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Empirical Study of DWT and FFT Techniques to Extract Intensity Based Features From the Images

Diksha Soni[1], Yogesh Kumar Gupta[2], Savita Dubey[3],

[1]Department of Computer Science, Banasthali Vidhyapith-304022, Jaipur, Rajasthan (INDIA)
[1]dikshasoni509@gmail.com
[2]Department of Computer Science, Banasthali Vidhyapith-304022, Jaipur, Rajasthan (INDIA)
Yogeshgupta1005@gmail.com
[3]Department of Computer Science, Banasthali Vidhyapith-304022, Jaipur, Rajasthan (INDIA)
Savi16dubey@gmail.com

Abstract:-*To capture the visual essence or context of any image is known as process of feature extraction which represents the transformed raw image in reduced dimensionality form. However in our paper, we have reviewed several global and local feature extraction techniques such as for CBIR system based techniques, parallel extraction techniques for large scale medical images (MRI, CT Scan Images), linear and non linear techniques for low dimensional and high dimensional etc. in order to reduce the dimensionality. To handle such challenging task, some researchers recommended many techniques for the purpose of extracting the features of image data. So as to reduce more dimensionality and time complexity, here in our paper we have only shown the empirical study of DWT and FFT which extracts the wavelet and frequency coefficient vectors so as to offer the information about intensity based features. The analysis results are concluded in the end with the purpose of showing the performance level for feature extraction through both the techniques.*

Key Word: Intensity Feature, DWT, FFT

1. Introduction:

In the region of Image Processing and Pattern Recognition the image exploitation is the term that is frequently used which may encourage image features exponentially. In broad-spectrum, image analysis aims to analyze the spatial context and automatic extraction which distinguish the spatial features for the purpose of further awareness business [1]. In this world of 21's century the call for multimedia retrieval has amplified with the recent explosion of multimedia enabled systems [2]. This image manipulation from these systems may need to include some important properties or operation to perform over them such as: enhancement of image quality, filtration, segmentation, preprocessing, feature selection or extraction and classification.

Since there is no comprehensible definition of what is a feature but to have a "Point of Interest" in any image, collected from the external or internal sources for the purpose of full image description defines it roughly. The properties of good features which we would likely to have in any images includes: perceptually meaningfulness, identifiable on distinct images, insensible to noise, analytically special, invariant towards certain kind of transformation etc. [11]. As a result of mounting population and enduring demand intended for improved medical care, the need of CAD (Computer Aided Diagnosis) systems in radiography is fetching increment regularly which may possibly direct to more consistent and reliable diagnoses by providing precise measurements [3]. Image pattern recognition, evaluation and implementation are the three phases incorporated in the design of CAD systems where the pattern recognition problem is well intended to consisting of three key steps such as: preprocessing, feature selection or extraction and classification.

The extraction of feature is the procedure of transformation of any original image or generating spatial features so as to be used for classification task. From the above three mentioned activities the feature extraction is the most critical part as the best selection of feature set can influence the higher accuracy and reliability in classification i.e. the performance of classification phase significantly influenced by feature extraction stage [2, 14].

The purpose of our study is to focus on various feature extraction techniques which have been found practical for pattern recognition and processing of radiographic images. The feature extraction techniques aim to mine the precise and application-dependent information from the object image.

2. Literature Review:

Manojbhai D.D, Rajamenakshi R. (2016). "Large Scale Image Feature Extraction from the Medical Image Analysis", the paper focused on the comparative and generic review of feature extraction techniques through both parallel and non parallel computing which is used to mine the main features from the medical images without affecting its robust performance parameters that is again proven as a challenging task through the intelligent analytics techniques in healthcare [1]. To solve the problem with the large scale image processing they reviewed some scalable analytical algorithms and models in order to get high performance utilizations in favor of efficient diagnosis. The challenges occurred in the image processing can be focused as their future work.

Mane A.S, Kulhalli K.V. (2015). "Mammogram Image Features Extraction and Classification for Breast Cancer Detection", presented some techniques for feature extraction and classification of medical image using digital mammography which is most reliable way to detect the breast cancer. Initially they proposed some advanced preprocessing techniques that provide accuracy in mammographic images of breast cancer. Secondly to extract the optimum feature set, they suggested about the Gabor Wavelet function which is considered as a well suited method for feature extraction [2]. According to them the best selection process of feature sets is crucial for having higher accuracy and reliable classification.

Eqbal S, Ansari A.M. (2015). "Medical Image Feature Extraction for Computer Aided Diagnosis of Lung Cancer", presented numerous and distinct approaches for the idea of cheer the computer aided diagnosis in healthcare to detect the lung problems. Here in this paper they reviewed some of the emerging techniques for the detection of lung nodules (whether they belongs to benign or to malignant) [3]. For the stage categorization detection of different normal and abnormal tissues has to be reviewed by them. They focused on the development of the CAD systems in the medical image processing. As a future work they paid attention over the imaging protocols and CT image reconstruction algorithms for the prospect prediction of lung tumor [3].

Zhou S.X, Cohen I, Tian Q, Huang S.T. (2013). "Feature Extraction and Selection for Image Retrieval", introduced a revised approach which is an edge based structural feature extraction technique. According to them the scope of the paper centralized on two approaches: one of them is perceptron centered and second one is machine centered approach [4]. The researchers proposed a novel feature set from the PFA (Principle Feature Analysis) through which they got better results as compare to the random sets generated from the PCA (Principle Component Analysis) and multivariate linear discriminate analysis.

Rajaei A, Rangarajan L. (2011). "Wavelet Feature Extraction for Medical Image Classification", in their proposed work they extracted wavelet features of medical images which are belongs to various modalities. They used Discrete Wavelet Transform for the decomposition of medical image. After computing the mean and standard deviation of the extracted features they fed them as an input to the K- Nearest Classifier for classification, and as results they efficiently found 99.96% accuracy through DWT than DCT [5]. As a future work they will work on another novel approach to reduce the dimensionality and time complexity.

Chadha A, Mallik S, Johar R. (2012). "Comparative Study and Optimization of Feature Extraction Techniques for Content Based Image Retrieval", the comparative study of several feature extraction techniques based on CBIR systems have been reviewed individually with their results such as Average RGB, Color moments, Co-occurrence, Local and global color histogram, Geometric moment [6]. To get the improved and efficient results they proposed an efficient combination of these techniques which provided better results shown in the paper. They suggested an idea of cropping the image which enables the user to identify the region of interest to refine the image retrieval results. They concluded the paper as their future work by providing the idea of integration of the system with the powerful relevance technique [6].

Rinky B.P, Mondal P, K Manikantan S Ramachandran. (2012). "DWT Based Feature Extraction using Edge Tracked Scale Normalization for Enhanced face recognition", this paper presented a new approach for improved rate in face recognition systems. They proposed ETSN process which performed edge detection (as a preprocessing) along with the use of scale normalization to remove the background details. In their paper DWT is used for wavelet feature extraction followed by BPSO (Binary Particle Swarm Optimization) as a feature selection technique [7]. As a classification technique they used Euclidean classifier. They found the efficient results by their proposed technique. In the end they recommended the SVM classifier and Gabor wavelet for better performance considerably.

Mandloi G. (2014). "A Survey on Feature extraction Techniques for Color Images", authors reviewed some color feature extraction techniques based on Text based

and content based image retrieval systems. The paper focused on canny edge detection technique proposed by John F. Canny (JFC) in 1986 [8]. Additionally they have presented few feature vector estimation techniques such as: Grid color moment, Canny Edge detection, Gabor filter and wavelet and local binary pattern, which are commonly used for new color feature recognition [8]. They found useful these techniques for clearer and efficient edge detection.

Tian P.D. (2013). "A Review on Image Feature Extraction and Representation Techniques", since the extraction ideal features from the image is still a problem from the last decades, through this paper authors focused on comprehensive study of feature extraction and representation techniques which are based on CBIR systems. The combination of global and local feature using some classic models has been also illustrated in the paper [9]. They discussed some interesting issues which needed to be solved as their future work such as exploring the relationship between feature number or representation and their initial performance is a challenging issue especially in case of block based and region based [9].

Balasubramanian C, Sudha B. (2014). "Comparative Study of De-noising, Segmentation, Feature extraction, Classification Techniques for Medical Images", the various preprocessing, segmentation, features extraction and classification techniques are reviewed in this paper. To extract the tumor region from the MR brain image and to get the clear or smooth vision of edges they used non-linear filters as preprocessing [10]. According to them co-occurrence matrices are well appropriate for extraction of statistical features seeing as it deals with pixel co-occurrences. But for texture features these matrices are not good so they can improve their results probably in future [10].

3. Feature Extraction Techniques:

Between the series of stages involved in pattern recognition systems, the two phases which affects the general design and recital of the system are: feature extraction and classification [15]. Here in our paper we focused on the extraction techniques that affect the classification stage. Generally to express the property of any pattern, the number of feature sets is chosen which determines about the dimension of original feature space (also known as sample space of image). The collection of finest feature sets from the background of the inappropriate facts for the purpose of dimensionality reduction considered as crucial issue in the pattern recognition and artificial intelligence [22]. Feature extraction is also considered as an important research area in image processing which is supplementary hitch and area dependent [15]. The problem arises with the high dimensional sample space (when the sample space is small). The aim of this extraction of discriminatory and significant information is to reduce the sample space in high dimensional before the classification stage [23]. This occurred problem in the high dimensional space can be handled by the linear feature extraction methods which provide the good performance and reliability and yield time consumption and reduction in memory. The worst effect of curse of dimensionality may also alleviated by the stage of feature extraction. Basic set of image features that can be extracted from extraction techniques are given below in the table [1].

Table-1: Image Features with Their Properties

Image features	Properties
Color based feature	RGB, LUV, HSV and HMMD [9,20], Color features such as: Color histogram, Color moments, Color coherence vector (CCV), Color Correlogram [20].
Texture features	Spectral and spatial [17,20],Contrast, Correlation, Homogeneity, Sum of square variance [16].
Shape based features	Area, Roundness, Circularity, Irregularity, Perimeter [16].
Intensity features	Mean, Median, Skewness, Intensity, Standard deviation, Variance, Kurtosis, entropy and energy [17].

On the basis of various set of features, there are number of techniques for extraction purpose mentioned below, some of which are explained in next section.

3.1 Color Features:

In image processing and retrieval, color is measured as one of the most relevant features which are subject to define a particular color model or space. After the selection of the color space model mentioned in the above table, any color feature can be extracted through the most common extraction method (i.e. color histogram, color moments) [12].

3.2 Texture Feature:

The extraction process of texture feature is robust technique for the images which have repetition section. On the basis of field, the texture feature is extracted, theses feature are of two types: spectral and spatial texture feature [9]. As according to the researchers the Gabor

wavelet and Gabor filter applied through the Gabor wavelet transform has been widely used for texture feature extraction [9].

3.3 Shape Features:

For the purpose of real world object recognition and identification the shape feature is an important clue. Contour based and Region based shape feature extraction methods are the two broadly classified techniques which formerly calculates the shape feature from the boundary of image by ignoring its interior and later methods is used to extract the shape feature from the complete region [12].

3.4 Intensity Features:

The intensity measurements from the images are extracted as absolute values. On the basis of these absolute values, intensity features are recognized. These intensity features are related to the intensity values of the pixels in the images. The considered intensity features for our study are:

Mean: an average value.
Minimum Energy: lowest energy value obtained.
Maximum Energy: highest energy value obtained.
Minimum Amplitude: lowest value of amplitude.
Maximum Amplitude: highest value of amplitude.
Variance: the average of squared distance from the mean.
Average Frequency: average value of frequency in the terms of power spectral density and frequency vector.

4. DWT (Discrete Wavelet Transform):

Discrete Wavelet transform is a well known wavelet transform intended for feature extraction, which produces a multi-resolution image for interpretation of image information (i.e. information about time and frequency etc.).

In DWT, extraction of characteristics form the signal has taken place which is based on its position and scale, scheduled by successive low pass and high passes filtering. After applying DWT, the global and rough approximation description is hold by the low pass filtering (i.e. low frequency content of the image) while the high pass filtering yields the finer or detailed description (i.e. edge information) of the original image. The approximation description facilitates high scale, low frequency coefficient, on the other hand detailed description provides low scale, high frequency coefficient [18]. Generally low pass filtering and high pass filtering is used to extract wavelet coefficient which are function of position and scale. These obtained coefficient represents the correlation of wavelet with its picky section of image (i.e. how close the wavelet correlate with its image section).

Fig-1: (Decomposition through Wavelet Transform) [26]

Basically the feature extraction using DWT consists of:

1. Using filtering and decimation, decomposition of selected image or signal into N level to obtain the approximation and finer coefficient.
2. By using DWT coefficient, extraction of features.

Depending upon the different types of wavelets (such as: HARR transform, Bi-orthogonal and inverse Bi-orthogonal, Symlet etc.) DWT is categorized into two types: 1D-DWT and 2D-DWT [18]. To obtain the vector coefficient, in 1D-DWT the image is reformed where filtering is only done in one direction. 1D transform yields the two components such as approximation coefficient (known as cA) and detailed coefficient (known as cV) while the 2D-DWT generates 4 sub-bands and obtained from two detach 1D transforms in both directions (i.e. horizontal and vertical) [7, 19]. To extract the edge localized information from the detail coefficient sub-bands, the approximation coefficients are decomposed further the formation of 2D transform. As depicted in the above diagram of 2D-DWT the decomposition of image into 4 separate sub-bands named as LL, LH, HL and HH. These sub-bands also known as cA, cV, cH and cD subsequently [7, 19].

Fig-2: (Original Image) [27]

Fig-3: (1 level DWT) [27]

Fig-4: (2 level DWT) [27]

This multi-level decomposition of transformed image allows the extraction of both large and small sets features such as: mean, energy (maximum & minimum), variance, maximum & minimum amplitude, frequency (average, mid, maximum & minimum) etc.

5. FFT (Fast Fourier Transform):

Generally FFT is used for driving the frequency coefficient i.e. features from the frequency domain while DWT is used for extracting the wavelet coefficient from the time and space domain. Fast Fourier transform is the extended version of DFT because of its less time computation property [19, 23]. In Spatial domain any image is defined in the terms of intensity or grayscale value (i.e. by its location or its position in space), so to represent the each image channel in its amplitude form where its amplitude values are stored in X, Y frequencies (i.e. in frequency domain) DFT is used which nevertheless not only transforms the spatial domain into frequency domain but vice-versa is also possible (only to extract the frequency features or components). The sequence of DFT and the inverse is performed by FFT by ignoring the transparency. FFT is well known algorithm for extracting the features so as to avoid the property of replication that cannot be hold by FT, for this reason FFT is implemented which reorganize the computation of FT components for improving the speed noticeably [23,25]. Separability property comprised into two stages: firstly rows are transformed using 1D-FFT and secondly again the same data is transformed in columns (but applicable only for orthogonal functions). After applying the FFT, the position of each and every component reflects its frequencies as results. As shown in figure low frequency components (i.e. for 0 frequencies) placed as centered components while high frequency components are further away in the form of edges.

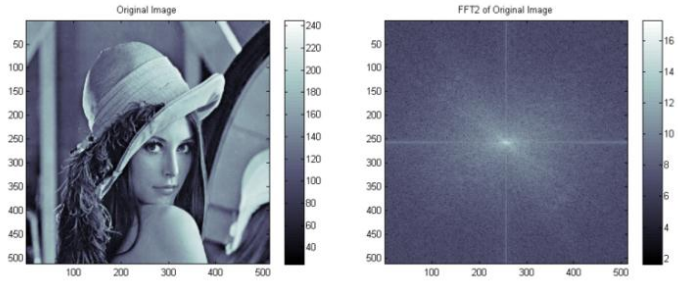

Fig-5: (2D-FFT) [28]

This results of transformed image allows the extraction of frequency features such as: mean, energy (maximum & minimum), variance, maximum & minimum amplitude, frequency (average, mid, maximum & minimum) etc. [23].

6. Conclusion:

To pick the potential, it is mandatory to utilize the high performance solution in image processing. Regarding this context our paper presents a generic review over some existing feature extraction techniques such as DWT and FFT. As results are vary from domain to domain, however we found that performing the DWT over the specific data images (Hyperspectral data) provides superior results as other techniques such as FFT as it only consider the frequency components. While in the context of some dynamic activities FFT outperformed the DWT. On the basis of analysis study we found that applied DWT results gives better classification accuracies as it also includes the localization property and for frequency and time domain information FFT is well matched. Both the techniques are suitable for extraction of the intensity based features, which provides as frequency content as well as the localized information of any image.

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