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Identification of Institutional Logo based on Wavelet Features

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ABSTRACT
The main aim of this paper is to recognize the logos of the input document so as to process the document for its classification and analysis, an algorithm is proposed using texture features based on Discrete Wavelet Transform (DWT) and Fast Fourier Transform (FFT) of object occurrence in a new tessellation of logo images and these features are given to the SVM and KNN classifier for recognizing the logos. The proposed algorithm is experimented on a data set of Institutional logos. The experimental results have shown the average recognition accuracy as 67.74% using NN classifier, 79.35% using KNN classifier and 87.09% using SVM classifier. It is an initial attempt towards the classification of documents based on logos.

General Terms
Document Image Processing, Pattern Recognition

Keywords
Wavelet Transforms - DWT, FFT, Classifiers - NN, KNN, SVM.

1. INTRODUCTION
One among the long-standing goal of computer vision is certainly object recognition. Most of the research work in image processing has been dedicated to the object recognition in general and various sub-problems in particular, nevertheless the task remains challenging. In this paper focus is more on logo recognition. Logo recognition is a part of pattern recognition problem, since logos can be considered as objects on a planar surface. In addition logos are designed to catch someone’s attention. However, a specific logo class can be used to recognize the logos in natural images. The advantage of logo recognition is to create the databases based on logos. This may help for efficient usage of database.

Large amount of work has been carried out on complex document containing combination of printed and handwritten characters [3,12], bilingual and multilingual scripts [4]. The work also has been carried out to identify logos of different shape and size. David S. et al [1] have presented a multi-level staged approach to logo recognition using global invariants to prune the logo database and local affine invariants to obtain a more refined match. Their approach allows to obtain a signature which can be used for recognition under a variety of transformations. Doermann et al [3] have applied algebraic and differential invariants for logo recognition by extracting text and primitive shapes like line, circles and rectangles from logos using many specific feature detection and used global and local geometric invariants for matching. Neuman et al [5] used projection profiles, normalized centroid distance, eccentricity and various density features for logo recognition. Pham and Chen et al [6,7] have used the task of group membership recognition(6 classes in Pham and 20 logos classes in Chen et al). These approaches generated rotated, noise corrupted or manually edited logos as test images using different schemes and making the comparison difficult. Seiden et al [8] have developed a detection system by segmenting the document image into smaller images which consists of several document segments such as small and large texts, pictures and logos. Their segmentation process is based on a top-down, hierarchical X-Y tree structures and they have extracted 16 statistical features from the segment and set of rules are developed using ID3 algorithm to recognize the presence of logo in unknown region. Zhu et al [9] developed a detection system which is segmentation free, fast and layout independent based on generic features and shape descriptors of the connected components and line profiles. Hongye Wang [10] has identified the deficiency of the available method lacking in adoptability to variable real-worl documents. He observed this deficiency from different point of view and reveal its inherent causation, then re-organize the structure of the logo detection and recognition process and integrated into unified frame work. Sina Hassanzadeh et al [11] developed a novel logo detection and recognition framework based on spatial and structural features especially for separated part logos application is proposed. They have used morphological operations to merge separated parts of the logos. The spatial features used in their work were defined based on histogram of object occurrence in a new tessellation of logo images. KNN was used to recognize the detected logos from the Maryland University dataset. From the discussion it is clear that the detection and recognition of logos is a challenging problem in document authenticity, indexing, retrieval etc.

From the works carried out from the past it is observed that recognition of logo using spatial features like shape, geometric and structural features suitable for logos of limited shapes and textures, this addresses the need for enhancing the accuracy in the logo identification. Hence, proposed work in this paper uses texture features from the frequency domain for robustness for identifying logos of different shape, size, texture, etc.

The rest of this paper is organized as follows. Section 2 deals with Data collection and Preprocessing, details of Feature extraction method is presented in Section 3. The Experimental Result is provided in Section 4 and Section 5 summarizes the paper in the form of Conclusion and Future scope.

2. DATA COLLECTION AND PREPROCESSING
To evaluate the proposed algorithm on the logo images, no standards data set is available that contains only logo part of the complex document. Hence, the hard copy of the various printed complex documents containing logos from the different Universities and Institutions are collected. These documents are then scanned and segmented manually and stored in a ‘jpg’ file format. These segmented images may be colour or binary images and contain noise due to quality of scanner and printer, hence they are made noise free using morphological operations and colour conversion from RGB to Grey Scale is carried out.

The noise free grey scale images are then used for feature extraction. A Total of 31 classes of logos of different shapes are considered and for each logo class four logos with salt-pepper noise and a black strip noise is added to test the accuracy of the algorithm by taking these four noisy images. Therefore this makes a total of 155 test images for 31 Trained images. Figure 1 shows the sample of train and test images. Type1 is both stripped and noise added image, Type 2 and Type 4 are only noise added images and Type 3 is stripped image.

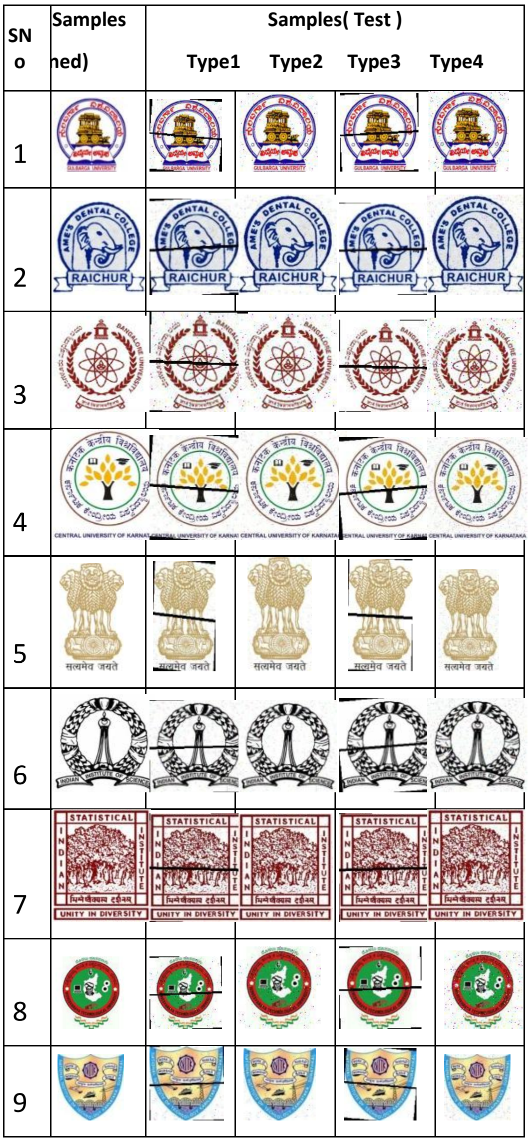

Fig – 1 Samples Datasets of Logo images

3. FEATURE EXTRACTION METHODS

3.1 Discrete Wavelet Transform (DWT)

A wavelet transform in which the wavelets are discretely sampled are known as discrete wavelet transform. The fundamental idea of using discrete wavelets is to analyze the signals according to scale. It has gained a lot of attention in the area of signal processing, numerical analysis and mathematics during recent years [9] [11]. Generally, the wavelet transforms is an advanced technique used for signal and image analysis. It is an alternative technique to the short time Fourier Transform[13] to overcome problems related to its frequency and time resolution properties. The basic idea of DWT is to provide the time-frequency representation.

The 2D-DWT represents an image in terms of a set of shifted and dilated wavelet functions ψ^{LH}, ψ^{HL}, ψ^{HH} and scaling functions ϕ^{LL} that form an ortho-normal basis for $L^2(R^2)$. Given a j-scale DWT, an image x(s, t) of size NxN is decomposed as

$$x(s,t)=\sum_{k,i=0}^{Nj-1}u_{j,k,i}\phi^{LL}{}_{j,k,i}(s,t)+\sum_{B\in B}\sum_{j=1}\sum_{k,i=0}^{N-1}\omega^{B}{}_{j,k,i}\psi^{B}{}_{j,k,i}(s,t) \quad (1)$$

The function defined in (1) can be described as

$$\phi^{LL}\equiv 2^{-\frac{j}{2}}\phi(2^{-j}s-k,2^{-j}t-1),\psi^{B}{}_{j,k,i}(s,t)\psi^{B}{}_{j,k,i}(s,t)\psi^{B}{}_{j,k}$$

$$\equiv 2^{-\frac{j}{2}}\psi^{B}(2^{-j}s-k,2^{-j}t-1),\ B\in B,\ B$$

Where LH, HL and HH are called wavelet or DWT sub-bands $u_{j,k,i}=\iint x(s,t)\phi_{j,k,i}\,ds\,dt$ is a scaling coefficient and $\omega^{B}{}_{j,k,i}=\iint x(s,t)\psi^{B}{}_{j,k,i}\,ds\,dt$ denotes the (k, i)th wavelet coefficient in scale *j* and sub-band *B*. The scaling concept in wavelet transform is presented in Figure 2.

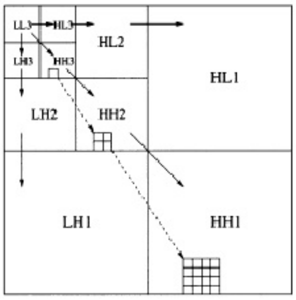

Figure 2: Joint spatial and frequency representation of a 2-D three-scale DWT.

3.2 Fast Fourier Transform

The FFT is applied on spatial domain image to obtain FFT coefficients. The features are extracted from FFT coefficients are real part, imaginary part, magnitude value and phase angle. The FFT computation is fast as compared to Discrete Fourier Transform (DFT), since the number of multiplications required to compute N-point DFT are less.

3.3 Feature

The features of DWT are obtained from approximation band only. The features of FFT are computed using the magnitude values.

After applying the Fast Fourier Transform, the set of 64 DC coefficients and the AC coefficients in the form of 8×8 matrix are obtained, where the coefficient at first row first column contains DC coefficient and rest of them are AC coefficients, these coefficients are then converted into a one-dimensional zig-zag sequence in order to extract dominant features as shown in Figure 3, where the numbers are the zig-zag orders, notified as ZZ(0), ZZ(1),...,ZZ(63). Out of these 64 coefficients first 20 coefficients are considered by trial and error method as feature set for further process.

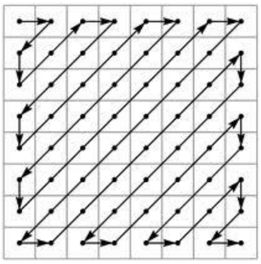

Figure 3: Zig-Zag Order

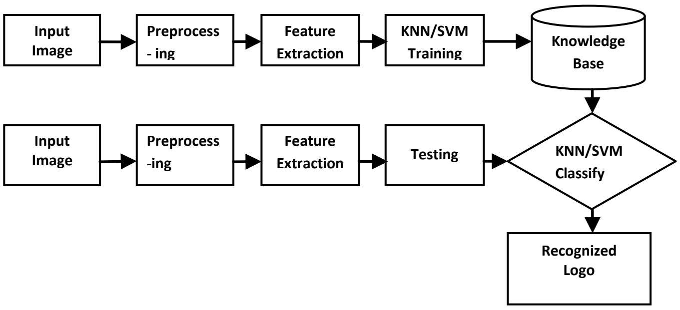

Figure 4 : Block diagram of Wavelet based Logo Recognition System

The brief procedure about the proposed system can be unambiguously visualized in Figure 4. The input image is acquired for both training and testing phases and preprocessing is performed using colour conversion and morphological operations. Features are extracted using DWT and FFT. Trained vector generated after extracting the features are stored as Knowledge base. The test feature is inputed to the classifiers and compared with trained data to obtain the recognized logo.

Initially the discrete sample of wavelets for the input image is obtained from the discrete wavelet transform. The fundamental idea behind wavelets is to analyze signal according to scale. In the proposed algorithm we will make the scale to 0-255 which is called normalization. Normalization should be done after selecting the approximate component LL. Later apply FFT to shift zero frequency component to the centre of the spectrum. The FFT is applied on spatial domain image to obtain FFT coefficients. The features are real part, imaginary part, magnitude value and phase angle. Repeat the normalization procedure to make scale 0-255. Finally apply jpeg zigzag ordering to make the DC coefficient and the AC coefficients into a one-dimensional zigzag sequence and select first twenty frequency components as feature vector. These vectors are generated for both training and testing phase and used for identification of the logo using KNN and SVM classifier. Algirithm-1 gives the flow of Testing, Training and Classification procedure used in the proposed work.

Algorithm1: Logo Recognition

Input: Colored images of Logos

Output: Recognised Logo

Method : Discrete Wavelet Transform and Fast Fourier Transform

Feature vector of size : 20.

Train Phase:

Start

Step 1 : Input the preprocessed image.

Step 2 : Extract Features using 2-dimension DWT at level 1 using Daubechies wavelets.

Step 3 : Select the signals at the approximate band and Normalize the signal to 0-255 scale.

Step 4 : Apply 2-dimension FFT to the features obtained at Step-3, this results an 8×8 matrix, out of 64 features 1 is DC component and 63 are AC components.

Step 5 : Perform zero frequency shifting to strengthen the frequency components.

Step 6 : Apply JPEG zigzag ordering and select first 20 frequency components as dominant features and store them as a feature vector in train library with labels.

End

Test Phase:

Start

Step 1 : input the preprocessed image.

Step 2 : Extract the Features using 2-dimension DWT at level 1 using Daubechies Wavelet.

Step 3 : Select the signals at the approximate band and Normalize the signal to 0-255 scale.

Step 4 : Apply 2-dimension FFT to the features obtained at Step-3, this results an 8×8 matrix, out of 64 features 1 is DC component and 63 are AC components.

Step 5 : Perform zero frequency shifting to strengthen the frequency components.

Step 6 : Apply JPEG zigzag ordering and select first 20 frequency components as dominant features and store them asa feature vector in test library.

Step 7 : Identify the Logo by label of the test logo using NN, KNN and SVM Classifiers with Euclidean distance measure.

End

4. EXPERIMENTAL PROCEDURE AND DISCUSSION

Figure 5 below indicates the menu display of the proposed system, containing three phases database training, auto testing, and the exit.

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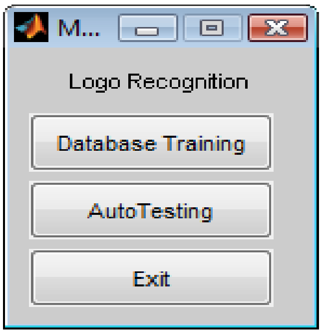

Figure – 5 Menu of the logo recognition System

In the further analysis there are five types of results obtained among which the first one original input image with its snapshot displayed in Figure 6.

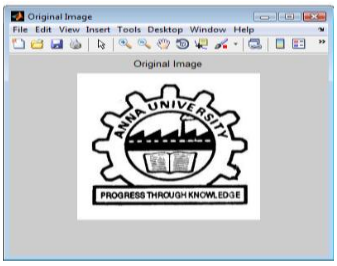

Figure – 6 : Original image

The second image describes about the one step decomposition i.e. the image is divided into four frequency bands LL, LH, HL, HH as shown in figure 7.

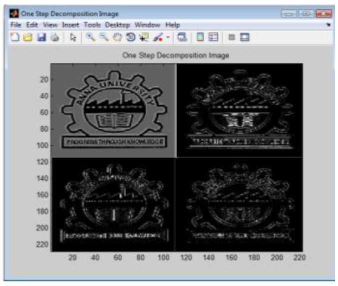

Figure – 7 : One step decomposition image

Out of these four bands after one step decomposition the LL band contains more detailed information of the image, hence this approximation band is selected for further process. The Figure 8 represents the image after selection of approximation band.

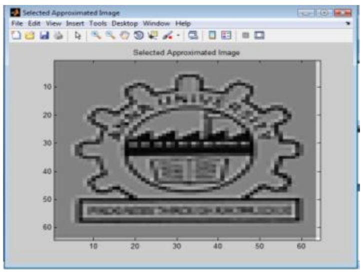

Figure – 8 : Selected approximation

Figure 9 represent the outcome of 2D FFT image, which results a 8×8 matrix containing 1 DC component and 63 AC components. This information is at the upper left corner of the 2D FFT image.

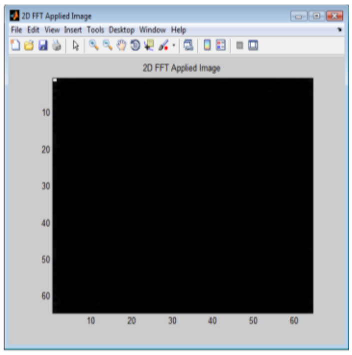

Figure – 9 : 2D FFT image

Frequency components after 2D FFT are shifted to the center by zero frequency shifting as shown in figure 10.

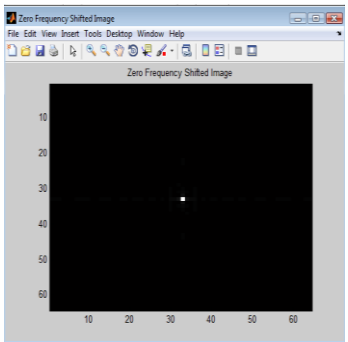

Figure – 10 : Zero frequency shifted image

Table-2shows the database for training and testing phase and accuracy rate for NN, KNN and SVM Classifiers.

Table-2 : Details of Dataset and identification rates of logo recognition using NN, KNN and SVM classifiers

Logo Classes	No. of Trained Images	No. of Tested Images	% accuracy by NN	% accuracy By KNN	% accuracy by SVM
L1	01	05	100%	100%	100%
L2	01	05	60%	60%	100%
L4	01	05	60%	60%	100%
L6	01	05	60%	60%	100%
L7	01	05	80%	80%	100%
L8	01	05	60%	80%	100%
L9	01	05	80%	100%	100%
L10	01	05	60%	60%	100%
L11	01	05	100%	100%	100%
L12	01	05	60%	60%	100%
L13	01	05	60%	60%	100%
L14	01	05	80%	80%	100%
L16	01	05	80%	80%	100%
L19	01	05	60%	60%	100%
L20	01	05	100%	100%	100%
L21	01	05	80%	80%	100%
L23	01	05	60%	100%	100%

L25	01	05	100%	80%	100%
L27	01	05	60%	80%	100%
L28	01	05	40%	60%	100%
L3	01	05	80%	60%	80%
L18	01	05	80%	80%	80%
L5	01	05	60%	60%	60%
L15	01	05	60%	60%	60%
L22	01	05	60%	60%	60%
L17	01	05	60%	60%	60%
L24	01	05	80%	60%	60%
L26	01	05	100%	100%	60%
L29	01	05	60%	60%	60%
L30	01	05	60%	60%	60%
L31	01	05	60%	60%	60%
Average Accuracy			**67.74%**	**79.35%**	**87.09%**

From the Table 2 it can be observed that for the same feature set the SVM classifier gives better results compared to NN and KNN classifier. Out of 31 logo classes 20 logo classes are identified with 100% accuracy, 2 logo classes with 80% accuracy and 9 logo classes with 60% accuracy using SVM classifier, this gives an overall accuracy of 87.09%. Similarly for NN and KNN 67.74% and 79.35% accuracy has been obtained.

5. CONCLUSION

A system for recognizing logo object is developed using the DWT and FFT features. These features are best suitable for recognition of any object of irregular shape. Features are considered from the approximation band of the decomposition. Logo recognition using wavelet features is an efficient method for identifying any image object among large number of classes. Proposed system uses University and Institutional logos. SVM classifier gives the optimal identification rate compared to NN and KNN classifiers. Efforts will be continued to modify the algorithm by deleting non-potential features from the feature set and adding some mother potential features to the feature set to increase the recognition accuracy of the logo from the document images. As a future work the system can be developed which is invariant to Rotation, Scaling and Transformations for identifying the logo from the complex document. The system can be extended to identify any object in the real world documents which is static as well as dynamic (video) in nature.

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