, poor personal organizational and spoken language problems [2]. Dyslexia persists throughout life; it is a chronic condition that affects to quality of life. Therefore, treatments should mitigate dyslexic's symptoms and overcoming i.e. remedial instruction and compensatory strategies.

Agnosia is a perception disorder in sensation which is a disability to recognize a stimulator or know the objects. Patients with agnosia cannot understand or recognize what they see, hear or feel. Agnosia results from lesions that disconnects and isolates the visual, auditory and somatosensory input from higher level processing. Less than one percent of all neurological patients have agnosia [4]. It is usually associated with brain injury or neurological disease [3]. The specific symptoms depend on the cause of the agnosia. Some cases of these patients are unable to copy drawings, but they are able to manipulate objects with good dexterity [5]. Commonly, they can describe objects in their visual field in great detail, including such aspects as colour, texture and shape but are unable to recognize them. Similarly, patients can often describe familiar objects from memory despite their visual problems [6].

An apperceptive agnosia is a type of disorders that describes a failure in object recognition due to problems in early stage perceptual processing [7]. It refers to a disorder when the early stage perceptual processing is unchanged [8]. Most cases of associative agnosia probably have deficits in early stage processing and perceptual and memory representations in object recognition are not clearly. Boundaries of apperceptive agnosia and associative agnosia are not as clear [9]. Accordingly, agnosia is a disability of object recognition. Therefore, it means that the agnosia is commonly subset of the dyslexia. In this study is proposed to measure and evaluate the activation areas of the brain on Dyslexia patients. The software is utilized the image processing technique to detect and analyze the MRI brain image. Image processing technique uses for separating brain's area from skull and adjusting an image for recognition will be developed. Pattern recognition method is used to detect and measure activation area on 3D programming. 3D reconstruction is used for reconstruct 3D view from MRI image. Reconstruction method is used with Microsoft DirectX engine to show human brain in 3D. This work emphasizes for development the software by using C# language. Program interface consists of three anatomical planes such as sagittal, coronal and transverse planes of the human brain picture. Generally, there are many applications which are used to detect the area of the disorder in the brain, such as MRI, or FMRI.

The basic of Magnetic Resonance Imaging, or MRI, typically measures the response of hydrogen molecules to a formal pattern while they are in a magnetic field [10]. However, some basic knowledge of the

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principles is required to fully understand the subsequent sections. There are four basic steps involved in obtaining an MR image of the brain. The first step is to place the brain in a magnetic field. Second step is the application of a brief radiofrequency (RF) pulse. This RF-pulse perturbs the hydrogen nuclei in the brain. Third, it is measuring the radio signal emitted from the hydrogen nuclei. Last step is transforming this signal to obtain a 3-dimensional MRI image. Each step will be considered in turn, concluding with a discussion of the pulse cycles that are commonly used.

Functional magnetic resonance imaging (fMRI) has been become a popular tool for measuring brain function. fMRI observes any parts of the brain which are activated by behavioral with a spatial resolution of 2−5 millimeters, which is superior to many of the other techniques in cognitive neuroscience. An activity area in the brain those are as close as 2−5 millimeters in the brain may be separate from each other. The temporal resolution (the minimal distance in time between two data points that can still be difference) is relatively poor 5−8 seconds. However, the first section shows the principles underlying MRI and how MR images are obtained. Second section will be given to a specific protocol of MRI used to indirectly infer the functional activity of the brain that referred to as functional Magnetic Resonance Imaging (fMRI) [10, 11].

The fMRI besides looking at structural scans of the brain, MRI can also be used to look at functional activity of the brain, in which case it is referred to as functional magnetic resonance imaging (fMRI). Normally, the echo planar imaging (EPI) is the most common used to obtain fMRI images is and the most common contrast technique in fMRI is called blood oxygenation level-dependent contrast (BOLD) technique [11, 12]. This technique is based on the fact such as under normal circumstances, neuronal activity and haemodynamics are linked in the brain.

There are many types of the digital imaging file. For medical field, the Digital Imaging and Communications in Medicine (DICOM) files type standard is a common type of file that was created by the National Electrical Manufacturers Association (NEMA) to viewing of medical images, such as computed tomography (CT) scans, MRI, fMRI and ultrasound.

DICOM file contains with a header (to contain a DICOM detail) and image data (to contain a value of pixel). This DICOM file format is different from the Analyze format. The analyze format stores the image data in image file (.img) and header data in high dynamic range (*.hdr) file. Difference between DICOM and Analyze is DICOM image data can be compressed to reduce the image size.

In the past decades dyslexia is a hidden disability until the advent of neuro imaging especially fMRI. This equipment measures the changing of metabolic activity and blood flow in brain during person has a specific cognitive task that relates to understand of reading dyslexia. Data from fMRI indicates that there are three brain's areas which concern with reading skill, such as the inferior fontal gyrus, parieto−temporal region, and occipito-temporal regions. These regions are especially important for articulation, word analysis, and visual word form area (VWFA), respectively [13, 14]. In case of dyslexia reader, disruption of posterior reading systems occurs.

Nowadays, fMRI is widely used for studying the brain's function that includes with reading and dyslexia, because of fMRI is a noninvasive technique, safe and it can be used repeatedly which is suitable for studying humans, especially in children. Joseph Diena et al. presented about the fMRI characterization of the language formation area. They found that the respond of the language formation area to close probabilities may indicate a role in correlation the lexical and non-lexical reading pathways.

2. METHOD

This study consists of two major parts. First, researcher designed and developed software to analyze the datasets. Second, using the software to process and verify subject data. The software includes with the image acquisition and reconstruction, pattern recognition, and verifying output. The software consists of 4 parts, i.e. data acquisition, pattern recognition, rendering and image processing. Software part can be shown as a diagram in Figure 1.

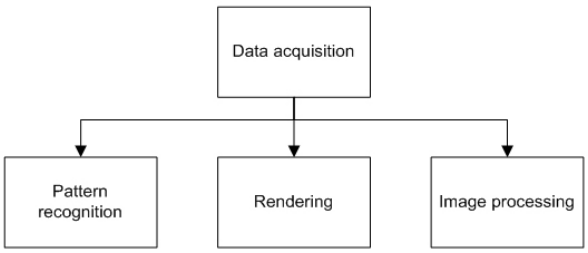

Fig.1: *Software diagram.*

The software in this study is designed and developed by on Microsoft dot net 3.5 platform (.net 3.5) by Microsoft visual c sharp (C#) language programming which is called Neural Image Analysis (NIA). From in data acquisition in this study, there are three parts for analysis the datasets, as pattern recognition, rendering and image processing.

2.1 Image acquisition

NIA was designed for importing the single and/or multiple image dataset. User can be set the importing

condition by using the file management group. When number of series is equal to zero, the software might read all files in the folder automatically. The fMRI dataset must be having a time series data. User might be set the series number to send software read by step by step. Figure 2 was shown the import diagrams of the software.

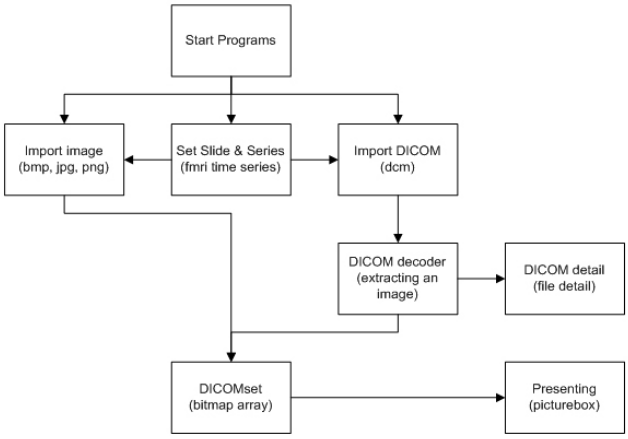

Fig.2: *Image acquisition diagram*

This software was supported a many types of files, such as DICOM, Bitmap, Joint Photographic Experts Group (JPEG) and included with the Portable Network Graphics format (PNG) file. If imported files were the DICOM file, the DICOM decoder was used to extract the DICOM detail. The DICOM detail was presented at the new windows after clicked on detail button. After the software extracted an image, it sent the image pixel data to DICOMset. The DICOMset variable was an image data collector. It was an array of the bitmap image which numbers of array were presented the number of input files. When DICOMset was not equal to null variable, this software was presented an input image by using a picturebox. After that, the following C# code could be expressed the mapping pixel data to DICOMset.

2.2 Image processing

NIA software also comprised of an image processing toolbox for processing an image that was explained in Fig. 3. This toolbox might be work if user clicked on properties button. Image processing is used for the enhancement and improvement the input image. Moreover, the user can be processing an image over the toolbox and saving the processed image to the new input. The processed image can be save to the bitmap image by use the save button.

2.3 Pattern recognition

Pattern recognition method was used for automatic computational recognition. This method was

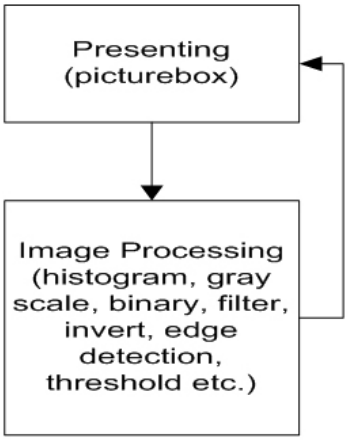

Fig.3: *Image processing diagrams*

used to classify the activation of brain's areas on fMRI image.

Data acquisition and pre − processing step was described on the previous topic. For the feature extraction, the following equation is used to define the activation area over the time domain. This step was designed to reduce the data input of the system. If the system did not reduce an input, system might be run on 64x64x5010x10 inputs for train this system. This equation was used to define a feature input to represent an input image. By using following equation, the pixel feature of each subject image was calculated.

$$I = \sum_{k=0}^{l-1} \sum_{j=0}^{n-1} \sum_{i=0}^{m-1} (x_{i,j,k} - x_{i,j,0}) \qquad (1)$$

Image feature was presented in term of summation. Two patterns were calculated by series summation (SSE) and slide summation (ss) after the process. The result was showed the feature recognition of the subject image. For the network part, multilayer perceptron (MLP) was used to classify the feature data between 2 subject groups.

2.4 3D Rendering

NIA software was able to render the input image dataset by using the IP engine. The IP engine was a 3−dimensional engine that was used for reconstructing a slicing image. This engine was created by Microsoft XNA game studio and linked with windows form. Microsoft XNA framework was designed to develop the game programming. Developer used the XNA to control the directX library. It was an easy way to control direct library directly. IP engine would reconstruct a 3D model by the volume rendering using import a model. The FBX cube model was created on other 3D software and import to the engine, which was shown as Fig. 4. After that, the engine would reconstruct 3D by loading image pixel data,

pixel by pixel. The pixel data was set up to the voxel texture intensity, thus if input pixel intensity was 255 the voxel texture intensity must be equal to 255. This following syntax was used to import a model to the engine.

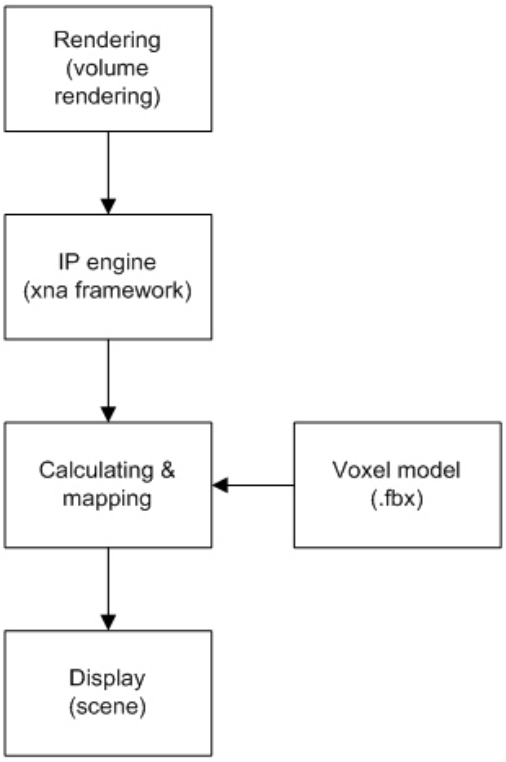

Fig.4: *Rendering diagrams*

2.5 Verifying output and analysis

Comparison input and output was checked the accuracy of the program. The program set the loop of verifying on the program for checking the recognition data. After the networks training, healthy people and patients data were represented into the system. At last, the software must compare between 2 sets of data, healthy people and Agnosia subjects. This software must be containing with 2 dataset for each patient. Each dataset was analysed and compared by this software. The compared condition was set on the position of activation area and size of activation area on 3D visualization.

3. RESULTS

The subject dataset was required from www.fmridc.org. 10 subjects came from Binder JR. et al, *Neural Correlates of Lexical Access During Visual Word Recognition*, Journal of Cognitive Neuroscience 2003 April, 15(3): p.372−393. However, the dataset file format was analyze7.5 file format. This software supported the DICOM, Bitmap, Joint Photographic Experts Group (JPEG) and included with the Portable Network Graphics format (PNG) files, so it could convert this format to PNG file.

3.1 Feature Extraction

Image feature was presented in term of summation. Two patterns were calculated by slide summation (ss) after the processed. The result was showed about the feature recognition of the subject image.

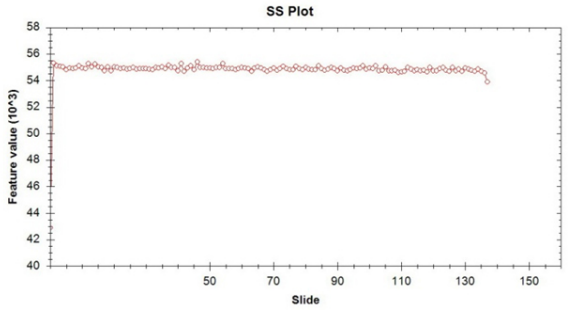

Fig.5: *Normal subject's SS feature*

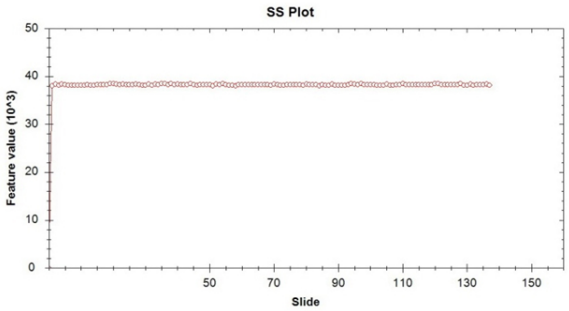

Fig.6: *Agnosia subject's SS feature*

3.2 Training

Figure 5 and 6 were expressed the error propagation, the three values, e.g. the number of hidden node, learning rate and momentum, were evaluated to fit architecture. For this study, the number of hidden was set at 4, learning rate was 0.001 and momentum was 0.1 for getting a design error.

3.3 Testing

The 8 subjects were tested by MLP architecture, including 6 normal subjects and 2 abnormal subjects. Table 1 was shown the MLP classified of 8 subjects.

Table 1: *SENSITIVITY, SPECIFICITY, AND ACCURACY OF SOFTWARE AFTER TESTING*

		Patients with Agnosia (as confirmed by *,**)		
		positive	negative	
MLP Classified	Positive	5	0	
	Negative	5	0	
		Sensitivity = 83.33%	Specificity = 100%	Accuracy = 87.50%

3.4 Three dimensional reconstructions

Next, there was a software property that related to 3D reconstruction. The software constructed a 3D image from 2D image by using xna frameworks. Fig. 8 showed the 3D mapping from a single 2D image and fig. 9 showed the 3D mapping from multiple 2D images.

4. DISCUSSION

This study provided a dataset from www.fmridc.org. Since, this dataset was received that concerned with the normal healthy subjects, but it did not has the dataset of dyslexia patients. There are 29 normal subjects which received, however in this study received the dataset that related to the abnormal function subjects, as an agnosia subjects. Accordingly, agnosia is subset of dyslexia. Therefore, in this study used the patients with agnosia to test this software. There are 4 dataset of agnosia subjects, for testing and training. These dataset was separated into 2 subjects for train the network and 2 subjects for testing.

The MLP network had a problem on error propagation. The software was running to a highly iterative, the error didn't increase to a design error and it didn't change in much difference architecture, while the system error was a constant and did not change. During MLP architecture was changed in number of hidden node, learning rate and/or momentum, the system presented different error propagation.

The MLP testing was examined after design of architecture was set for training the network. The result showed that 2 agnosia subjects were classified correctly. The 6 normal subjects were classified correctly in 5. The 2 of 6 normal subjects had a more different feature than other normal subjects. Mostly, the normal subject had a feature value as a straight line, but other subject feature value was a saw tooth.

3D reconstruction was used to reconstruct a 3D model from 2D image. Software reconstructed a model by using Microsoft XNA frameworks. The reconstruction engine was used as the box to represent a voxel and mapping a texture over the box. The box was arranged by compare between original images. The advantage of this engine was the image processing over 3D frame and high detail resolution of the 3D model. Disadvantage was high resource consumption that can be given CPU usage nearly 100%.

5. CONCLUSION

This study proposed to develop the software for classification between the normal and abnormal brain fMRI images. Since, there were only 4 agnosia subjects from www.fmridc.org. If in this study have more subject data, software can classify better than previous data.

There is some problem in feature extraction to define a region of interest (ROI). Software properties were shown that the image processing cannot set value for all of image dataset because the dataset is too large. Even if this variable was developed, the software might consume higher memory. However, MLP spent long time to train the system and its algorithm usually made the system to non response.

Three dimensional reconstructions engine was represented in this study. This engine was a basic 3d reconstruction engine by using a voxel model to construct a 3d image. When engine was run, engine did not use higher memory (RAM) but engine required higher CPU usage. So, this engine was used to define the area inside a brain but still use to define area on the brain edge. A new surface rendering was required for a smooth brain rendering to define a brain 3d model.

6. FUTURE WORKS

This software should be recoding and debugging, it made for rearrangement of code and flow chart. The new features are applied on the software. 3D reconstruction engine will be changed an algorithm to reduce resource consumption and reconstruction faster. This software will be made for cover another image file. At last period of this software will cover support for all of medical image instrument.

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