International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 6, June - 2013

Detection Of Tumour Using Grey Level Co-Occurrence Matrix And Lifting Based DWT With Radial Basis Function

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ABSTRACT

Magnetic Resonance Imaging (MRI) is an advanced medical imaging technique providing rich information about the human soft tissue anatomy. In this paper, a tumour detection technique, applied to an MR Image using Grey Level Co-occurrence Matrix (GLCM) and Lifting DWT (LDWT) is proposed. Radial Basis Function Network (RBFN) is used to differentiate between abnormal tissues and the normal tissues. The Comparative analysis is carried out with the Feed Forward Neural Network (FFNN) and the obtained results are analysed in terms of the performance metrics. Simulation results prove that the proposed technique have higher performance in terms of Sensitivity Specificity and Accuracy.

Keywords -- *Grey Level Co-occurrence Matrix, Lifting Discrete Wavelet Transform, Feed Forward Neural Network, Radial Basis Function Network*

I. INTRODUCTION.

Due to the advent of computer technology, image processing techniques have become increasingly important in a wide variety of applications. This is particularly true for medical imaging such as Ultrasonography, CT, MRI, and Nuclear Medicine which can be used to assist doctors in diagnosis, treatment, and research. These systems are talented in discovering the structure, the function and the diseases that influence the human anatomy. It is highly difficult task to categorize tumour types though MRI seems to be competent in offering information considering the position and volume of tumours. To overcome this, Biopsy and Spinal Tap methods are used, which are complex and time consuming techniques. Various methods proposed in the literature have met with only limited success due to overlapping intensity distributions of healthy tissues, tumour, and surrounding edema. To overcome the challenges in diagnosis, a tumour detection technique using GLCM and Lifting based DWT is proposed. The proposed technique show higher performance in terms of Sensitivity, Specificity and Accuracy.

Feature extraction using GLCM is presented in section II, feature extraction using LDWT is presented in section III, tumour detection using RBFN is given in section IV, and finally, simulation results and conclusions are presented in sections V and VI respectively.

II. Feature Extraction Using GLCM.

One of the most famous texture study techniques, GLCM [1], assesses image properties associated to Second-Order statistics. Using Gray Level Co-occurrence Matrix (GLCM), the statistical characteristics from MR images are obtained are also known as Gray Level Spatial Dependence Matrix (GLSDM). Haralick[2] put forward GLCM, which is a statistical strategy that can well explain the spatial connection among pixels of dissimilar gray levels. GLCM is a two dimensional histogram in which (i, j) the element is the frequency of event ‘i’ that takes place with ‘j’. Texture feature extraction is categorised into two steps: the first step is computing the co-occurrence matrix and the second step is calculating texture features based on the co-occurrence matrix [3][4]. Minimum value, Maximum value, Angular Second Moment (ASM), Entropy, Inverse Difference Moment (IDM), Moment and Peak value of histogram are the texture features computed.

Minimum: This minimum value can be used to differentiate the abnormal images since most of the abnormal regions are pure white pixels.

Maximum: Other feature used in the proposed method is maximum value. From the corresponding GLCM features image a maximum value is selected.

The ASM is known as uniformity or energy. It measures the homogeneity of an image. When pixels are very similar, the ASM value will be large.

$$ASM = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\{p(i,j)\}^2 \qquad .... (1)$$

This measure of contrast or local intensity variation will favour contributions from P(i, j) away from the diagonal, i.e. ‘i’≠’j’. Entropy refers to the quantity of energy that is permanently lost to heat every time a reaction or a physical transformation occurs. Entropy cannot be recovered to do useful work. Because of this, the term can be understood as amount of irremediable chaos or disorder. The equation of entropy is:

$$Entropy = -\sum_{i=0}^{G-1}\sum_{j=0}^{G-1} p(i,j)\log p(i,j) \qquad .... (2)$$

IDM is usually called homogeneity that measures the local homogeneity of an image. IDM feature obtains the measures of the closeness of the distribution of the GLCM elements to the GLCM diagonal.

$$IDM = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\frac{1}{1+(i-j)^2}\,p(i,j) \qquad \ldots\ldots\ (3)$$

Similarly moment and Peak value of histogram is computed. The block diagram of the feature extraction using GLCM process is shown in figure 2.1.

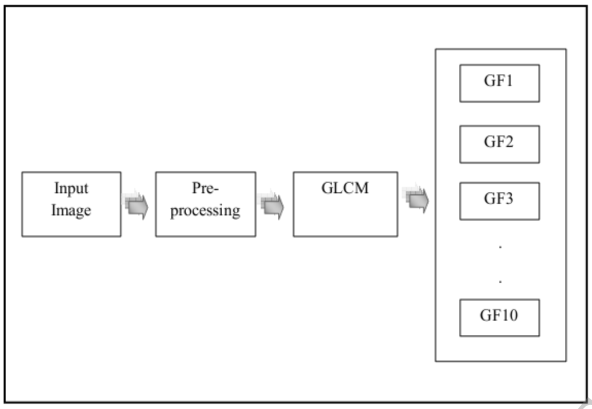

Fig.2.1. Feature extraction using GLCM.

The obtained feature for a given MR image is applied to a RBFN.

III. Lifting DWT.

The lifting scheme is an alternative method of computing the wavelet coefficients [5]. A spatial domain construction of bi-orthogonal wavelets consists of the following four basic operations as shown in figure 2.2. These are summarized as follows.

Split : $s_k^{(0)}=x_{2i}^{(0)},\ d_k^{(0)}=x_{2i+1}^{(0)}$ …(5)

Predict : $d_k^{(r)}= d_k^{(r\text{-}1)} – \sum p_j^{(r)}\, s_{k+j}^{(r\text{-}1)}$ …(6)

Update : $s_k^{(r)}= s_k^{(r\text{-}1)} + \sum u_j^{(r)}\, d_{k+j}^{(r)}$ … (7)

Normalize: $s_k^{(R)}=K_0 s_k^{(R)}, d_k^{(R)}=K_1 d_k^{(R)}$ …(8)

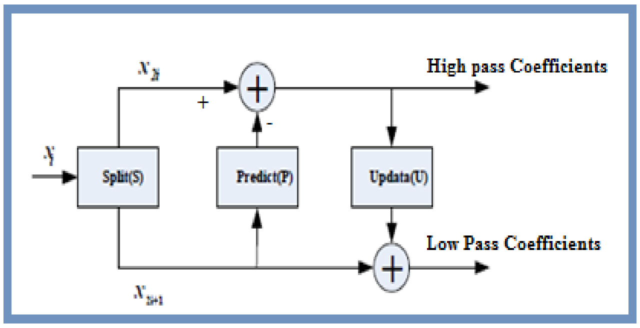

Fig.2.2. Lifting scheme block diagram

Lifting based DWT requires less computation time, less memory [6][7], and easily produces integer-to-integer wavelet transforms for lossless compression. Similarly, Second Order statistical features are extracted from the Lifting DWT MR Image as shown in figure 3.1.

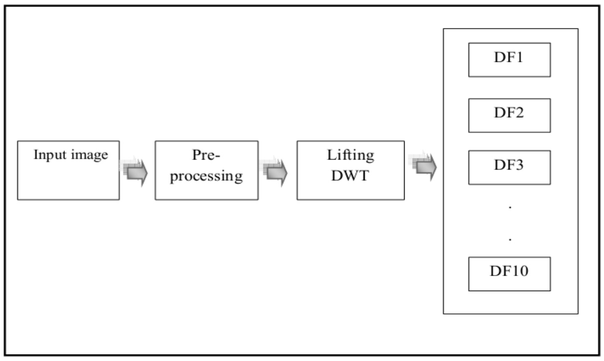

Fig.3.1. Feature extraction using LDWT.

The features extracted are then applied to RBFN.

IV. Tumour detection using RBFN.

The features extracted using GLCM method and LDWT are applied to a RBF Network. RBFN consists of three layers, namely an input layer, hidden layer and out layer. The most popular Gaussian Activation Function is used in Radial Basis Function. Classification of MRI images using RBFN requires training and testing phase. In training phase the network is trained with around 30 tumour as well as non tumour images. In the testing phase the candidate MR Image is applied to the system. The performance of the system is evaluated using three parameters Sensitivity, Specificity and Accuracy [9]. These values are computed from the parameters True Positive (TP), True Negative (TN), False Negative (FN) and False Positive (FP) for each of the input image, based on the definitions given in table I.

Table I: Defining the terms TP, FP, FN, and TN.

Outcome	**Condition as determined by the Standard of Truth**		**Row Total**
	Positive	**Negative**	
Positive	TP	FP	TP+FP
Negative	FN	TN	FN + TN
Column total	TP+FN	FP+TN	N= TP+TN+FP+FN

Based on the computed TP, FP, FN, and TN values the evaluation metrics can be defined as follows

Sensitivity is the fraction of true positives that are correctly identified by a diagnostic test. It shows how good the test is at detecting a disease.

$$Sensitivity = TP/(TP + FN)$$

Specificity is the fraction of the true negatives correctly identified by a diagnostic test. It suggests how good the test is at identifying normal (negative) condition.

$$Specificity = TN/(TN + FP)$$

Accuracy is the fraction of true results, either true positive or true negative, in a population. It measures the degree of veracity of a diagnostic test on a condition.

$$Accuracy = (TN + TP)/(TN + TP + FN + FP)$$

V. Simulation Results.

The MRI image dataset utilized here is taken from the publicly available sources. GLCM and LDWT applied on the input MR Image (A) are shown in (B) and (C) respectively in figure 2.4.The features computed for a given MR image is tabulated in table II.

The obtained results obtained with the proposed technique are compared with FFNN [8] based technique. The comparative analysis is given in table III.

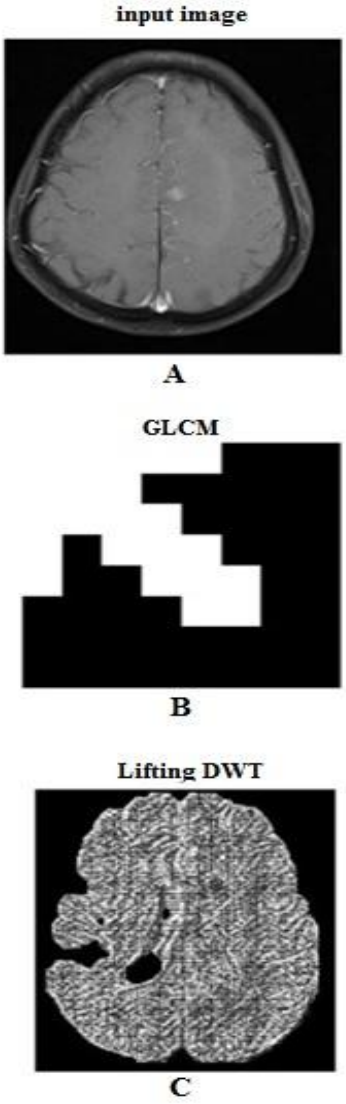

Fig 4.1. (A) Input MR Image, (B)GLCM applied Image., (C) LDWT applied Image

Table II: Features extracted with values

Features	**GLCM**	**LDWT**
Min	0	-607
Max	70811	26066
ASM	7319650424	368370697
Entropy	0.928362072	0.938712075
IDM	2260.057904	0.184747626
Moment	4399360510392.18	42676.8488
Peak of histogram	42	96052

Table III: Performance Metrics.

Parameters	FFNN	RBFN
Sensitivity	0.94	0.91
Specificity	0.65	1
Accuracy	0.79	0.93

From table III, it is evident that the Accuracy of the technique is observed as 93%.The Specificity of the technique is also proved to be maximum. But the Sensitivity of the proposed technique is slightly less than FFNN based system. This method is a simple method using which tumour can be detected easily.

VI .Conclusions & Future Scope.

Tumour detection technique using both GLCM features and Lifting DWT features applied to a RBF network is proved to be a successful technique for the detection of tumour in MR Images as compared with FFNN.

The future scope of the work deals in improving the sensitivity and accuracy in detecting Tumours of MR Images using this technique.

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