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Classification of EGF and Insulin Receptors Using Gabor Wavelet Transform

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Abstract: This paper presents how the Texture feature extraction by Gabor Wavelet transform (GWT) has been used for colour texture classification problem. Till yet maximum calculations have been done on gray scale images. In this paper a CAD system has been proposed for the classification of EGF and Insulin receptors, called EGFR and IRS using Gabor wavelet transforms. The EGFR and IRS kinase are categorised into two classes namely present or absent. The feature space dimensionality reduction has been carried out by using PCA. For the classification task, kNN, PNN and SVM classifiers have been used for two-class classification. The maximum accuracy of 86.67 % was obtained using SVM classifier.

Keywords: Computer aided diagnostic system, EGFR, IRS, kNN, PNN, Support vector machine classifier.

I. Introduction

This paper presents the study of different receptors pathway [1-6] which lead to cell survival/ cell death due to the two different inputs i.e**. epidermal growth factor** (EGF) [7- 11] and **insulin** [10 - 15] commonly known as pro-survival proteins [15- 19]. The epidermal growth factor (EGF) binds with EGF receptor (EGFR) at the outer side of cell membrane and phosphorylates the tyrosine residues of the receptor sub-units. These phosphorylated tyrosine sites allow other proteins to bind through their Src homology 2 (SH2) domains leading to the activation of downstream signaling cascades: the phosphatidylinositol 3 kinase(PI3K) pathway [20-25], the RAS/extracellular signal regulated kinase (ERK) pathway [26-31] and the activator of transcription (JAK/ STAT) pathway. The EGF signal is terminated primarily through endocytosis of the receptor-ligand complex. Insulin is a hormone that binds to its receptor (the insulin receptor) on cell membranes and initiates signal transduction leading to cell survival/ death. Binding of insulin to its receptor induces phosphorylation of tyrosine residue on the inner part of the receptor. The phosphorylated tyrosine residues allow other intracellular proteins to bind to the intracellular domain of the receptor, and become phosphorylated.

A CAD tool was designed using different images taken from Weiss [2]. Features were selected using filter based method while transform domain analysis was used as feature extraction process (Gabor wavelet filter (GWT)) [32- 37]. There are different classification techniques, out of which kNN, PNN and support vector machine (SVM) classifiers [38-46] are used in this paper. The feature space dimensionality reduction has been carried out by using Principal Component Analysis (PCA).

II. Proposed Computer Aided Diagonistic Tool

The main objective of the research work presented in this paper is to enhance the diagnostic potential of images for identification of different receptors by developing efficient CAD system designs using a representative image database. Figure 1 shows the proposed CAD system design for the prediction of protein whether present or absent.

The various research objectives formulated for the present work are described below:

(i) *The collection of a database*: To develop efficient CAD systems, it is necessary that the classifiers used in the classification module of the CAD system are trained with an image database that contains representative images from each subclass. Thus collection of a database containing images is considered as the first objective of the present research work. The work has been done on image available from Weiss [2]. The data contains 300 images of EGFR, IRS and IEK.

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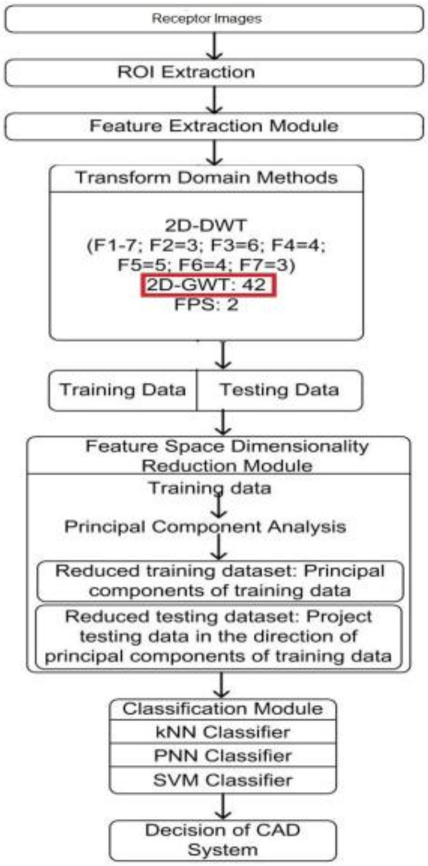

Fig 1: A Proposed CAD system

(ii) *Feature Extraction Module***:** The feature extraction is the process used to transform the visually extractable and non-extractable features into mathematical descriptors. These descriptors are either shape-based (morphological features) or intensity distribution based (textural features). There are a variety of methods to extract the textural features including statistical, signal processing based and transform domain methods. In this paper Feature extraction is done in the transform domain over various scales by using GWT. It is logical to compute texture features in the transform domain as human visual system processes images in a multiscale way and scale is considered to be an important aspect for analysis of texture [38-46].

Two Dimensional Gabor Wavelet Transform: The application of 2D-GWT results in a set of frequency and orientation selective filters that capture energy at a specific frequency and orientation. The 2D-GWT, considering three scales (0,1 and 2) and seven angles (22.5°, 45°, 67.5°, 90°, 112.5°, 135° and 157.5°) result in a group of 21 wavelets (7 × 3). When this group of wavelets is convolved with the ROI image, a set of 21 feature images are obtained. Each of these filtered images represents image information at a certain scale and orientation [40- 46]. From these 21 feature images, mean and standard deviation are computed as texture features forming a texture feature vector (TFV) of length 42.

(iii) *Feature Space Dimensionality Reduction Module:* The texture feature vector formed after computing the texture features in the feature extraction module may contain some redundant and correlated features which when used in the classification task can degrade the performance of the proposed CAD system. These redundant features give no extra information that proves to be helpful in discriminating the textural changes exhibited by different density patterns. Hence, to remove these redundant features and obtain the optimal attributes for the classification task, PCA is employed [32-34]. Steps used in the PCA algorithm are:

- ✓ Normalize each feature in dataset to zero mean and unity variance.
- ✓ Obtain co-variance matrix of the training dataset.
- ✓ Obtain Eigen values and Eigen vectors from the co-variance matrix. Eigen vectors give the directions of the PCs.
- ✓ Project the data points in testing dataset in the direction of the PCs of training dataset.

The obtained PCs are uncorrelated to each other and the 1st PC has the largest possible variance out of all

		CM		OCA (%)	$ICA_{Present}$ (%)	ICA_{Absent} (%)
RTFV		Present	Absent			
kNN-PCA	Present	20	60	60%	25 %	100%
	Absent	0	70			

		CM		OCA (%)	$ICA_{Present}$ (%)	ICA_{Absent} (%)
TFV		Present	Absent			
kNN	Present	30	50	26.67 %	37.5 %	14.28 %
	Absent	60	10			

the successive PCs. The optimal number of PCs is determined by performing repeated experiments by going through first few PCs i.e. by first considering the

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first two PCs, then first three PCs and so on, and evaluating the performance of the classifier for each experiment.

(iv) *Classification:* Classification is a machine learning technique used to predict the class membership of unknown data instances based on the training set of data containing instances whose class membership is known. We different classifiers like kNN, PNN, SVM and SSVM which were employed to classify the unknown testing instances of the images different classes based on the training instances. To avoid any bias caused by unbalanced feature values the extracted features are normalized in the range [0, 1] by using min-max normalization procedure. In this paper we are using kNN, PNN and SVM classifier [35-43].

III. Results And Discussions

For evaluating the performance of the proposed CAD system design, various experiments have been carried out to characterize the receptors for two-class classification. A brief description of the conducted experiments for two-class a classification is tabulated in Table 1.

Table 1: Description of experiments carried out for two-class classification of receptors

Experiment 1	To obtain classification performance using kNN classifier and PCA-kNN classifier
Experiment 2	To obtain classification performance using PNN classifier and PCA-PNN classifier
Experiment 3	To obtain classification performance using SVM classifier and PCA-SVM classifier

Experiment 1: To obtain classification performance using kNN classifier and PCA-kNN classifier

In this experiment the classification performance of the feature set containing instances of TFV and reduced training feature vector (RTFV) are evaluated using *k*NN classifier. The results are shown in Table 2.

From the table 2 it can be observed that a classification accuracy of 60 % is achieved using RTFV and 26.67 % is using TFV.

Table 2 : The classification performance using kNN classifier and PCA-kNN classifier

The individual class accuracy of present class is 25 % and 37.5 % for RTFV and TFV respectively. For absent class the individual class accuracy is 100 % and 14.28 % for RTFV and TFV respectively.

Experiment 2: To obtain classification performance using PNN classifier and PCA-PNN classifier

In this experiment the classification performance of the feature set containing instances of RTFV and TFV is evaluated using PNN classifier. The results are shown in Table 3.

Table 3 : The classification performance using PNN classifier and PCA-PNN classifier

From the table 3 it can be observed that a classification accuracy of 80 % is achieved using RTFV and 60 % is using TFV. The individual class accuracy of present class is 100 % and 100% for RTFV and TFV respectively. For absent class the individual class accuracy is 57.14 % and 14.28 % for RTFV and TFV respectively.

Experiment 3: To obtain classification performance using

		CM		OCA (%)	$ICA_{Present}$ (%)	ICA_{Absent} (%)
RTFV		Present	Absent			
PNN-PCA	Present	80	0	80%	100 %	57.14 %
	Absent	30	40			

		CM		OCA (%)	$ICA_{Present}$ (%)	ICA_{Absent} (%)
TFV		Present	Absent			
PNN	Present	80	0	60 %	100 %	14.28 %
	Absent	60	10			

SVM classifier and PCA-SVM classifier

In this experiment the classification performance of the feature set containing instances of RTFV and TFV is evaluated using SVM classifier. The results are shown in Table 4.

Table 4 : The classification performance using SVM classifier and PCA-SVM classifier

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		CM		OCA (%)	$ICA_{Present}$ (%)	ICA_{Absent} (%)
RTFV		Present	Absent			
SVM- PCA	Present	80	0	86.67 %	100 %	71.4 %
	Absent	20	50			

		CM		OCA (%)	$ICA_{Present}$ (%)	ICA_{Absent} (%)
TFV		Present	Absent			
SVM	Present	20	60	33. 33 %	25%	42.85 %
	Absent	40	30			

From the table 4 it can be observed that a classification accuracy of 86.67 % is achieved using RTFV and 33.33 % is using TFV. The individual class accuracy of present class is 100 % and 28.57 % for RTFV and TFV respectively. For absent class the individual class accuracy is 71.14 % and 42.58 % for RTFV and TFV respectively.

IV. CONCLUSION

In the present work a CAD tool for the classification of EGF and IRS receptors has been developed by using Gabor wavelet technique. From the above experimentations it can be concluded that for two-class, PCA-SVM classifier achieves highest classification accuracy of 86.67 % using first 8 PCs. Thus, it can be concluded that for two-class receptor classification, first 8 PCs obtained by applying PCA to the TFV derived from Gabor are sufficient to account for the textural changes exhibited by the receptors.

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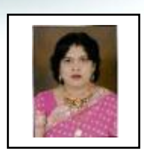

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