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Texture and Shape Based Classification of Brain Tumors Using Back-Propagation Algorithm

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***Abstract* - Accuracy and efficiency are two major issues in designing CAD (Computer Aided Diagnosis) systems. Most of CAD systems are dedicated to visual feature extraction because it has been shown that visual information extracted from images can achieve similarity retrievals with high performance of effectiveness of the diagnosis, at the same time reducing the pain of the patients also. In the brain MR image, the tumor may appear clearly, but for further treatment, the physician also needs the quantification of the tumor area. The computer and image processing techniques can provide great help in analyzing the tumor area. In this paper features based on content of image were tested for analysis and classification of brain tumor using texture and shape analysis. After feature extraction back-propagation algorithm is used to classify brain tumor in to malignant & benign. MATLAB ® 7.01, its image processing toolbox and ANN toolbox have been used to implement the algorithm. The results show that texture and shape features can be effectively used for classifying brain tumor with high level of accuracy.**

***Keywords*- medical image, shape, texture, malignant, benign, tumor**.

I. INTRODUCTION

Image processing techniques are playing important role in analyzing anatomical structures of human body. Image acquisition techniques like magnetic resonance imaging (MRI), X-Ray, ultrasound, mammography, CT-scan are highly dependent on computer technology to generate digital images. After obtaining digital images, image processing techniques can be further used for analysis of region of interest. A tumor is a mass of tissue that serves no useful purpose and generally exists at the expense of healthy tissues. Malignant brain tumors do not have distinct borders. They tend to grow rapidly, increasing pressure within the brain and can spread in the brain or spinal cord beyond the point where they originate. They grow faster than benign tumors and are more likely to cause health problems.

Benign brain tumors, composed of harmless cells, have clearly defined borders, can usually be completely removed, and are unlikely to recur. A benign tumor is basically a tumor that doesn't come back and doesn't spread to other parts of the body. Benign tumors tend to grow more slowly than malignant tumors and are less likely to cause health problems. In brain MR images, after appropriate segmentation of brain tumor, classification of tumor in to malignant and benign is difficult task due to complexity and variations in tumor tissue characteristics like its shape, size, gray level intensities and location [1]. Feature extraction is an important issue for any pattern recognition problem. Most of the reported work is dedicated to tumor segmentation or tumor detection [1-5]. This paper presents a hybrid approach to classify malignant and benign tumors using fusion of texture and shape futures. MATLAB ® 7.01, its image processing toolbox is used for feature extraction and ANN toolbox has been used for classification.

II. OVERVIEW OF FEATURES EXTRACTION

An effective shape descriptor is a key component of content description; since shape is a basic property of an object present in the image itself [6]. Most of existing shape descriptors is usually either application dependent or non-robust, making them undesirable for shape description [7]. In this paper, a Fourier descriptor (FD) and moment invariants are used to overcome the drawbacks of existing shape representation techniques [8, 9, 10].

Another set of features which we used to describe a medical image is texture feature. Medical images possess different texture depending upon area of body considered for imaging. According to Smith and Chang texture refers to visual patterns which have properties of homogeneity and cannot result from the presence of only a single color or intensity. Texture perception has a very important aspect in the human visual system of recognition and interpretation. Two main approaches concerning with texture analysis are statistical model-based and spectral measure [9, 11]. We use Haralick's texture features [12] such as energy, correlation, inertia, entropy, inverse difference moment, sum average, sum variance, sum entropy, difference average, difference variance, difference entropy, information measure of correlation 1 and information measure of correlation 2.

III. EXPERIMENTS AND RESULTS

A) Database Preparation and ROI Extraction:

80 brain MRI images consisting of 40 malignant and 40 benign tumors were collected from open source database and some hospitals. Expert radiologists were consulted to confirm whether the tumor is malignant or benign. Figure 1 shows some sample images from the database.

Before feature extraction, region of interest (ROI) Consisting of tumor region was extracted using MATLAB imtool function for further analysis. Figure two shows extracted ROIs from some MRI Images from database.

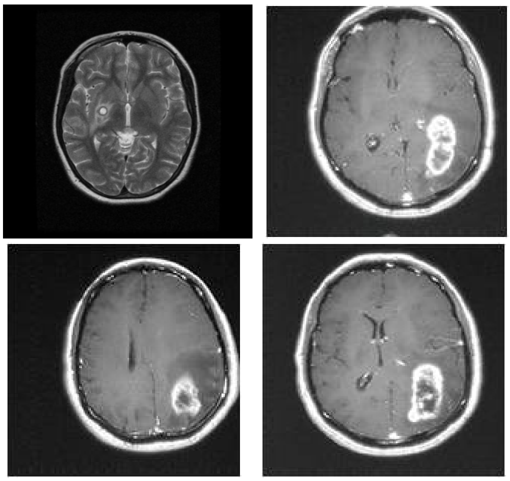

Figure.1. Example images from the database

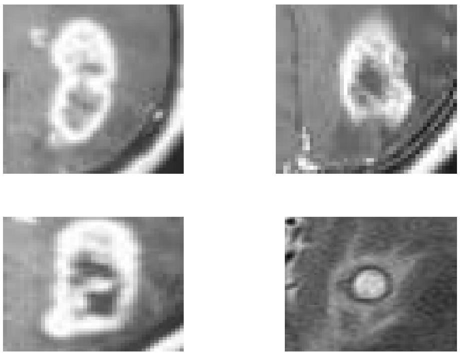

Figure.2. Extracted ROI consisting of brain tumors before feature extraction

B) Calculation of Feature Vector:

Feature extraction is the main aspect of any CAD system in our case the feature vector is a row consisting of shape features such as Fourier Descriptor coefficients and seven moment invariants along with 13 texture features discussed in section 2. The feature vector of each image in the database is stored as .mat file. Table.1 below shows texture features of three malignant tumors and Table.2 shows texture features of three benign tumors. It is concluded from table that textures features of both benign and malignant tumors are very close to each other and hence texture feature alone may not give desired classification efficiency. Thus we use shape features along with texture features.

C) Classification Using Back-Propagation Algorithm

In this research back-propagation algorithm is finally used for classifying the pattern of malignant and benign tumor. The back-propagation learning rule can be used to adjust the weights and biases of networks to minimize the sum-squared error of the network [13, 14]. As the simple back-propagation method is slow because it requires small learning rates for stable learning. Improvement techniques, such as momentum and adaptive learning rate or an alternative method to gradient descent, Levenberg–Marquardt optimization, can be used.

TABLE 1:
TEXTURE FEATURES OF THREE MALIGNANT TUMORS FROM THE DATABASE

S.No	Texture Feature	Image id_M1	Image id_M2	Image id_M3
1	Energy	$0.0000*10^4$	$0.0000*10^4$	$0.0000*10^4$
2	Correlation	$0.0001*10^4$	$0.0001*10^4$	$0.0001*10^4$
3	Inertia	$0.0323*10^4$	$0.0350*10^4$	$0.0461*10^4$
4	Entropy	$0.0013*10^4$	$0.0012*10^4$	$0.0012*10^4$
5	Inverse Difference Moment	$0.0000*10^4$	$0.0000*10^4$	$0.0000*10^4$
6	Sum Average	$1.0011*10^4$	$0.0344*10^4$	$0.0355*10^4$
7	Sum Variance	$0.0611*10^4$	$1.4312*10^4$	$1.7302*10^4$
8	Sum Entropy	$0.0008*10^4$	$0.0008*10^4$	$0.0008*10^4$
9	Difference Average	$0.0012*10^4$	$0.0011*10^4$	$0.0013*10^4$
10	Difference Variance	$0.0181*10^4$	$0.0236*10^4$	$0.0303*10^4$
11	Difference Entropy	$0.0005*10^4$	$0.0005*10^4$	$0.0005*10^4$
12	Information Measure of Correlation1	$-0.0000*10^4$	$-0.0000*10^4$	$-0.0000*10^4$
13	Information Measure of correlation 2	$0.0001*10^4$	$0.0001*10^4$	$0.0001*10^4$

The Levenberg–Marquardt algorithm is a non-linear least square algorithm applied to learning of the multilayer perceptron. A feature vector consisting of shape and texture attributes was generated for each tumor image and save in .mat file in MATLAB environment. 50% of the data has been used for training and remaining 50% was used for testing and validation. Fig.3 below shows performance of the training of the input data and target data sets.

TABLE 2
TEXTURE FEATURES OF THREE BENIGN TUMORS FROM THE DATABASE

S.No	Texture Feature	Image id_B1	Image id_B2	Image id_B3
1	Energy	$0.0000*10^3$	$0.0000*10^3$	$0.0000*10^3$
2	Correlation	$0.0009*10^3$	$0.0009*10^3$	$0.0009*10^3$
3	Inertia	$0.1890*10^3$	$0.1657*10^3$	$0.2618*10^3$
4	Entropy	$0.0117*10^3$	$0.0114*10^3$	$0.0108*10^3$
5	Inverse Difference Moment	$0.0002*10^3$	$0.0002*10^3$	$0.0002*10^3$
6	Sum Average	$0.1950*10^3$	$0.1948*10^3$	$0.1765*10^3$
7	Sum Variance	$5.8488*10^3$	$6.2039*10^3$	$3.8211*10^3$
8	Sum Entropy	$0.0081*10^3$	$0.0070*10^3$	$0.0073*10^3$
9	Difference Average	$0.0085*10^3$	$0.0081*10^3$	$0.0092*10^3$
10	Difference Variance	$0.1167*10^3$	$0.0993*10^3$	$0.1776*10^3$
11	Difference Entropy	$0.0045*10^3$	$0.0045*10^3$	$0.0046*10^3$
12	Information Measure of Correlation1	$-0.0004*10^3$	$-0.0004*10^3$	$-0.0003*10^3$
13	Information Measure of correlation 2	$0.0010*10^3$	$0.0010*10^3$	$0.0010*10^3$

TABLE 3
ATTRIBUTES PROPOSED NEURAL NETWORK

S.No	Information
1.	Number of instances =80 (Malignant: 40, Benign:40)
2.	Number of attributes =111+ class attributes. (Texture attributes:13, shape attributes:98)
3	Classes: 02 (Class 1: Malignant, Class 0: Benign)

For testing and validation, remaining 50% data are divided into two parts. Fig. 3 shows the training graph of neural network using Levenberg–Marquardt algorithm. Fig. 4 below shows the testing result graph. From this it is clear that one error has occurred in the pattern sets i.e. one data id wrongly classified by the classifier. Fig.5 below shows graph of validation

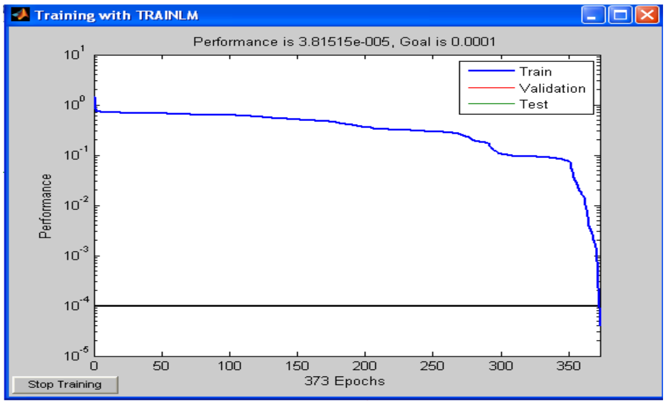

Fig.3. Training Graph of Neural Network Using 50% of dataset.

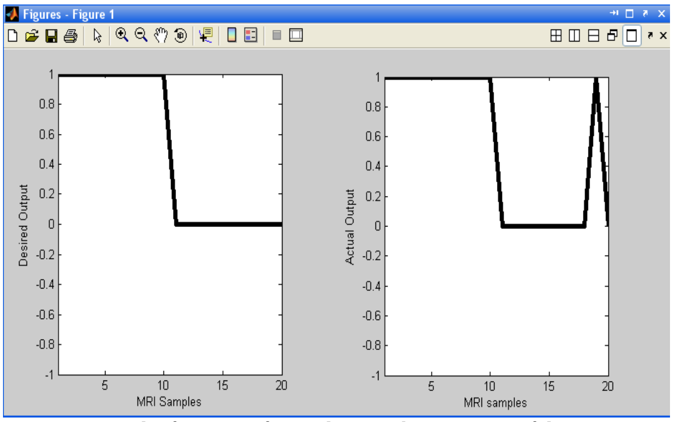

Fig. 4 Result of Testing of Neural Network Using 25% of dataset.

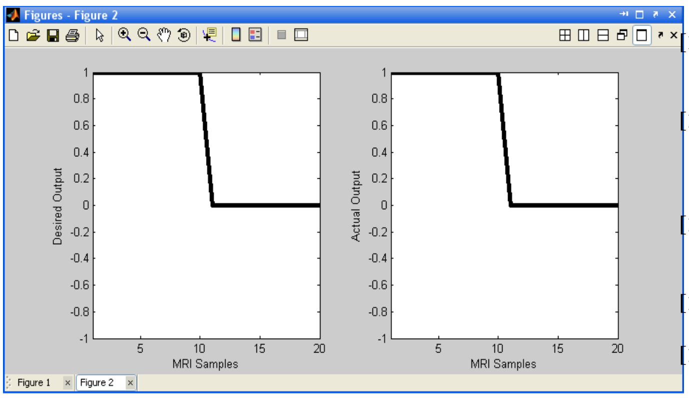

Fig.5 Result of Validation of Neural Network Using 25% of dataset.

IV. EXPERIMENTS AND RESULTS

In this paper an automatic method for classification of brain tumors in to malignant or benign using fusion of shape and texture features is proposed. After extracting features, a one dimensional feature consisting of shape and texture attributes was used for training and testing. Back-propagation algorithm with Levenberg–Marquardt algorithm was used for training, testing and classification of the tumor. Results show that texture and shape features can give satisfactory result in analysis and classification of brain tumors. The performance of the system can be further improved by fusing other shape and texture features. Further work is to check the performance of the system by increasing the database.

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