NORMALIZED SINGULAR WAVELET FEATURE FOR PATTERN RECOGNITION

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Abstract— In the process of pattern recognition, feature descriptors are of major importance. Among various approaches of feature representation, wavelet based feature representation in spectral domain, is of greater importance. In the representation of wavelet features, wavelet resolution coefficients are extracted using set of filter banks and the obtained spectral bands are used for feature extraction based on the descriptive features. However the accuracy of these feature representation purely depends on the spectral information it reveals. The suitability of wavelet features is more effective due to its finer resolution representation. However, it is observed that these features are very randomly distributed and finer variations were mostly suppressed by the coefficients having high variation. In the process of pattern recognition, these finer features also hold information, which affects the retrieval accuracy. With this objective in this paper a normalized feature for wavelet feature extraction is proposed.

Index Terms— Wavelet features, Normalized singular features, pattern recognition.

I. INTRODUCTION
The process of pattern recognition is now emerging at a very rapid rate, with its applications, been diversified from basic school level learning to high precision applications, such as medical applications, military applications etc. wherein all these applications, the basic motivation is to retrieve information for observed patterns from a remote server, the process of retrieval and the descriptive features describing the observation plays an important role. Various approaches were observed in past literature to improvise the retrieval accuracy by introducing new process of recognition methods, or by proposing new feature representations, to achieve higher recognition. Towards such approaches in [1] for the purpose of efficiently and effectively retrieving the desired images from a large image database, the development of a user-friendly image retrieval system is developed. In [2] an approach for feature extraction using wavelet transforms using its property of multilevel decomposition in pattern recognition application is proposed. The multilevel decomposition property of discrete wavelet transform provides information of an image at different resolutions. Towards the applicability of DWT based feature representation in [3] an iris feature extraction method based on wavelet-based contourlet transform (WBCT) for obtaining high quality features is proposed. In [4] a content based image retrieval method for diagnosis aid in medical fields is proposed. A model of wavelet coefficient distribution is used to enhance results, a weighted distance between signatures is used and an adapted wavelet base is proposed. In a similar approach to medical application in [5] an evaluation and comparison of the performance of four different and shape feature extraction methods for classification of benign and malignant micro calcifications in mammograms is proposed. clusters, and shape features were extracted for the DWT bands. For each set of features, most discriminating features and their optimal weights were found using real-valued and binary genetic algorithms (GA) utilizing a k-nearest-neighbor classifier. In [6] a new method for classification of human emotions based on multiwavelet transform of electroencephalogram (EEG) signals is proposed. The extracted features used as an input to multiclass least squares support vector machine (MC-LS-SVM) for classification of human emotions. In [7] a novel method towards multi-script identification at block level is proposed. The recognition is based upon features extracted using Discrete Cosine Transform (DCT) and Wavelets of Daubechies family. In [8] an Eyebrows identity authentication based on wavelet transform and support vector machine is proposed. The features of the eyebrows image are extracted by wavelet transform, and then classifies them based on SVM. The system show a low FAR of 0.22%and FRR 28%. In [9] A new algorithm for image indexing and retrieval using Daubechies Wavelet Transform (DWT) is presented. In this DWT has been implemented by using wavelet sub-bands of R, G and B components of images from Coral-1000 database. An Adaptive wavelet-based image characterizations is proposed in [10]. The wavelet basis was tuned to maximize the retrieval performance in a training dataset. A different wavelet basis is used to characterize each query image. A regression function, tuned to maximize the retrieval performance in the training dataset, is used to estimate the best wavelet filter, in terms of expected retrieval performance, for each query image. In [11] a pixel-based classifier that integrates multiple feature extraction methods in order to identify the regions of an input image that...
Content-Based Image Retrieval (CBIR). The problems of image retrieval are becoming widely recognized and the search for solutions is an increasingly active area for research and development. As more digitized images are collected, the number of multimedia computers increases, and networks became more predominant, large on-line databases (collections) of images and video become more popular. Those available resources have created a need for retrieving specific images from the image databases. So developing a user-friendly image retrieval system is more important in current scenario. A lot of research has been carried out on Content based image retrieval (CBIR) in the past decade. The goal of CBIR systems is to return images that are similar to a query image. Such systems are designed to retrieve images using low-level perceptual features like color, shape and texture. The overall similarity of a query image with database images. Due to rapid increase in tremendous amount of digital image collections, various techniques for storing, retrieving images have been investigate in recent years. The traditional approach to image retrieval is to annotate image by text and then use text based data base management system to perform image retrieval. The image retrieval systems are computed with basically the content features of the image namely color, shape and texture. The color-based information are considered as the referencing index in this paper and the spectral variation for the color information is computed using discrete wavelet transformation technique. DWT are found to be very efficient approach is extracting the frequency information from the image information based on the input information. Where the resolution information was passed as additional information for retrieval in past, the incremental in the feature count result in computational complexity improvement. To achieve the objective of image retrieval, the operation is performed in two operational stages, training and testing. A Basic operational architecture for such a system is shown in Fig 1.

II. PATTERN RECOGNITION

The developed pattern recognition systems are basically designed on the process of CBIR. The problems with conventional methods of image indexing have led to the rise of interest in techniques for retrieving images on the basis of automatically-derived features such as color, shape – a technology now generally referred to as...
The samples are preprocessed for filtration, resizing and data precision. The pre-processed sample is then processed for feature extraction.

III. WAVELET BASED FEATURE DESCRIPTOR

In the process of feature extraction process, the images are processed with a bank of filters aligned on a pyramidal mode, wherein pass filters results of high and low are cascaded to obtain the basic description of spectral information. This approach of feature extraction is referred to as wavelet feature extraction. The discrete wavelet transform is a very useful tool for signal analysis and image processing, especially in multi-resolution representation. In image processing, it is difficult to analyze the information about an image directly from the gray-level intensity of image pixels. The multi-resolution representation can provide a simple method for exploring the information about images. The two-dimensional discrete wavelet transform can decompose an image into 4 different resolutions of sub-bands. Those sub-bands include one average sub-bands and three detail component sub-bands. Detail component sub-bands represent different features for an image. Wavelets \( \psi_{a,b}(x) \) are functions generated from mother wavelet \( \psi \) by dilations and translations.

\[
\psi_{a,b}(x) = \frac{1}{a} |a|^{-1/2} \psi \left( \frac{x-b}{a} \right)
\]

The basic idea of wavelet transform is to represent any function \( f \) as a superposition of wavelets. Using weighting coefficients, the wavelet can be decomposed as an integral over a range \( a \) and \( b \) of \( \psi(x) \). In a multi-resolution analysis, a scaling function \( \phi(x) \) is employed to process the multi-resolution. The wavelet get decomposed into \( a_{m,n} f(x) \) called as approximate coefficients of \( a_{m,1} \) and \( c_{m,n} f(x) \) termed as detail coefficients of \( a_{m,1} \) using a low-pass and a high-pass filter in cascade. The two-dimensional decomposition is carried out by the combination of two one-dimensional decomposition of wavelet transform. Two-dimensional discrete wavelet transform can be achieved by two 1-D DWT operations performing operations isolately on rows and columns. Firstly the row operation is performed to obtain two sub-bands by using 1-D DWT, one low-pass sub-band (L) and one high-pass sub-band (H) as shown in Fig 4. The 1-D DWT image is transformed again to obtain four sub-bands by another 1-D DWT operation. Fig 4 shows the filter bank realization for the decomposition process of a 2-D DWT operation. The LL sub-band represents the approximate component of the image and other three sub-bands (LH, HL and HH) represent the detail components. This is a non-uniform band splitting method that decomposes the lower frequency part into narrower bands and the high-pass output at each level termed as detail coefficients are left without any further decomposition. This procedure is done for all rows. Next, the filtering is done for each column of the intermediate data. The resulting two-dimensional array of coefficients contains four bands of data, each labeled as LL (low-low), HL (high-low), LH (low-high) and HH (high-high). A high wavelet coefficient (in absolute value) at a coarse resolution corresponds to a region with high global variations. The idea is to find a relevant point to represent this global variation by looking at wavelet coefficients at finer resolutions. A wavelet is an oscillating and attenuating function with zero integral. We study the image \( f \) at the scales of \( 1/2, 1/4, \ldots, 2^j, j \in \mathbb{Z} \), the resolution decomposition of the color feature reveals the color feature variation of the image. A Generic pyramidal decomposition architecture is been suggested for the spectral decomposition as shown,

These spectral bands are processed to compute features using different feature descriptors such as the mean, standard deviation, entropy, energy etc. However all these features are extracted over the total extracted bands which are very random in distribution. Each of the variation in a distribution results in variation in the feature values. Hence in the process of obtaining a linear feature value a normalization process is proposed.

IV. NORMALIZED SINGULAR FEATURE (NSF) DESCRIPTOR

The spectral bands of the wavelet filtration process have large spectral variations at a very nearby region. A spectral plot for a spectral band for a wavelet coefficient illustrates the variation, as shown in Fig 3.

These spectral variations suppress the lower spectral coefficient and with it the information’s content into the band is also suppressed. Hence these variations if normalized to a common scale could result in proper...
feature description. To develop the stated approach a normalization process over a singular feature is proposed. The proposed method is as outlined. For the obtained spectral bands a process of singular value decomposition (SVD) is carried out. This transformation transform the obtained bands to eigen space which derive the variations in the obtained bands. In the process of SVD transformation, the band B, is decomposed into a singular matrix observation, where the variations are represented by a diagonal matrix. The SVD of an N×N band matrix has a decomposition form;

\[ F = U \times S \times V^T \]

Where ‘U’ and ‘V’ are N×N orthogonal matrices and ‘S’ is a N×N diagonal matrix here ‘S’ diagonal elements represents the variation in the given coefficient. The variations for this coefficient is a non-linear distribution. This non-linearity is minimized by amplifying the ‘S’ matrix by a Norm parameter ‘\( \gamma \)’. To achieve the amplification a Norm to the normalized Singular matrix is made defined by;

\[ B = U \times S' \times V^T \]

called the Normalized singular feature (NSF) representation. Where this Norm parameter ‘\( \gamma \)’ is varied in the range of \( 0 \leq \gamma \leq 1 \). This range of value linearizes the ‘S’ matrix to one common level. The singular normalization when applied back to the band coefficient results in normalized band variations. The normalized bands are then process for feature descriptors. As the variations are linearizes to a common scale, the obtained features are linear in scale and any variation in the input observation will only effective to the feature rather to the band information. These features are then processed for classification, in the classification phase, the features are extracted from the test sample x using the proposed feature extraction algorithm, and then compared with the corresponding feature values of all the classes k stored in the feature library using the distance vector formula,

\[ D(M) = \frac{1}{N} \sum_{j=1}^{N} [f_j(x) - f_j(M)]^2 \]

where, N is the number of features in \( f_j(x) \), where j represents the jth feature of the test sample x, while \( f_j(M) \) represents the jth feature of Mth class in the library. The test is classified using the K-nearest neighbors (K-NN) classifier. In the K-NN classifier, the class of the test sample is decided by the majority class among the K nearest neighbors. A neighbor is deemed nearest if it has the smallest distance in the feature space. In order to avoid a tied vote, it is preferable to choose K to be an odd number. The experiments are performed choosing K=3. The classification of the feature vector is performed based on the Euclidian distance approach. For a given test image \( T \sim cR^{xos} \) is transformed into a feature matrix \( Y \sim cR^{xos} \). For the computed feature the distance between a test image \( T \) and a training images \( X_i^{(j)} \) is calculated by \( R_{ij} = \delta(Y, X_i^{(j)}) = |Y - X_i^{(j)}| \), using a Frobenius norm. From the Retrieve top 8 subjects of the database according to the rank of \( R_{ij} \) given by \( \arg \text{Rank} \{ R_{ij} = \delta(Y, X_i^{(j)}) \leq \gamma \} \leq 1 \). The image with the highest Rank is declared as the recognized image. For the evaluation of the image retrieval a performance analysis is carried out for spatial similar images and compared with the conventional retrieval system.

V. EXPERIMENTAL RESULTS

To evaluate the process of proposed normalized feature descriptor logic, a test analysis is carried out over different orientation test samples. These test samples were processed from coil-100 [16] data set. The data set is formed with various orientations of a test sample. Few samples of this data set is as shown in Fig 4.

![Fig 4. Database samples from coil-100 Dataset.](image)

To evaluate the process of normalized feature processing a test sample with different orientation is passed to the developed system. The obtained observations for the developed system is as illustrated below.

Sample I: Sample with 0° orientation

![Fig 5. Original Query sample at 0° orientation](image)

A selected test sample for the recognition process is shown in Fig 5.

![Fig 6. Top 4 classified sample using Normalized-Singular Feature Descriptor](image)
When applied with orientation it is observed that the features are extracted from the normalized bands hence the feature variation due to spectral orientation is not effective, as these bands are normalized to a uniform scale. However this variation is retained in wavelet based feature descriptor hence the classification process is affected.

Sample II: Sample with 15° orientation

The test sample is oriented by 15° orientation, and passed as a query sample to the developed system. The features are extracted using conventional wavelet bands features and normalized feature bands. Using theses feature bands, recognition process is carried out using K-NN classifier as outlined in section 4. The obtained results of the classified observations are illustrated in Fig 10.
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An analysis is carried out for different test samples at different orientations. The test result for these samples is outlined in Fig 17.

Fig 17. observations obtained for different test samples at 0, 15, 45\(^{\circ}\) orientations

CONCLUSION

A process of pattern recognition based on a normalized singular feature descriptor for wavelet based feature descriptor is defined. In the process of feature extraction, the randomly scattered spectral coefficients are processed using a spectral feature singular normalization process. The feature description to such proposed coding is as normalized to a uniform scale, the retrieval accuracy of such system is observed to be improved in comparison to conventional recognition system.

REFERENCES


AUTHOR PROFILE

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