ANN BASED COMPUTER AIDED DIAGNOSIS AND CLASSIFICATION OF VERTEBRAL COLUMN IMAGES

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ABSTRACT

This paper presents a computer based diagnostic tool (CADT) for tumor detection in vertebral column (VC) images that involves preprocessing of noise removal and gray scale conversion, segmentation, feature extraction and classification. The preprocessing step employs Median filter for removing noises, while the segmentation delineates the tumor region from the normal region. The method uses 46 reduced statistical features along with 13 GLCM based texture features that represent the unique characteristics of VC images, and an ANN classifier based on the evaluated features to classify the VC images into tumor and non-tumor. It presents the results of sample VC images and discusses the performances.

Keywords: denoising, segmentation, artificial neural network.

1. INTRODUCTION

The vertebral column (VC) is a crucial part of humans and extends from the skull to its anchoring point in the pelvis and houses the spinal cord. Tumors in the VC affect many people over the world, as it is the most probable site for tumor cells to form metastases, following the lung and the liver cancers. The malignant bone tumor is quite rare and grows slowly in the bone or disc elements of the spine. Early diagnosis of tumor helps in reducing the morbidity and cost of therapy. Statistics indicate that the patient will make a complete recovery, if the tumor is surgically removed at earlier stages. This is the precise reason of why it is vital for early detection [1, 2].

Tumors are usually detected by CT or MRI examination yielding different characterization of tissue. Radiologists analyze the medical images, and diagnose a patient's disease by interpreting medical images with their experience, knowledge, and wisdom. The details of the type, precise position and volume of tumors are essential for appropriate treatment with surgical planning. The radiologists require a computer aided diagnostic tool (CADT) that has the abilities of learning and pattern recognition, for the purpose of attaining a correct diagnosis. The CADT engrosses preprocessing, segmentation, feature extraction and classification [3].

In recent years, vertebral column have been studied, and a few algorithms involving contour and edge detection, seeded region growing and B-spline active surface, have been suggested [4-7].

The focus of this paper is to develop an artificial neural network (ANN) based CADT for classifying the VC images into tumor or non-tumor. The paper comprises four sections. The first section provides the introduction, the second section suggests the proposed CADT (PCADT), the third section discusses the results and the forth section concludes.

2. PROPOSED CADT

The PCADT comprises preprocessing, segmentation, feature extraction and classification. Denoising is the one of the most important preprocessing step, as digital images contain noises and artifacts. Median filter is used for denoising in the developed model. Segmentation removes the healthy part from the image and finds the suspicious region of interest [8].

After segmentation, the important features of image data are extracted from the segmented image. The extracted features are the representatives for distinguishing the image into tumor and non-tumor. Thirteen GLCM based texture features representing Contrast, Correlation, Energy, Homogeneity, Mean, Standard Deviation, Entropy, RMS, Variance, Smoothness, Kurtosis, Skewness and IDM are identified to represent the characteristics of the segmented medical images [9]. Besides, wavelet decomposition based features are also considered [10, 11]. The number of wavelet features is usually large and hence the PCA is applied for reducing the dimension of the feature size.

Classifier is used for classifying tumor from healthy images. Based on the computational simplicity ANN based classifier [28] is used. The proposed classifier uses a feed forward multilayer ANN, which possesses an input, a hidden and an output layers. The structure of the ANN classifier is shown in Figure-1. The number of neurons in the input layer equals the number of extracted features, while the output layer comprises a neuron to produce the binary output. The hidden and output layer nodes adjust the weights depending on the error in classification. Back propagation (BP) algorithm is used for training. The network is trained with known training data set comprising extracted features and target. After training, network can perform classification of new VC images. The extracted features of VC images comprising both tumor or non-tumor images and their target classes are to be formed as input (X) and the target (Y) vectors with a view of training and validation. The target value for tumor-class is set to be +1 and non-tumor-class as -1.

$$\{X \leftrightarrow Y\} = \{f_1,\ f_2,\ f_3 \cdots\cdots,\ f_{59} \leftrightarrow Class\} \tag{1}$$

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The generated input-target data are split into two partitions: the first one is the training data, which is used to train the network and the second, the testing/validation data, is used to assess how well the network is generalized.

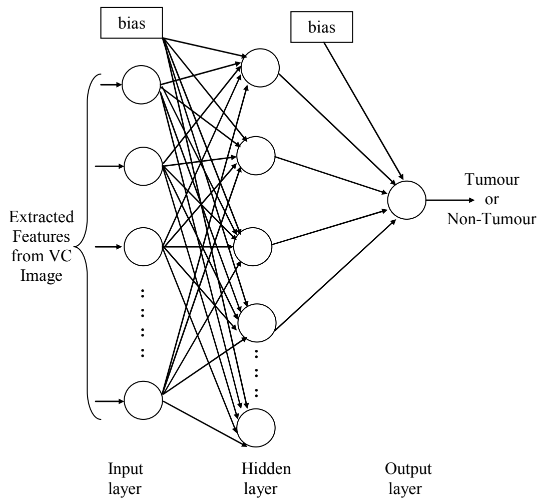


Figure-1. Structure of ANN classifier.

3. RESULTS AND DISCUSSIONS

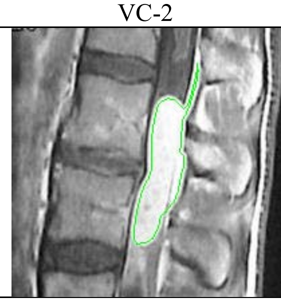
The PCADT has been built using 100 VC images, comprising 60 tumor and 40 non-tumor images. The database is therefore divided into training and testing datasets, each possessing both tumor and non-tumor class images by Holdout method, wherein 70% of the samples from both classes are allocated to the training set and the remaining 30% of the samples from both classes are allocated to the testing set. The details of the samples in training and testing sets are given in Table-1.

Table-1. Ratio of Sample images for training and testing sets.

	Number of images	Training set (70%)	Testing set (30%)
Class-1 (Tumor)	100	70	30
Class-2 (Non-Tumor)	60	42	18
Total VC Images	160	112	48

The suspicious regions of the preprocessed VC images are segmented and the segmented portions are marked and presented for two sample VC images in Table-2. After segmentation, 46 reduced statistical features along with 13 GLCM based texture features are evaluated in forming the database. The database is then divided into training and testing datasets by Holdout method.

Table-2. Segmented VC images.

VC-1	VC-2
	

When classification is done, results could have an error rate, either fails to identify an abnormality, or identify an abnormality that is not present. A confusion matrix, containing information about actual and predicted classifications, is usually formed to visualize the performance of the classifier. In addition, the common quantitative performance measures, such as, accuracy, sensitivity and specificity, are used in this paper. They are computed by

$$Accuracy == \frac{(TP + TN)}{(TP + TN + FP + FN)} \tag{2}$$

$$Sensitivity == \frac{TP}{(TP + FN)} \tag{3}$$

$$Specificity == \frac{TN}{(TN + FP)} \tag{4}$$

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Table-3. Confusion matrix.

		Predicted class	
		Negative (Non-Tumor)	**Positive (Tumor)**
Actual Class 18 Non-Tumor 30 Tumor	Negative (Non-Tumor)	16 (88.89%)	2 (11.11%)
	Positive (Tumor)	2 (6.67%)	28 (93.33%)

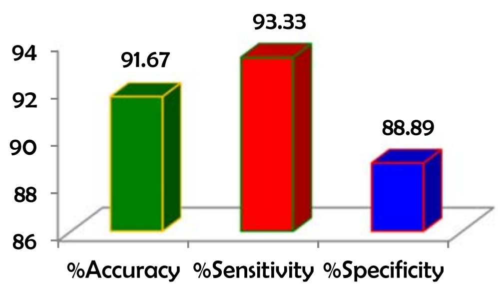

Figure-2. Performances.

The confusion matrix, obtained from the results of the test images, of the developed classifier is shown in Table-3. The accuracy, sensitivity and specificity are evaluated and presented in Figure-2. For all the test sets, the PCADT performs better in terms of achieving larger values for accuracy, sensitivity and specificity.

It is very clear from the above discussions that the PCADT perform better in view of classifying the VC images into tumor and non-tumor.

4. CONCLUSIONS

A computer based early tumor detection system for VC images has been suggested. It has employed preprocessing of noise removal and gray scale conversion, segmentation, feature extraction and classification. Median filter has been applied in removing the noises. The suspicious region has been extracted from the normal VC region by the process of segmentation. 59 features representing the characteristics of VC images have been identified and evaluated. Based on the evaluated features, ANN classifier has been designed to classify the VC images into tumor and non-tumor. The performances such as accuracy, sensitivity and specificity have exhibited the superior performance of the PCADT.

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