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Brain Image Severance Using Fuzzy Logic and Neural Networks for Tumor Exposure

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***Abstract*— Considering that brain tumor is one of the diseases which threaten members of a society and unless it is not diagnosed at the right time it can lead to people's death, its diagnosis is of too much importance. In most cases individual develops tumor lesion but since it is very small, it cannot be detected by first medical images such as CT and MRI and it may postpone diagnosis and may also lead to an irreparable lesion. During the past decade in order to help radiologists and specialized physicians, most experts have tended to pay more attention to computer algorithms for the diagnosis of this phenomenon. In this case they can use computer to analyze medical images taken from brain more precisely and tumor detection can be done. Using this method may lead to reduce the risk of tumor diagnosis. In this article extracts candidate abnormal areas by the use of morphological operations and then combination of artificial neural networks and fuzzy logic that refers to Neuro Fuzzy is used to classify tumor region from non tumor candidate areas. After localization of the tumor region Whole brain tumor boundary was extracted by the use of traditional level set method. The evaluation result with brain MRI tumor images shows that our proposed method is more precise and robust for brain tumor segmentation.**

***Index Terms*— image processing, MRI images, brain tumor, neuro fuzzy logic, neural networks, fuzzy logic, segmentation, etc..**

I. INTRODUCTION

Brain is responsible for controlling memory, learning, the senses, and emotions. Moreover, it controls body parts including muscles, organs, and blood vessels. As we all know, human body consists of different cell types each of which performs a specific duty. These body cells grow in such a way as to be able to produce new cells through cell division. Cell division is vital and necessary for correct functioning of the body. Therefore, if cells failed to properly control their growth, limitations arising from such failure in cell division would impair blood circulation. That is why tumors are produced [Upson M,2003]. Brain tumor is the term used for an unnatural growth in the form of a lump which might be benign or malignant. It should be noted that a benign tumor can cause as much disability as a malignant one unless it is properly treated.

II. PROPOSED METHOD

The images of patients are processed by the system to detect a brain tumor scope in more precise.
To achieve this goal, several steps have been proposed.
The overall procedure of the work is reviewed as follows:
1. Pre-processing
2. Extraction of candidate region
3. Classification
4. Whole tumor region boundary extraction.

1. Preprocessing

Before any processing for tumor extraction, it is necessary to standardize the photos.

2. Mask of Image

It is important to distinguish between background and foreground, because most of the algorithms only need to consider the foreground pixels. for Mask Of Image used Canny Edge detector , Dilate result , Fill the holes AND Negated mask image.

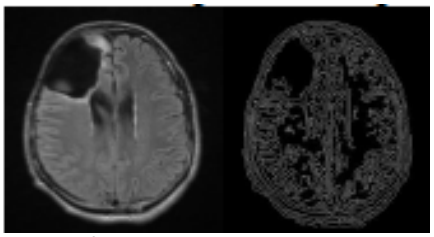

Figure1.Left: Original Image, Right: Extracted Edges

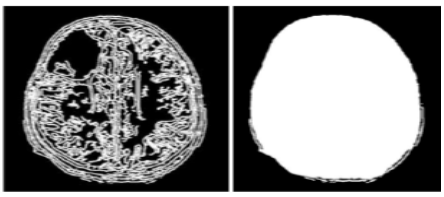

Figure 2: Left: Dilated Image, Right: Filled Image

3. Segmentation of Candidate Pixels

After separation of the background image from the main image (ROI), Image is segmented and the characteristic of each piece is examined to extract tumor position. To identify candidate points that are likely tumor's locations, the images became negative so that the dark spots of tumors become

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bright. To aim this goal the average of image was calculated and subtracted from the image extent and then the result was compared with number 25 that is the scale of darkness. All points that are less than 25 took into account as the candidate points, and their extent was supposed 1as shown in figure 3.3. (i.e. the point become bright).

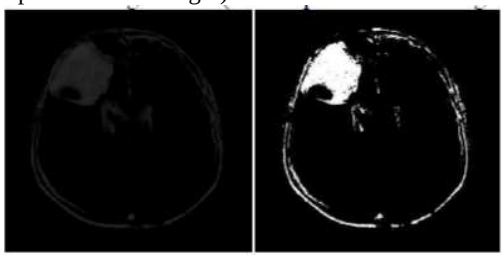

Figure 3: Extraction of candidate regions.

4. Labeling

After separating candidate points, numbering each connected pixels in the extracted candidate matrix so that each connected candidate pixels got same label. In order to better classify the detection of diseases, each connected areas as shown in figure 4, will be labeled so the properties of each label will be delivered to the classifier

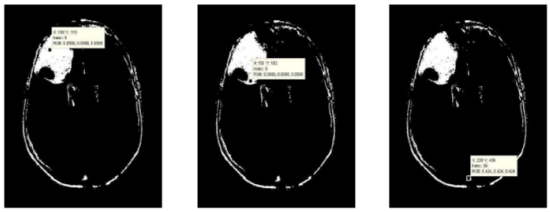

Figure 4: Labeling candidate areas

III. LIMITATIONS

Including two parameters representing positive and negative cases called sensitivity and specificity respectively,

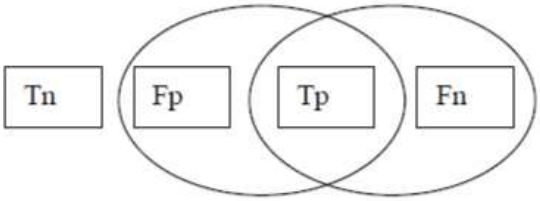

Figure 5: Validation of algorithm based on comparison of extracted region and Gold standard

The accuracy of computer-assisted segmentation of medical images is difficult to quantify in the absence of a ground truth. Traditionally, there are two mechanisms for validation, if no ground truth data are provided (Fan, 2003)

I. Create synthetic images with known size and shapes, segment them with the proposed method, and contrast the values to those used when generating the image.

II. Train some human operators to segment a set of defined volumes (most of the time it is necessary to repeat the segmentation in order to evaluate their variability), then compare the segmentations results using proposed method with their manual segmentations. In order to quantitatively assess the quality of an automatic binary segmentation in comparison to a manual binary segmentation produced by the above method, choosing to use the Jaccard measure for the abnormal class (where M is the set of manually defined tumor pixels, and A is the set pixels classified as tumor by the automatic method):

$J\ A, M = A \cap M$

$A \cup M = tp$

$tp+fp+fn$

The Jaccard measure provides a single easily interpretable measuring the similarity between the two segmentations. This score will be 1 if the segmentations are identical, while it will approach 0 for completely dissimilar segmentations.

The evaluation of segmentation performance is also carried out quantitatively by employing false positive function (FPF), false negative function (FNF).

The false positive function (FPF) represents the error due to the misclassification in class i and the false negative function (FNF) represents the error due to the loss of desired pixels of class i they are defined as follows:

Lower value of FPF, FNF gives better segmentation result.

$FPF = B - (A \cap B)/A$ Eq.:323

$FNF = A - (A \cap B)/A$ Eq.:342

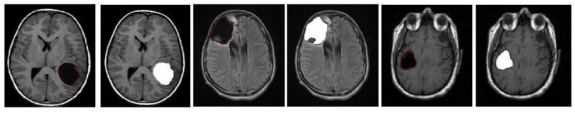

Figure 6: Extracted region and Gold standard of three images (A, B, C) of our data base, Left column: Extracted region Right Column: Gold standard.

IV. CLASSIFIED METHODS

After selecting the appropriate properties form the available sample, an appropriate classifier will be used to classify them.

1. Fuzzy Methods
2. Artificial neural network Methods
3. Neuro-fuzzy Methods

Neuro-fuzzy Methods

Fuzzy interpreter systems and neuron systems are each other's counterpart in designing and making intelligent systems. Artificial neuron networks (ANN) has the ability of learning (through changing weighted coefficient if inter layers connections) which makes this method unique.

Fuzzy interpreter systems (FIS) work based in the theory of fuzzy series and logic. The main characteristic of these systems is the use of linguistic verbs instead of numbers which is similar to humans' control and processing function.

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As Neuro-fuzzy systems benefit from both neuron network and fuzzy processing, it become favored. In simple words, a neuro-fuzzy system is defined as a fuzzy interpreter (FIS) which is taught by learning methods of neuron network. In this teaching method the fuzzy system
parameters are adjusted and makes the system function improve.
There are miscellaneous methods for making artificial intelligence in machines. In recent years, neuro-fuzzy methods show outstanding efficiency the precious characteristics of neuron system is the ability of learning which expands its generalization and right reactions towards unfamiliar inputs.
While fuzzy systems use some kinds of linguistic verbs instead of numbers and makes outputs by the help of simple conditional rules (if x and y then z). In fact, there happens a kind of non-linear mapping in fuzzy systems in which inputs are transported from numerical to the fuzzy area and finally outputs brought back from fuzzy area to numerical area. The main advantageous of fuzzy methods are: natural stability, not having high sensitivity towards noise and the ability of applying human experience in different processing steps.

V. FEATURES EXTRACTION

In this part, characteristics of candidate's area are extracted from data. The goal of choosing these characterizations is better tumor distinguishing. By comparing extracted data with the amount of following characteristics, recognition of the tumor location more precisely.

- Average intensity:
- Standard deviation:
- Maximum intensity:
- Minimum intensity:
- Summation of intensity
- Entropy of intensity
- Summation of absolute Gradient of candidate region.

for increasing the speed and decreasing the volume of the matrix of assumed attributes, the number of attributes, which due to their separation possibility, are 12 in mlp and other systems is restricted to the above attributes which results in decreasing the volume of matrix and as a result faster extraction of the tumor area.

1. Neuron fuzzy based classification.

As mentioned before neuro-fuzzy refers to combinations of artificial neural networks and fuzzy logic in the field of artificial intelligence. Neuro-fuzzy was proposed by J. S. R. Jang(Jang, J.-S. R. et al. 1995). Neuro-fuzzy crossbreeding results in a hybrid intelligent system that synergizes these two techniques by combining the connectionist structure of neural networks with the human-like reasoning style of fuzzy systems. Neuro-fuzzy hybridization is widely termed as Fuzzy Neural Network (FNN) or Neuro-Fuzzy System (NFS) in the literature. Neuro-fuzzy system incorporates the human-like reasoning style of fuzzy systems through the use of fuzzy sets and a linguistic model consisting of a set of IF-THEN fuzzy rules. The principle power of neuro-fuzzy systems is that they are universal approximators with the ability to interpretable IFTHEN rules So the neuro-fuzzy based approach is used for MRI brain tumor region detection from other candidate regions. Actually, this tool is like a fuzzy inference system, but the difference is in the use of a back propagation algorithm for minimizing the error.
For every candidate regions eight mentioned features in previous sections are calculated. Here used integration is neuro fuzzy Takagi-Sugeno classifier. Its rules, parameters and membership functions will be optimized during the learning process with the use of Back Propagation algorithm. Learning in this process is supervised. Although all the rules and parameters are optimized automatically by the way one can set them manually that this characteristic is one of the best character of neuro-fuzzy systems.

The first step in this regard is to define the primary structure of the system. This primary structure combines the inputs, outputs, fuzzy rules, and the shape of membership functions. The number of inputs is the number of selected features, and the number of outputs is one that means it is considered one neuron in outer layer and learn the system so that the output of this neuron show the class of regions in classification procedure. If the candidate region be tumor region the output of this neuron will be one, otherwise it will be zero. Among the different types in the shape of membership functions such as trapezoidal, Gaussian, triangular, and etc. Here it is selected Gaussian shape membership function with normal distribution that give best results in our examinations.
The block diagram of the system is illustrated in figure 3-5.

Figure 7: The block diagram of proposed neuro fuzzy system.

2. Extraction of whole tumor region boundary

As described in section 3-6 after detection of tumor region, the boundary of tumor is determined by using level set deformable model. For this purpose:

1. The initial level set contour is defined around the detected tumor region. For each iteration:
2. The steepest descent gradient flow is computed to minimize total energy function of the contour

VI. PREPROCESSING

Many MRI images become noisy and therefore unusable because most of the patients carry metal objects such as watches, bracelets, etc. during the MRI imaging. Therefore, it's necessary to apply a series of initial processing procedures on the image before any image processing for special purposes. This set of operations is called the preprocessing. This is a necessary stage for improving the image quality and removing the noise. The improved image will then be scanned in order to find the important areas. Since the brain images are

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more sensitive than other medical images, they should be of minimum noise and maximum quality.

Firstly trying to remove noise, background and other specific signs from the image, and then find the range of skull and brain in it, and finally improve its quality. Some other people may try to improve the whole image quality.

Each MRI image of the brain includes the following parts:

1. The range of brain
2. Background
3. Signs and labels (May be present)

Because in most MRI images, a large volume of the image is occupied by a dark background which is unnecessary and may be a source of error in image processing due to its coloring similarity to the tumor; try to remove this part from the images. Removing the background decreases the amount of the memory used which in turn increases the processing speed. The following four phases are commonly used for the application of preprocessing and removing the additional parts of the image:

1. Creating the mask image
2. Using the Canny edge detector operator
3. Using the morphological operators

VII. EXTRACTION OF CANDIDATE AREAS

Tumor segmentation and separation in MRI images using the image of a brain is based on this fact that the pixels inside the tumor have different behavior than the other pixels. These behaviors include the pixel's brightness and color. Since the tumors are created in various shapes, the apparent shape of a tumor is rarely used in its separation.

Segmentation is generally done in two ways: With or without an observer.

In segmentation with an observer, the system has a series of previous information which uses them for segmentation. In segmentation without an observer though, the image is divided into different areas considering a series of common properties including gray colored surfaces, texture and color.

VIII. EXTRACTING TUMOR BOUNDARIES

Extraction of the tumor boundary after generating the area classification results output, if there will be tumor area among the candidate areas; the central pixel is usually determined and grows until it reaches the edge. When it reaches the edge of the desired area, it can be said that the tumor boundary is identified. If the classifier was not able to detect the tumor location among the candidate locations, it can be concluded that the image does not have any tumor. Contours are usually used to identify tumor areas.

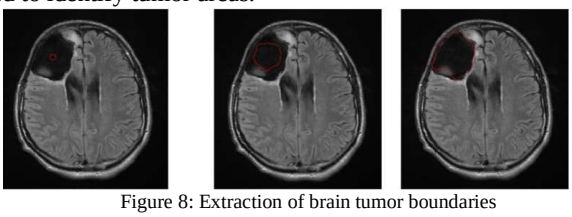

Figure 8: Extraction of brain tumor boundaries

IX. EXTRACTING THE PROPERTIES

After finding the candidate areas and labeling them, it's time for extracting the properties. This stage has a special importance because selecting the appropriate properties may greatly facilitate the correct diagnosis of the disease.

Different areas in an image create properties based on different behaviors. Image processing properties are placed into four categories

I. Brightness
II. Differentiate
III. Texture
IV. Shape

CONCLUSION

The validation of the segmentation results is very important, especially for medical images. The reason is because any significant disagreement between the detected results and the real targets might lead to severe damages in clinical activities. a tumor segmented method which combines both Neural Network and fuzzy clustering method and extraction of boundary based on level set deformable Model is presented. Here it's verified the proposed method with brain tumor MRI images. The obtained results are quantitatively verified with other existing method shows that our proposed method provides better result. The proposed methodology of this research has been able to increase correctness of the process of diagnosis and isolation of tumor dramatically. The automatic procedure was compared with tumor segmentation by manual outlining.

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