Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 02, February -2018

Identification of Diabetic Damage Detection in Retinal Images using ANFIS

NaluguruUdaya Kumar[1], Dr.T.Ramashri[2]

[1]*Research Scholar, Department of Electronics and Communication Engineering,*
S.V.U College of Engineering, S.V.University, Tirupati
[2]*Professor, Department of Electronics and Communication Engineering,*
S.V.U College of Engineering, S.V.University, Tirupati

Abstract—*Digital retinal images plays very crucial role inmedical domain and applications. The role of these images vary across different diseases like micro aneurysms, hemorrhages, hard exudates, cotton wool spots or venous circles etc. One of the important application of retinal image processing is required in diagnosing and treatment of many diseases affecting the retina and the choroid behind. With huge volume of images being taken from the drive database, it is imperative to have an automated classifier system. In this work Adaptive Neuro Fuzzy Inference System (ANFIS) has been designed and developed for detection of abnormalities in the retinal images. Using wavelet decomposition & Principal Component Analysis (PCA), image features are extracted & segregated. These image features form the basis for ANFIS based classification system. The proposed approach has been validated with help of data sets comprising over 40 images sourced from DRIVE data base. The classifier performance has been evaluated through different performance measures and this research demonstrates the suitability of proposed approach in identifying retinal diseases.*

Keywords*-Retinal images, ANFIS, Wavelet, PCA, Drive database*

I. INTRODUCTION

One of the major diseases that cause severe threat to the eye is named as Diabetic retinopathy (DR). It creates thereby create blindness among the people in the small age itself. The retinal image processing is used for analyzing and detecting the disease with the retinal blood vessels. A standout amongst the most critical sicknesses that cause retinal veins structure to change is diabetic retinopathy that prompts to visual impairment. The diabetic influences very nearly 31.7 million Indian populaces, and has related entanglements like stroke, vision misfortune and heart disappointment. The Diabetic is happens when the pancreas does not discharge enough measure of insulin. This ailment influences gradually the circulatory framework including that of the eye. Diabetic retinopathy is a typical reason for vision misfortune among the diabetic people.

The Diabetic retinopathy (DR) is the resultant disorder influencing the retinal vasculature, prompting to progress inferential harm that can end in misfortune to vision and visual deficiency. DR is the most successive reason for new instances of visual deficiency among adults aged 20–74 years. The issue is expanding in its scale, with diabetes distinguished as a critical becoming worldwide open health problem. In the United Kingdom alone, three million individuals are estimated to have diabetes and this figure is relied upon to twofold in the next 15–30 years .Diabetic patients are required to go to customary eye screening appointments in which DR can be evaluated, with the aim of early location of the sickness to take into account convenient mediation. During these arrangements retinal pictures are caught and these pictures then experience various phases of manual evaluation via prepared people. This assessment can be an extremely tedious and expensive assignment because of the large diabetic populace. Along these lines this is a field that would greatly benefit from the presentation of computerized recognition frameworks .The harm to the retinal veins will bring about blood and fluid to spill on the retina and shape components such as microneurysms, hemorrhages, exudates, cotton fleece spots and venous loops. With movement, the blockages and harm to blood vessels deny zones of the retina with their blood supply. These areas of the retina send signs to the body to develop fresh blood vessels for sustenance.

II. LITERATURE SURVEY

Elaheh Imani et al. (2015) have developed a Diabetic retinopathy method it was the major cause of blindness in the world. It had been shown that early diagnosis could play a major role in prevention of visual loss and blindness. Diagnosis could be made through regular screening and timely treatment. Besides, automation of this process could significantly reduce the work of ophthalmologists and alleviate inter and intra observer variability. It provides a fully automated diabetic retinopathy screening system with the ability of retinal image quality assessment. It lies in the use of Morphological Component Analysis (MCA) algorithm to discriminate between normal and pathological retinal structures. To this end, first a pre-screening algorithm was used to assess the quality of retinal images. If the quality of the image was not satisfactory, it was examined by an ophthalmologist and must be recaptured if necessary. Otherwise, the image was processed for diabetic retinopathy detection. In this stage, normal and pathological structures of the retinal image were separated by MCA

algorithm. Finally, the normal and abnormal retinal images were distinguished by statistical features of the retinal lesions [20].
Rashmi Panda et al. (2016) have introduced an automated retinal vessel segmentation it plays an important role in computer-aided diagnosis of serious diseases such as glaucoma and diabetic retinopathy. However they contributes, (1)new Binary Hausdorff Symmetry (BHS) measure based automatic seed selection, and (2) new edge distance seeded region growing (EDSRG) algorithm for retinal vessel segmentation. The BHS measure directly provides a binary symmetry decision at each pixel without the computation of continuous symmetry map and image thresholding. In a multiscale mask, the BHS measure was computed using the distance sets of opposite direction angle bins with sub-pixel resolution. The computation of the BHS measure from the Hausdorff distance sets involves point set matching based geometrical interpretation of symmetry. Then, they design an edge distance seeded region growing (EDSRG) algorithm with the acquired seeds[17].

Sayon Roy et al. (2016) have stated a response to injury, reparative processes it were triggered to restore the damaged tissue; however, such processes were not always successful in rebuilding the original state. The formation of fibrous connective tissue was known as fibrosis, a hallmark of the reparative process. For fibrosis to be successful, delicately balanced cellular events involving cell proliferation, cell migration, and extracellular matrix (ECM) remodeling must occur in a highly orchestrated manner. While successful repair may result in a fibrous scar, this often restores structural stability and functionality to the injured tissue. However, depending on the functionality of the injured tissue, a fibrotic scar could have a devastating effect. For example, in the retina, fibrotic scarring may compromise vision and ultimately lead to blindness[18].

SudeshnaSilKar et al. (2016) have proposed an automatic blood vessel extraction method on retinal images using matched filtering in an integrated system design platform that involves curvelet transform and kernel based fuzzy c means. Since curvelet transform represents the lines, the edges and the curvatures very well and in compact form (by less number of coefficients) compared to other multi-resolution techniques, it uses curvelet transform for enhancement of the retinal vasculature. Matched filtering was then used to intensify the blood vessels' response which was further employed by kernel based fuzzy c-means algorithm that extracts the vessel silhouette from the background through non-linear mapping. For pathological images, in addition to matched filtering, Laplacian of Gaussian filter was also employed to distinguish the step and the ramp like signal from that of vessel structure. The algorithm had also been applied to images in presence of additive white Gaussian noise where the curvelet transform had been used for image denoising [19].

III. METHODOLOGY

A. Proposed Algorithm

Step1: Create training & testing dataset using DRIVE Retinal image data base.
Step2: Find the 3 level decomposition of training images Using Daubechies (db4) wavelet.
Step3: Find Principle Component Analysis (PCA) for Decomposed images.
Step4: Extract the statistical features.
Step5: Train the ANFIS classifier using extracted statistical Parameters.
Step6: Plot mean square error.
Step7: Test the trained ANFIS using test data set.
Step8: Calculate performance evaluation measures.

B. Data Set

The training & testing data set are taken using DRIVE database images. Digital fundus images normally contain a main region at the center of the image, surrounded by dark background pixels. In the automatic diagnosis of DR, as only the main retinal pixels are required for processing, we therefore separate the background pixels from the foreground in the preprocessing step. Daubechies (db4) waveletare utilized because of their upgrade capacities. Adaptive Neuro Fuzzy Inference System (ANFIS) has been assists the huge vessels along with thin capillaries vessels. At first, the images are preprocessed for noise elimination utilizing median filter. The contrast upgrade procedure is elaborated and adopted to the green segment of the images. This strategy is depending upon the Daubechies (db4) waveletand ANFIS classifier. The optic disc is focalized utilizing an averaging filtering and determining the circular area with the maximum intensity values.

DRIVE database consists of three different manual diseased sets: First manual, second manual and masks.

In order to have the improved classifier accuracy, heterogeneous data set mix has been considered to train the proposed ANFIS classifier. The data set comprises of different images having the presence & absence of disease in then. The purpose is to have a wide sense of categorization through data set mix that is representative of different scenarios. Some of these scenarios includes considering images having different diseases.

C. Discrete Wavelet Transforms

The advantage of wavelet transforms over Fourier transform is that, it has temporal resolution i.e. it capture both frequency and location information [21]. A discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. Thus discrete wavelet transform (DWT) is a linear transformation that operates on a data vector whose length is an integer power of two, transforming it into a numerically different vector of the same length. It is a tool that separates data into different frequency components, and then studies each component with resolution matched to its scale. DWT is computed with a cascade of filters followed by a factor 2 sub sampling. The advantages of DWT are more robust, maintains good image quality and good spatial resolution at each level of decomposition. DWT transforms array of original sample into wavelet coefficients and IDWT Transforms wavelet coefficients into the original sampled data. The Daubechies wavelet transform is named after inventing the mathematician Ingrid Daubechies. The db4 transform has four wavelet and scaling functions coefficients. The scaling function coefficients are

$$h_0 = \frac{1+\sqrt{3}}{4\sqrt{2}},\ h_1 = \frac{3+\sqrt{3}}{4\sqrt{2}},h_2 = \frac{3-\sqrt{3}}{4\sqrt{2}} \text{ and } h_3 = \frac{1-\sqrt{3}}{4\sqrt{2}}. \quad (1)$$

The wavelet function coefficients values are

$$g_0 = h_3,\ g_1 = -h_2,\ g_2 = h_1 \text{ and } g_3 = -h_0 \quad (2)$$

The scaling and wavelet functions are calculated by taking the inner product of the coefficients and four data values as shown in below equations[14]
Scaling function:

$$a_i = h_0 s_{2i} + h_1 s_{2i+1} + h_2 s_{2i+2} + h_3 s_{2i+3} \quad (3)$$

Wavelet function:

$$c_i = g_0 s_{2i} + g_1 s_{2i+1} + g_2 s_{2i+2} + g_3 s_{2i+3} \quad (4)$$

H and L denote high and low-pass filters respectively followed by sub sampling. Outputs of these filters are given by equations

$$\left.\begin{array}{l} a_{j+1}[p] = \sum_{n=-\infty}^{+\infty} l[n-2p]\,a_j[n] \\ c_{j+1}[p] = \sum_{n=-\infty}^{+\infty} h[n-2p]\,a_j[n] \end{array}\right\} \quad (5)$$

Elements a_j are used for next step (scale) of the transform and elements c_j, called wavelet coefficients, determine output of the transform. l[n] and h[n] are coefficients of low and high-pas filters respectively as shown in Fig.1.

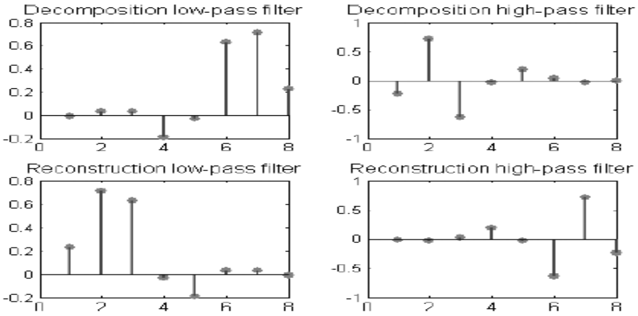

Figure 1. Low pass & high pass filter coefficients

DWT involves decomposition of image into frequency channel of constant bandwidth. This causes the similarity of available decomposition at every level. DWT is implemented as multistage transformation. Level wise decomposition is done in multistage transformation. At level 1: Image is decomposed into four sub bands: LL, LH, HL, and HH where LL denotes the coarse level coefficient which is the low frequency part of the image. LH, HL, and HH denote the finest scale wavelet coefficient. The LL sub band can be decomposed further to obtain higher level of decomposition. This decomposition can continue until the desired level of decomposition is achieved for the application.

Figure 2. Three level wavelet decomposition

The LL sub band is the result of low-pass filtering both the rows and columns and contains a rough description of the image. Therefore the LL sub band is also called the approximation sub band. The HH sub band was high-pass filtered in both directions and contains the high-frequency components along the diagonals. The HL and LH images are the result of low-pass filtering in one direction and high-pass filtering in the other direction. LH contains mostly the vertical detail information, which corresponds to horizontal edges. HL represents the horizontal detail information from the vertical edges. All three sub bands HL, LH and HH are called the detail sub bands, because they add the high-frequency detail to the approximation image. Three level wavelet decomposition is shown in Fig.2.

D. Principle Component Analysis(PCA)

PCA is also known as Karhunen-Loeve expansion, it is probably the most widespread multivariate statistical technique. It is a method to study the structure of the data, with emphasis on determining the patterns of covariance among variables. Thus, PCA is the study of the structure of the variance-covariance matrix. In practical terms, PCA is a method to identify variable or sets of variables that are highly correlated with each other.As it removes the redundancy; it is used as data compression technique. PCA create an image subspace with reduced dimensionality, while maintaining a high level of discrimination between the images.PCA method is also known as Eigen face Method, because reduced dimensionality is obtained using Eigen values and vectors.

Procedure

Step1: Create 'M' training images with different size.
Step2: Construct Covariance matrix for individual images
C = AAT. Where A is image matrix in training set.
Step3: Find the Eigen values of the covariance matrix
$$|C-\lambda I| = 0$$
Step4: Find Eigen vectors for Eigen values
Step5: Form the Eigen vector matrix.
Step6: Calculate Statistical parameters of the above matrix

E. Statistical Parameters

Let intensity in Eigen value matrix 'Z' is assumed to be random variable whose value is varies from 0 to (L-1), where 'L' is no. of intensity levels is equal to 2N-1 and 'N' is no. of bits allocated to each pixel. The probability of random variable intensity 'Z' is called "Probability Density Function" (PDF) and denoted as in image processing, the probability density function is often called as "Histogram" and it is used to describe the nature of the image.
The moment about origin or the first order statistical parameters can be obtained as follows

$$m_n = \sum_{i=0}^{L-1} z_i{}^n \; f_Z(z_i) \quad (6)$$

Where n = 1, 2, 3, 4 ………… is the order of the momentsm1, m2, m3 are very useful parameters called mean & mean square in statistical analysis respectively. They called average or DC value & total power of an image respectively in electrical systems. The moments about mean or central moments can be obtained as follows

$$\mu_n = \sum_{i=0}^{L-1} (z_i - m_1)^n f_Z(z_i) \quad (7)$$

Where n = 1, 2, 3, 4 ……….. is the order of central moments and m1 is mean value. μ_1 is always zero, μ_2 is called variance in statistical analysis and ac power in electrical systems, Square root of is called standard deviation in statistical analysis and rms value in electrical system if average value is zero, μ_3 and μ_4 are called skew and kurtosis respectively which describes the nature of probability density function or histogram. The following nine parameters are extracted from the image for training & testing the ANFIS classifier.

Mean $$m_1 = \sum_{i=0}^{L-1} z_i \, f_Z(z_i) \quad (8)$$

Mean Square $$m_2 = \sum_{i=0}^{L-1} {z_i}^2 f_Z(z_i) \quad (9)$$

Contrast $$\alpha_C = \sum_{i,j} \frac{x_{ij}}{1+|i-j|} \quad (10)$$

Inverse Difference Movement $$\alpha_{IMD} = \sum_{i,j} |i-j|^2 \, x_{ij} \quad (11)$$

Energy $$\alpha_E = \sum_{i,j} (x_{ij})^2 \quad (12)$$

Correlation $$\alpha_{CR} = \sum_{i,j} \frac{(i-m_{1i})(j-m_{1j})x_{ij}}{\sigma_i \sigma_j} \quad (13)$$

Variance $$\mu_2 = \sum_{i=0}^{L-1} (z_i - m_1)^2 f_Z(z_i) \quad (14)$$

Skew $$\mu_3 = \sum_{i=0}^{L-1} (z_i - m_1)^3 f_Z(z_i) \quad (15)$$

Kurtosis $$\mu_4 = \sum_{i=0}^{L-1} (z_i - m_1)^4 f_Z(z_i) \quad (16)$$

Where x_{ij} is the intensity value of the pixel at location (i,j), m_{i1} $m_{1j}$are mean values, σ_i and σ_j are standard deviations with respect to i, j respectively.

IV. ANFIS CLASSIFIER

The block diagram of proposed system is shown in Fig. 3, in which images from training set are wavelet decomposed at three levels, analyzed using PCA and then statistical features are extracted to train the ANFIS classifier.

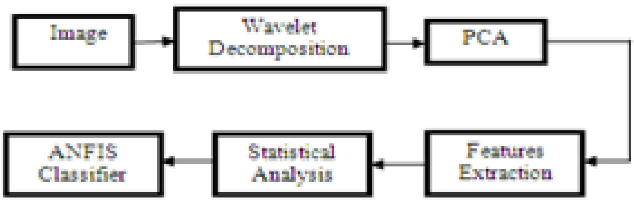

Figure 3. Block diagram of proposed system

The ANFIS combines both fuzzy logic principle and the concept of the neural networks. The ANFIS has advantage [16] of smoothness property from the fuzzy principle and adaptability property from the neural networks training structure. ANFIS contain five layers, membership function is generated in the first layer, and triangular membership function is used. Second layer multiplies incoming signals, weight normalization is done in the third layer, fuzzy rules generated in fourth layer and fifth layer acts as summer. The weights are adaptively changed based on rules generated errors. ANFIS training error plot and testing data set Vs ANFIS output are shown in Fig. 4 & 5 respectively.

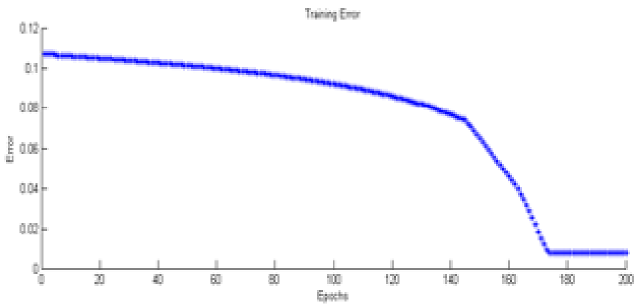

Figure 4. Training error plot

V. RESULTS AND DISCUSSION

The GUI helps in providing seamless interface in loading & analyzing the retinal images. The GUI has the scope to provide histogram analysis as well as color map function for better visualization of retinal images. The histogram of retinal images are shown in Fig.5.

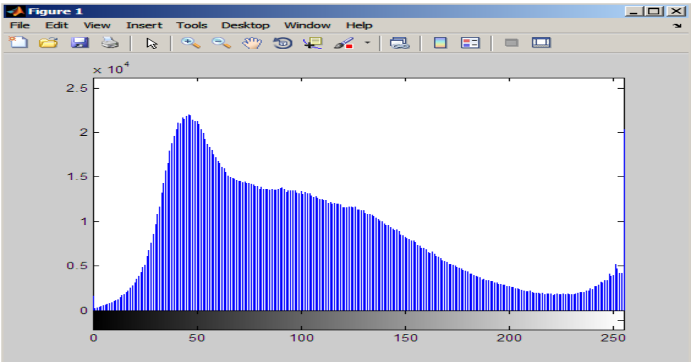

Figure 5. Histogram of retinal image

Using GUI the trained ANFIS classifier can be called to classify the image under study. The result of classifier is given through text display indicating possible presence or absence of disease. The GUI also opens up another interface which can help to evaluate the classifier performance. The classifier performance has been evaluated with help of 5 different performance measures like sensitivity, specificity, accuracy etc.

Table 1. Results comparison

Methods	Sensitivity	Specificity	Accuracy
Girima Gupta [16]	92.40	92.60	97.55
Proposed Method	98.28	97.62	98.67

It is also observed that during the analysis the classifier have delivered better performance. This is especially in true those cases when the retinal image are damaged.

VI. CONCLUSION

In this research work, a novel approach for classification of images identifying diabetic retinopathy has been presented. The approach has exploited the decomposition of wavelet & PCA to extract the features. The ANFIS classifier has demonstrated with its accuracy and other performance parameters validated through different data sets. This predictor formulation leads to image level categorization of absence or presence of PDR. The results have been validated for promise to be applied in both high sensitivity and high specificity operating conditions. The classification performance found to be satisfactory even classifying images. It is suggested further improvement in classification accuracy can be brought about by fusion of retinal images. Future work could examine integrating ideas presented in this method in a larger system for DR grading.

REFERENCES

[1] Akram, M.U, Tariq A., Khan, S.A., “Detection of neovascularization for screening of proliferative diabetic retinopathy”,in image analysis and recognition, pp.372-379, 2012.
[2] Akram, M.U.,khalid, S., Tariq, A., Javed, M.Y., “Detection of neovascularization in retinal images using multivariate m-Methods based classifier”,Comput.Med.Imaging Graph.37(5),pp.346-357, 2013.
[3] Fleming, A.D., Philip, S., Goatman,et al., “Automated microaneurysm detection using local contrast normalization and local vessel detection”, IEEE Trans.Med.imaging 25(9),pp.1223-1232, 2006.
[4] Frame.A, Undrill.P, Olson.J, McHardy,K. Sharp,P.orrester,J, “Texture analysis of retinal neovascularization”, In: IEE colloquium on pattern Recognition (Digest No.1997/018),IET,1997.
[5] Goatman,K.A.,Fleming,A.D.,Philip, S., Williams, G.J. Olson, J.A. Sharp, P.F., “Detection of new vessels on the optic disc using retinal photographs”, IEEE Trans.Med.Imaging 30(4),pp.972-979, 2011.
[6] Andrew Hooper, Fred Prata, and FreysteinnSigmundsson “Remote Sensing of Volcanic Hazards and Their Precursors” Procceeding of the IEEE, Vol.100, No.10, October 2012.
[7] Hart, W.E., Goldbaum, M., Côté, B., Kube, P., Nelson, M.R., “Measurement and classification of retinal vascular tortuosity”, Int. J. Med. Inf. 53 (2), pp.239–252.1999.
[8] Herrera, M., Manuel, V, “Am–Fm methods for image and video processing”, (Ph.D. thesis-2009)
[9] Hoover, A., Kouznetsova, V., Goldbaum, M., “Locating blood vessels in retinal images by piecewise threshold probing of a matched filter response”, IEEE Trans. Med. Imaging 19 (3), pp.203–210,2000.
[10] Jelinek, H.F., Cree, M.J., Leandro, J.J., Soares, J.V., Cesar, R.M., Luckie, A., “Automated segmentation of retinal blood vessels and identification of proliferative diabetic retinopathy”, JOSA A 24 (5), pp.1448–1456, 2007.
[11] Karperien, A., Jelinek, H.F., Leandro, J.J., Soares, J.a., Cesar Jr., R.M., Luckie, A., “Automated detection of proliferative retinopathy in clinical practice”,Clin. Ophthalmol. (Auckland, N. Z.) 2 (1), pp.109–122, 2008.

[12] Nayak, J., Bhat, P.S., Acharya, R., Lim, C., Kagathi, M., “Automated identification of diabetic retinopathy stages using digital fundus images”, J. Med. Syst. 32 (2), pp.107–115, 2008.

[13] Ramlugun, N.V.K., Singh, Girish, Chakraborty, C., “Small retinal vessels extraction towards proliferative diabetic retinopathy screening”, Expert Syst. Appl. 39, pp.1141–1146, 2012.

[14] Saranya, K., Ramasubramanian, B., Mohideen, S.K., “A novel approach for the detection of new vessels in the retinal images for screening diabetic retinopathy”, In: 2012 International Conference on Communications and Signal Processing (ICCSP), IEEE, pp. 57–61, 2012.

[15] Tuceryan, M., Jain, A.K., “Texture Analysis”, the Handbook of PatternRecognition and Computer Vision”, vol. 2, pp. 207–248.

[16] Girima Gupta, et al., “Local characterization of neovascularization and identification of proliferative diabetic retinopathy in retinal fundus images”, computerized medical imaging and graphics, vol.55, pp.124-132, 2017.

[17] Rashmi Panda, N.B. Puhan and Ganapati Panda, "New Binary Hausdorff Symmetry measure based seeded region growing for retinal vessel segmentation", Biocybernetics and Biomedical Engineering, vol. 36, no. 1, pp. 119-129, 2016.

[18] SayonRoy,Shruti Amin and Sumon Roy, "Retinal fibrosis in diabetic retinopathy", Experimental Eye Research, vol. 142, pp. 71-75, 2016.

[19] SudeshnaSilKar and Santi P. Maity, "Blood vessel extraction and optic disc removal using curvelet transform and kernel fuzzy c-means", Computers in Biology and Medicine, vol. 70, pp. 174-189, 2016.

[20] Elaheh Imani, Hamid-Reza Pourreza and ToukaBanaee, "Fully automated diabetic retinopathy screening using morphological component analysis", Computerized Medical Imaging and Graphics, vol. 43, pp. 78-88, 2015

[21] Piotr Lipinski, and MykhayloYatsymirskyy, “Efficient ID and 2D Dauchechies Wavelet Transformwith Application to Signal Processing”, Spinger, Part II, LNCS 4432, pp.391-398, 2007