Stroke Area Detection using Texture Feature and iFuzzyLDA Algorithm

Lee Ming-Sian, Chen Chong-Guang Chin Chiun-Li, and Liu Shih-Hua
Department of Medical informatics
Chung Shan Medical University, Taichung, Taiwan
Email: {errorre, mindplayer}@livemail.tw; ernestli@csmu.edu.tw; a1025kbc@hotmail.com.tw

***Abstract*—According to the opinions of specialized doctors, being able to accurately make diagnosis with both the regions and types of stroke is very important, and with these information available, only then medical treatments can be applied properly. However, for any delay treatment or misdiagnosis, it is very likely as the key attributed to the fatal death of the patients. Currently, there are a lot of researches on the development of many methods with application of MRI for diagnosis of brain stroke out there already. However, in this paper, CT image is used to diagnosis brain stroke. And, we use laws' mask to extract texture feature on the CT image, and further to input them into our proposed iterative Fuzzy LDA (iFuzzyLDA) method for classification. Next, we will make classification of four different features (stroke, CSF, gray and white matter), as well as to put a link among them, in order to get better accuracy for diagnosis. Experimental result shows our method has a good accuracy, and be able to precisely help the doctors for marking out the regions of brain stroke. In addition, it can be verified that the accuracy rate of our method is up to 90% through object-level consistency error (OCE) method.**

***Index Terms*—CT scan, laws' mask, iFuzzyLDA, OCE**

I. Introduction

The cerebrovascular disease is a commonly seen death factor around the world; for example, in the United States, the brain stroke is ranked the third major death factor according to the survey of World Health Organization "Ref. [1]"; similarly in Taiwan, there are around 17,000 persons who died of brain stroke every year "Ref. [2]-[3]". In the paper, from the experiences of specialized doctors, to know that the accurate diagnosis is very important for people with preliminary brain stroke, if there is no good precaution taken in the beginning stage, there are usually to follow with severe effects subsequently, for example, within the first three hours when the brain stroke is taken place, if there is no proper medication given to the patient, the condition of the patient will become difficult to recover, turning into permanent damage instead.

For the DWI application of MRI, it just happens to clearly indicate the position of brain stroke, and this is why MRI is currently used massively for completion of same research we are doing here "Ref. [4]-[6]", however, in our study, the CT images often seen in the ordinary hospitals are used, even though MRI offers very good diagnosis results, the MRI machinery is too expensive to be affordable for a lot of small hospitals and clinical centers, and it is generally to exist in large hospitals only, moreover, due the costs of MRI are high, and the length of time is long to complete scanning, it is not suitable to be used for preliminary brain stroke. After solving the above mentioned problems on examination method and time, we find out that on the aspect of actual examination, using traditional examination method is sometimes with wrong results, and this is possibly due the examination doctor is a new comer who is lack of experience, as well as the trait of Ischemic brain stroke itself, for example, for the diagnosis in the preliminary stage of brain stroke, it is possibly to be wrong in a large degree due the changes of images are very delicate for brain stroke in the preliminary stage "Ref. [7]-[9]". It is comparably more obvious for the kind of situation to occur in the developing countries and underdeveloped countries, or rural villages and towns. Currently, there are very few researches done on the aspect, and being able to develop it out for implementation is very important. Even though it is unenhanced CT image, it can also help the doctors who are lack of experiences to create good diagnosis result. Below are introductions to the sections and contents in the chapter.

There are five chapters in this paper. The earlier part of the first section is Introduction. Then order description is the following sections, in section II is a detailed description of the complete process. In section III is experimental results. In section IV is conclusions.

II. Materials and Methods

In the paper, we use CT images with DICOM format for analysis and processing, all of which are 8 bites images at pixel size of 512×512 created by the instrument of TOSHIBA_MEC_CT3 from the doctors who are in cooperation with us. Next, we put our focus on regions likely to occur brain stroke at a division of 25×25 pixel size for extraction of texture features, further to make classification of them. There are a total of 90 cases in the study.

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The system process flow chart offered by us is shown in Fig. 1. The system is divided into four parts. Firstly, the system will work on preprocessing of the images. Afterwards, the system will use URGA (unsupervised region growing algorithm) to extract automatically for the parts in suspicion of brain stroke. Then, for the regions in suspicion of brain stroke, they are divided into sections for extraction of traits. Finally, we will enter the traits extracted into our proposed iFuzzyLDA method for classification "Ref. [10]", and the area with brain stroke can be obtained accurately right away.

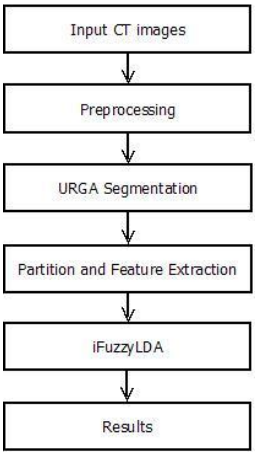


Figure 1. System flowchart.

A. Preprocessing

In the past, for most of the doctors, if they want to view CT or MRI images, they will use an approach called "window method" "Ref. [11]" to increase on the degree of contrast for images, for example, viewing a region with brain stroke, they will then put a set of parameters; window center is set as 40HU and the window width (W) is set as 80, however, for this approach, it is lack of flexibility, instead in the chapter, we will take adoption of cubic curve method "Ref. [12]" for contrast adjustment on images due the approach is with nice responsive effects in its sensibility to light changes, and its formula is shown as (1). The adaptive cubic curve is shown in Fig. 2. After preprocessing, we can enhance the brain tissue from the original image in Fig. 3(a), as well as the one with preprocessing in Fig. 3(b).

$$y = f(x) = ax^3 + bx^2 + cx + d \tag{1}$$

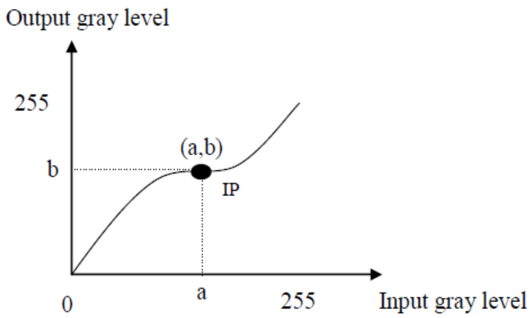
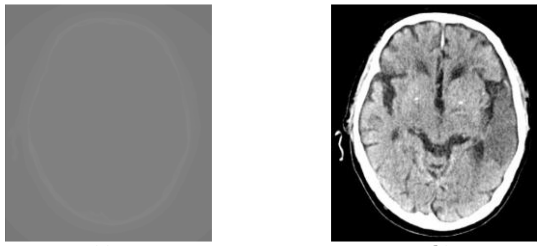


Figure 2. Adaptive cubic curve for backlight image compensation.



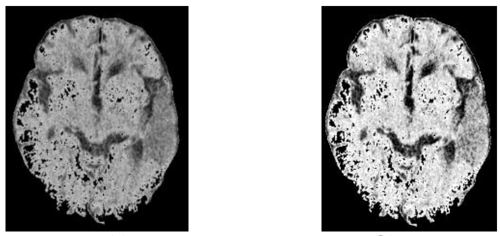
(a) (b)

Figure 3. (a) is original image. (b) is preprocessed image.

B. URGA segmentation

And in the following procedure, we will process an array to divide the region with brain stroke into segments, and the process flow is as shown below.

- *Step 1:* We will use anisotropic to process the input images into obscurity, and to clear out all the miscellaneous noises and frequencies, in order to be beneficiary for the processing of subsequent steps.
- *Step 2:* Use mathematical morphology to work on dilation and erosion of images, with elimination of skeletons not as part of cerebrum as well as areas not necessary, while the remaining part can be used to judge the region with brain stroke, as shown in Fig. 4(a).
- *Step 3:* Use Canny's edge detector to detect the edges of the images, as well as to collect the CT values nearby the edges for statistics, then to obtain the peak values of histogram, to be used as the seed values for automatic region growth.

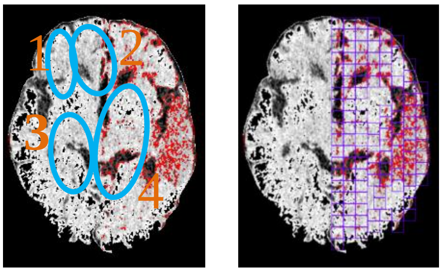


(a) (b)

Figure 4. (a) is brain tissue area. (b) is the result of region growing.

- *Step 4:* After using the peak values for completion of regional growth, the results are as shown in Fig. 4(b), and after completing the above steps, there is definitely a degree of difference in contrast to human eyes for the images; however, our system is still not able to clearly indicate where the area with brain stroke is, as a result, we are going to use an algorithm with search of regional position, for which it will make comparison of grey levels on both right and left sides, to see which side is with brain stroke.
- *Step 5:* After judgment, the final result is the part with brain stroke to be on the right side of brain, moreover, through statistical data "Ref. [13]", to know that CT values with brain stroke are usually within the range between 30 and 36, we then put

the points with color of red, which are very likely to be the regional points for brain stroke, as shown in Fig. 5(a).



(a) (b)

Figure 5. (a) is possible stroke area. (b) is a divided image for performing laws' mask.

C. Partition and Feature Extraction

When we obtain the red regions which are possibly as the areas of brain stroke, as shown in Fig. 5(a), some of the regions we will eliminate them, that is to say, the regions are without brain stroke, for example, the ones as shown in Fig. 5(a), such as region 1, region 2 and region 3. In order to making the further elimination of them, we will divide these regions, and use Laws'mask, whose size is 25×25 pixel to extract texture feature on these areas, as shown in Fig. 5(b), later on, extracting them as the input training values for iFuzzyLDA. The reason we will use texture feature extraction and classification is due there are a lot of tissues in the brain, and when there is clotting of blood vessels, the tissue brightness value of such a region will change along, moreover, the given tissues possibly with occurrence of brain stroke are respectively as White matter, Grey matter and Basal Nuclei, as a result, there are differences on textures, in the way for us to work on texture detection, an approach which is to extract Eigenvalue on the basis of texture energy principle, and it has one-dimensional mask, respectively as edge, level, spot, ripple, and wave, afterwards, using the 1D mask, we can create a combination of 25 2D masks, next, by filtering out the original images with the 25 masks, there will come up 25 sheets of result images, moreover, due the 25 sheets of result images will vary according to the different position of one-dimensional mask, there are creations of 14 sheets of images with constant spinning, while for each of image with constant spinning, it can calculate three eigenvalues [10] as Mean, Standard Deviation and Entropy.

D. iFuzzyLDA

Subsequently, given the result from the classification made by our proposed iFuzzyLDA, it is shown in Table I of Confusion Matrix, and the algorithm of iFuzzyLDA is shown as Fig. 6. To know from the Confusion Matrix, if the values in the diagonal positions are higher as well as lower values in other positions, it is meant that the result is more accurate accordingly.

Algorithm: iFuzzy LDA

1.Compute the membership function $U_{initial}$ to random numbers in the range [0, 1]
2. while(Threshold or Frequency is not equal to performance value)
3. Compute the membership function U_{LDA}

$$\mathrm{Uphi} = U_0 \times \text{Fuzzy Exponent}$$

$$\mathrm{Centroid} = \frac{\mathrm{Uphi} \times \mathrm{Data}}{\sum \mathrm{Uphi}}$$

$$\mathrm{Weight} = \mathrm{inverse}(\mathrm{Covariance}(\mathrm{data}))$$

$$U_{LDA} = \frac{1}{1 + \left(\frac{\mathrm{dist}(\mathrm{Centroid}, \mathrm{Weight})}{\max(\mathrm{dist})}\right)^{\frac{1}{\mathrm{Uphi}-1}}}$$

4.calculate $FS_W = \sum_{i=1}^{c} \sum_{k=1}^{l_i} U_{LDA}(X_k - m_i)(X_k - m_i)^T$

$$FS_B = \sum_{i=1}^{c} \sum_{k=1}^{l_i} U_{LDA}(\mathrm{Centroid} - m_i)(\mathrm{Centroid} - m_i)^T$$

5. Calculate the eigenvector of $(FS_W)^{-1} * FS_b$
6.Compute the eigenvector V of step 5
7. Compute the project data using eigenvector V
8. performance value is correction rate which is equal to 0.95.
9. Updata membership function with $U_o(P+1) = U(P)$ multiplication
10. Endwhile

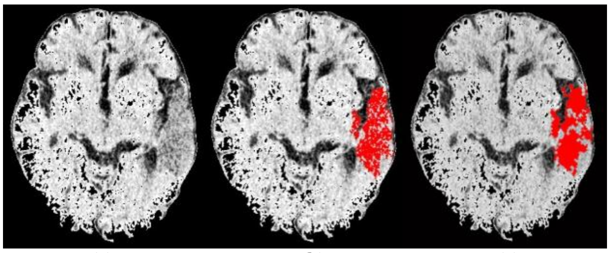
Figure 6. iFuzzyLDA algorithm.

TABLE I. CONFUSION MATRIX

Stroke	CSF	Gray Matter	White Matter	Classified as
3	0	0	19	White Matter
0	0	13	0	Gray Matter
0	21	0	0	CSF
25	0	7	2	Stroke

III. EXPERIMENTAL RESULTS

In order to evaluate the accuracy of our system, firstly we will request professional doctor of Radiology, to help us out by manually taking out the region with brain stroke from the image with brain stroke regions, to then use them as ground-truth image, as shown in Fig. 7(b), moreover, through calculation via iFuzzyLDA classification, we are able to obtain the calculation result for the final region with brain stroke, as shown in Fig. 7(c).



(a) (b) (c)

Figure 7. (a) is original image. (b) is ground-truth segmentation. (c) is our segmented images.

Also, in the results of iFuzzyLDA, there are respectively with indications as TPN, FPN, TNN and FNN. Meawhile, the DR (detection rate) is defined as

DR= TPN/ number of malignant cases;

FAR(false alarm rate) is defined as

FAR= FPN/ number of benign cases;

and CR(correct classification rate) is defined as

CR =(TPN+ TNN)/ total number of cases.

All three values can be calculated, and their results are as shown in Table II. Finally, we use a novel error measure, OCE for evaluating a segmentation algorithm at the object level "Ref. [14]". The OCE is a better approach on error than its precedent, and it can accurately look for whether there are divisions as being less or excessive, as well as to make differentiation with the segmented results more sensibly. The reason we use OCE in our case here is due OCE will not become flimsy under natural scenes, which can cause the rise of difficultness on high-level recognition tasks.

TABLE II. CLASSIFICATION RESULT

TPN	FPN	TNN	FNN	DR	FAR	CR
51	6	26	7	87.93%	18.75%	85.55%

TABLE III. OCE ERROR MEASURES RESULT

	LCE	GCE	OCE
Procedure rate	0.1011	0.1509	0.9078

In Table III, we sum up the deviation standards as result of comparison among one another, and the approaches used are respectively as GCE, LCE and OCE, in which the value of OCE is higher than 90%, to represent that the comparison results are satisfying.

IV. CONCLUSIONS

In the recent years, there are more and more academic researches on the examinations of brain stroke, but the rate of success to accurately predict the region with brain stroke is relatively low. In the paper, with adoption of image identification technology and image processing techniques, there is offering of brain stroke examination system with enhancement of visualized perception. This is able to effectively help the doctors of Radiology who are lack of experiences for diagnosis and treatment within a short period of time, as well as to reduce the rate of mistakes. In the future, we will continue to do researches of the related documentaries, enabling the system to become more ideal, as well as in auxiliary to the doctors from the hospitals we are in cooperation with, to have nice results in actual implementation of the software functions in the medical diagnosis system.

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Ming-Sian, Lee is a Master student in Medical informatics, at Chung Shan Medical University, Taichung (Taiwan). My current research interests are Medical Imaging, Bio-Medical Instrumentation, Embedded systems and Signal processing. The year of my birth is 1987.

Chiun-Li, Chin is an Assoc. Prof at Chung Shan Medical University, Taichung (Taiwan) since 2013. And he is also a teacher in Medical informatics. Since August 2006, he has graduated with the College of Electrical and Control Engineering Department, National Chiao-Tung University, Hsinchu, Taiwan, R.O.C. His research interests include fuzzy inference, neural network, color image processing, computer vision, pattern recognition, and document image analysis. The year of his birth is 1975.

Shih-Hua, Liu is a student in Medical informatics, at Chung Shan Medical University in Taiwan, Taichung. His research interests are .NET and android. The year of his birth is 1991.

Chong-Guang, Chen is a student in Medical informatics, at Chung Shan Medical University in Taiwan, Taichung. His research interests is image Processing. The year of his birth is 1991.

