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QUANTITATIVE APPROACH TO EXTRACT FEATURES FROM THE MEDICAL IMAGES USING 2D-DWT

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Abstract: In this world of digitized era there is immense need of image processing which manipulates the image information for analysis purpose. Any image can be characterized by its feature sets, which demonstrate the detailed information of the images and enhance their visual interpretation. To capture the visual essence or context of any image, the process is identified which is known as feature extraction which represents the transformed raw image in reduced dimensional form. For handling such challenging task and to reduce the time complexity the purpose of our paper is to concentrate on one of the feature extraction techniques (Discrete wavelet Transform) which are useful for defining the spatial or localized information of the data. We have shown the experimental results by performing the 2 Dimensional-DWT over the sample medical data which extracts the wavelet coefficient vectors so as to offer the information about some Statistics features using MATLAB.

Keywords: 2D-DWT, Statistics features, Daubechies wavelet, Medical Image, Histogram.

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 in business [12]. In this world of 21's century the call for multimedia retrieval has amplified with the recent explosion of multimedia enabled systems [15]. 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. [14]. 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 [15, 3]. 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. But before feature extraction from any image, the preprocessing is considered as a mandatory step for area of any image based application. Preprocessing step needs to involve filtration, scaling, conversion from RGB to gray scale and enhancement etc. which is more effective step in order to have promising results. In accordance of our paper this preprocessed data is then followed by feature extraction using wavelet transform whose concept is directly related to multi resolution applications [2]. Wavelet transform helps in providing the time & frequency representation of any signal. From the basic discrete wavelet transform we couldn't get the desired results as it provides the features through the approximation sub-band [as suggested by D. jude Hemanth, Hiremath in 2006] [7]. So to get the superior results 2D-DWT is suggested for extraction which provides features more efficiently from all the 4 sub-bands. Using this technique approximation and detailed coefficient is to be interpreted which are being used for further selection and classification process. As according to the Lori Mann Bruce et. al., 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. On the basis of analysis study they found that applied DWT results gives better classification accuracies as it also includes the localization property.

2. LITERATURE REVIEW

For revealing the hidden patterns, the process of research into the complex data analytics basically concerned with different feature extraction techniques. According the Daniel to expand a signal or any function in wavelet domain, he found that wavelet transform is suitable one: as with other transforms the goals of expansion of signal couldn't reach its apparent results (usually from the signal present in its original domain). To reduce the dimensionality and time complexity in the medical images collected from the various image modalities techniques, A. Rajaei and Rangarajan L in 2011 suggested a proposed work using DWT for feature extraction followed by K – nearest classification. As they used DWT for the decomposition of medical images, in their resulted work they found 99.96% efficiency through DWT than DCT [11]. Rinky B.P, Mondal P, K Manikantan S Ramachandran in 2012 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 [8]. To get the better performance they used Gabor wavelet in their proposed work identified for FR systems. To extract the invariant features for face recognition Vidya V, Nazia F, K Manikantan, S Ramachandran in 2012 suggested a novel approach known as Selective Illumination Enhancement Technique. They proposed a combination of SIET for illumination normalization and DWT for feature extraction which exhibited better performance even for pose disparity in face [9]. For the enhancement of local details present in image, Huang W, Z. Wei, W. Jun and S. Zebin in 2015 proposed an implemented novel idea of using CLAHE-DWT technique to overcome the problem of contrast overstretching and noise enhancement. Contrast limited adaptive histogram equalization with DWT alleviate the noise enhancement problem by averaging the reconstructed and original image in the end using their proposed weighting factor [1]. To enhance the clinical analytical investigations for diagnosis purpose (especially for Mycobacterium Tuberculosis) S. Saini, L. Dewan, in 2016 high lightened the strength of DWT which provides the graphical depiction of wavelet coefficient. This representation defines the similarity between the diverse sequences of MTB. Researchers have proven this method faster than the existing conventional techniques used for diagnosis in real time because it also calculates the energy of wavelet decomposition coefficient [5].

3. CONCEPTUAL PROCESS OF 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.). 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 [9]. 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). The intact route is computed by a binary tree structured representation with its corresponding nodes known as filter bank figured as below:

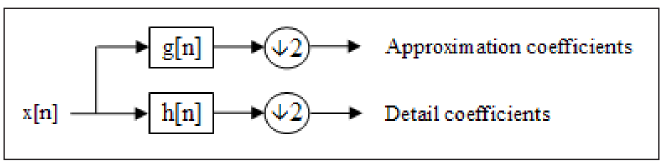


Figure 1: (a) Block diagram of Filter Analysis Bank: Divides the signal into coarse and detailed coefficient using low pass and high pass filter [25]

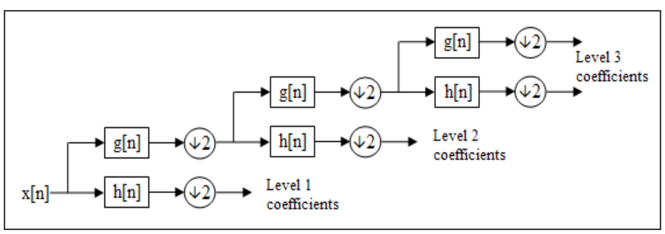


Figure 1: (b) Block diagram of Filter Analysis Bank: Divides the signal into series of coarse and detailed coefficient using low pass and high pass filter [25]

Generally to compute the DWT of any signal x for the purpose of having the coefficient vectors, the process of Filter Analysis bank is followed which is used to pass this signal through various series of filters. Firstly, the signal is passed through low pass filter with the g Impulse response function which is resulted in convolution of two and provides the Approximation coefficient. On the other hand same signal is passed through the high pass filter and provides the detailed coefficient. The iteration is repeatedly followed by applying the process on approximation coefficient i.e. this decomposition is recurring to augment the frequency resolution. After all decomposition process, the signal present in the wavelet domain needs to be reconstructed in its original domain, which is achieved by synthesis filters and expanders.

A. 2D-DWT (Discrete Wavelet Transform)

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 [9]. To obtain the vector coefficient, in 1D-DWT the image is reformed where filtering is only done in one direction.

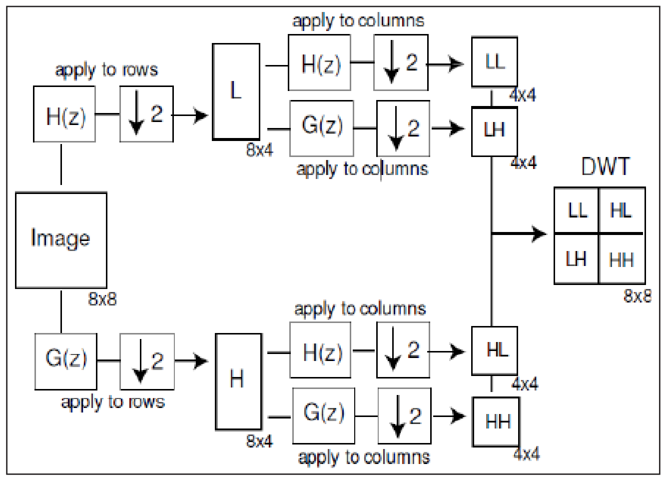


Figure 2: Block diagram of 2D-Discrete Wavelet Transform for 8 × 8 sample image [6]

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) [8,10]. At a time, it is operated only in one direction by analyzing the rows and columns of an image (in a separable manner). Analysis filters are applied firstly to the rows that produce 2 new images. Particularly one of the 2 images is a group of approximation coefficients and another one is a set of detailed row coefficients [6]. Likewise another analysis filters are applied to the columns which are responsible for formation of 4 distinct images known as sub-bands. In the depicted Figure H is designated only when rows and columns are analyzed by a high pass filer, similarly reason behind the designation of L is only identified when both the rows columns are analyzed by low pass filter. To extract the edge localized information from the detail coefficient sub-bands, the approximation coefficients are decomposed further the formation of 2D transform. In 2D-DWT the both coarse or approximation coefficient and detailed coefficient are formed at diverse scales by recursively iterate the process of its approximation coefficient of each level.

As depicted in the diagram of 2D-DWT the decomposition of image into 4 separate sub-bands named as LL (which provides approximation image detail), LH (vertical details), HL (horizontal details) and HH (diagonal details). These sub-bands also known as cA, cV, cH and cD subsequently, where only LL sub-band is used for next level decomposition as it retains most details [8,10].

The decomposition in sub-bands shown in the Figure given below:

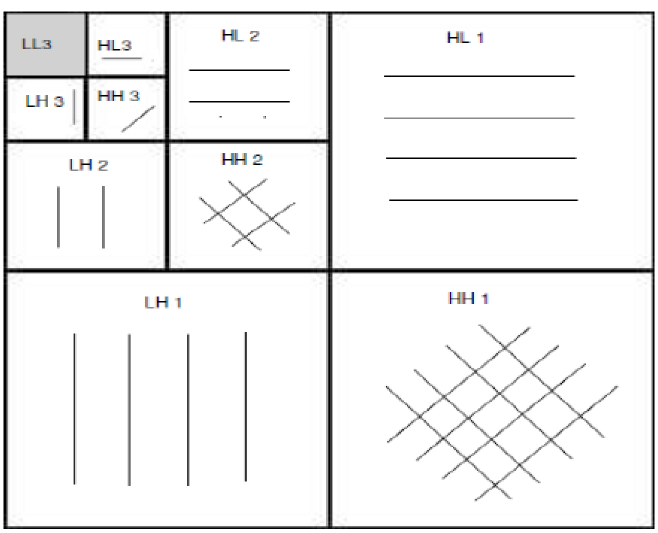


Figure 3: Decomposition of an image in approximation and detailed Sub-bands[25].

4. FEATURE EXTRACTION

The aim of this extraction of discriminatory and significant information is to reduce the sample space in high dimensional before the classification stage [24]. 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 [12].

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.

5. IMPLEMENTATION STEPS IN FEATURE EXTRACTION ALGORITHM

The following steps are involved in proposed algorithm of feature extraction using Discrete Wavelet Transform:

Step 1: Read the sample image.

Step 2: Apply preprocessing step on loaded images which converts the RGB image into gray scale image.

Step 3: The gray scale image data are decomposed into 4 sub-bands using one level Discrete Wavelet Transform which provides high frequency coefficient vector and low frequency coefficient vector.

Step 4: Create and display both the approximation and detail sub-bands from the 1 – level decomposition.

Step 5: Apply inverse wavelet transform over the retrieved coefficients to reconstruct image.

Step 6: 2nd level decomposition takes place to extract the local information by decomposing the approximation band from the step 4 into further sub-bands using Daubechies wavelet.

Step 7: Recreate and display both level 2 approximation and level 1 & 2 detail sub-bands.

Step 8: Repeat step 6 and 7 for level 3 decomposition.

Step 8: Display the resulted coefficients from where the entire detail band coefficient are chosen for analyzing and processing.

Step 9: Original image is reconstructed from the inverse transform.

Step 10: Some selected features are extracted in MATLAB environment by implementing corresponding formulae.

Extracted features: Max value, Mean value, Median value, Standard Deviation, Variance etc.

Mean:

$$\mu = \frac{1}{N}\sum_{i=1}^{N} A_i$$

Median: Middle value from the image matrix set.

Variance: the average of squared distance from the mean.

$$v = \frac{1}{N-1}\sum_{i=1}^{N} |A_i - \mu|^2$$

Standard Deviation:

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} (A_i - \mu)^2}$$

Step 11: The extracted features are then analyzed in the end for classification process.

The M-file program for 3rd level decomposition and feature extraction using DWT provides the results given in the tabular form.

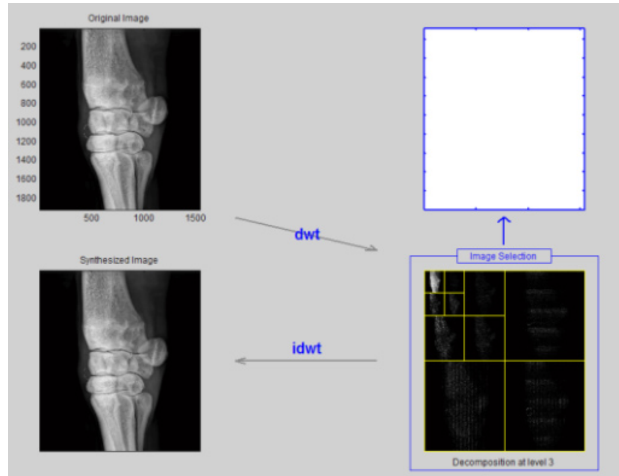
6. RESULTS AND DISCUSSION

A. Experimental Setup

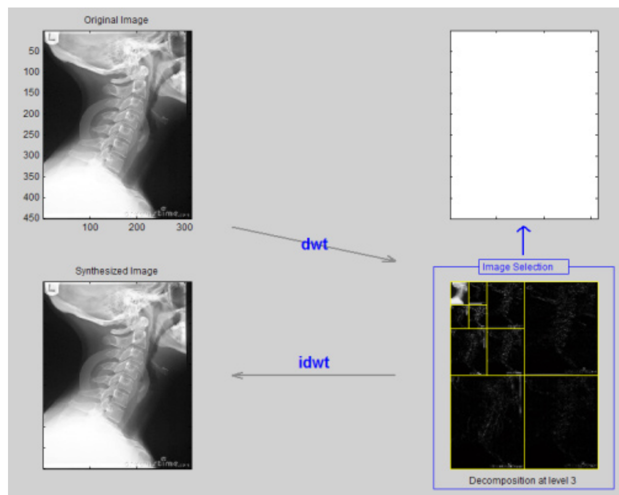
The experiment is done to display the results of 2D-DWT to extract some statistics features. For the this purpose we have taken 10-15 sample medical images from which here we have shown the results of only 3 images over which 2D-DWT is performed at 3 level and we got the following results as shown in Figure 4.

The results are shown with the help of MATLAB R2013a on Intel(R) Core(TM) i3 CPU 540 @ 3.07GHz processor, 4.00GB RAM and 64-bit operating system. Results may vary depending on the machine configuration.

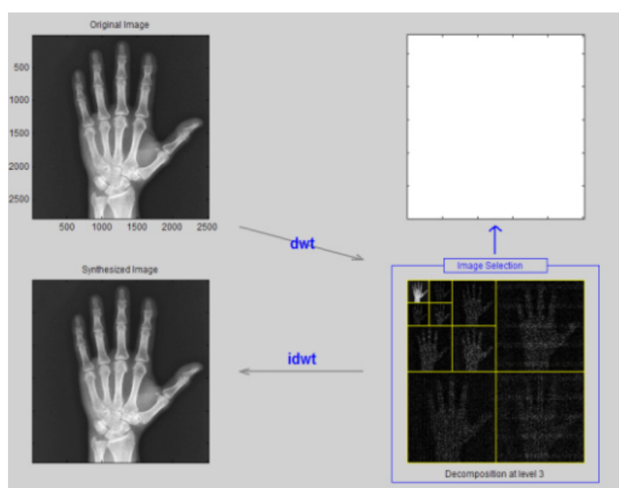
B. Results



(a) Knee Bone X-ray image



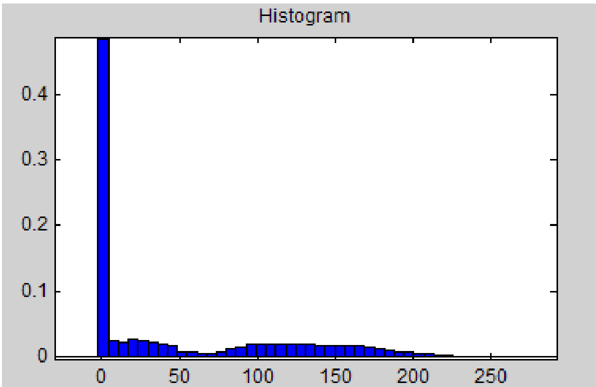
(b) Spinal cord X-ray image



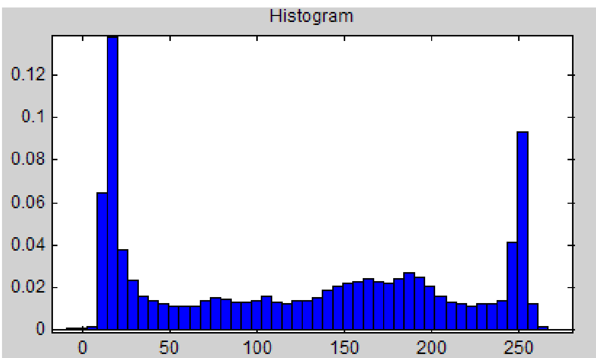
(c) Hand X-ray image

Figure 4: Sample Images after applying 2-D DWT and inverse DWT of level 3.

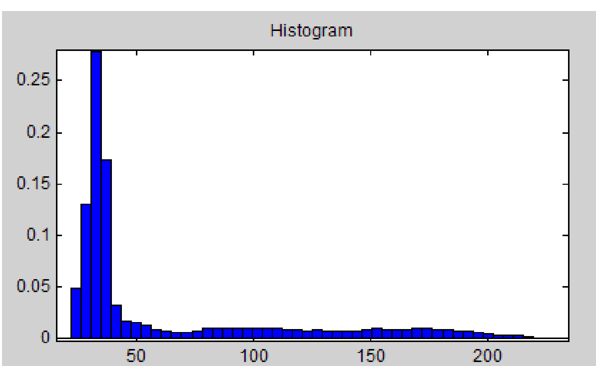
Analysis of histograms of approximated images at all 3 level is examined using MATLAB as shown in the Figure 5.



(a) Knee Bone X-ray



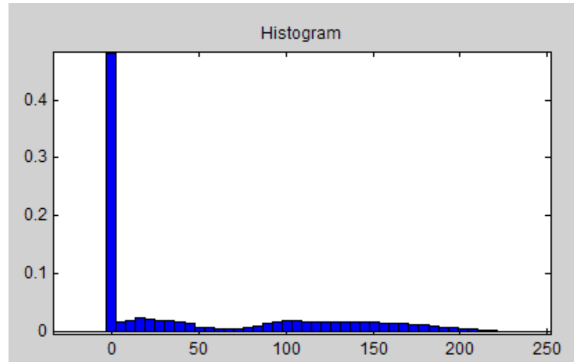
(b) Spinal cord X-ray



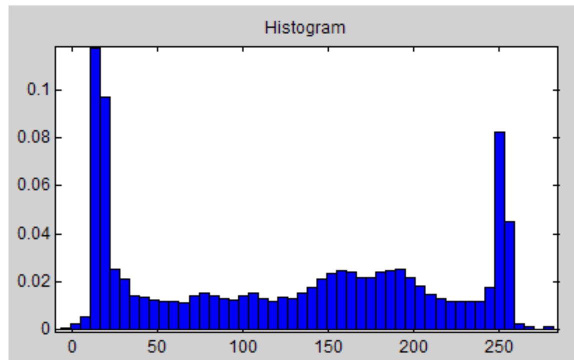
(c) Hand X-ray image

Figure 5: Histogram Obtained from 1st level Approximated Image

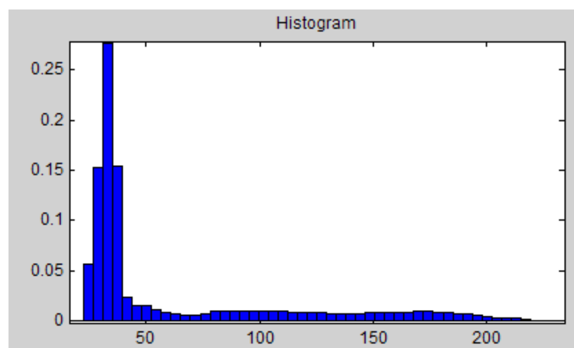
Table 1 shows the extracted feature values at level 1 for the 3 sample images which can be differentiated with the values shown in Table 2 and 3. Table 2 & 3 also shows some feature values as obtained from the all 3 approximated images at distinct level up to level 3.



(a) Knee Bone X-ray

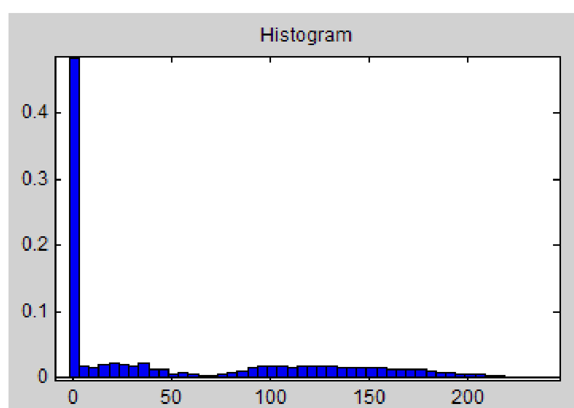


(b) Spinal cord X-ray

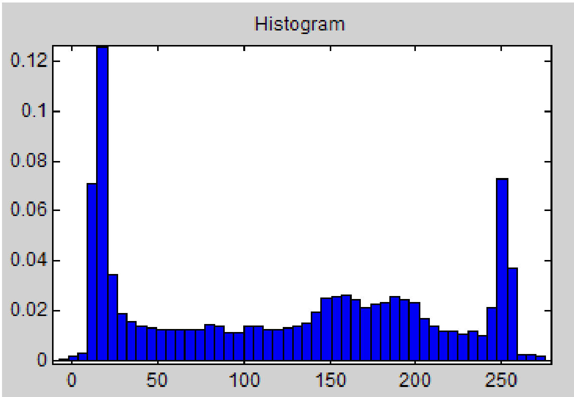


(c) Hand X-ray image

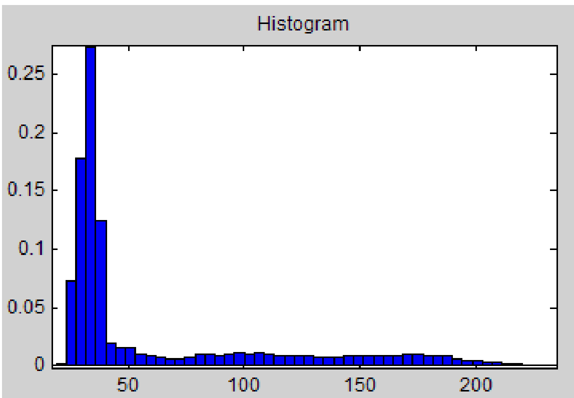
Figure 6: Histogram Obtained from 2nd level Approximated Image



(a) Knee Bone X-ray



(b) Spinal cord X-ray



(c) Hand X-ray image

Figure 7: Histogram Obtained from 3rd level Approximated Image

Table 1
Extracted Features from the Approximated Image at level 1

Features/Images (Approximation at level 1)	*Image 1*	*Image 2*	*Image 3*
Minimum	–27.31	–14.74	17.48
Maximum	289.1	278.4	232
Mean	51.46	126	62.13
Median	8.264	133.7	35.63
Standard Deviation	65.98	86.79	50.18
Median abs Dev.	8.264	86.77	5.865
Mean abs Dev.	58.16	77.64	40.37
Max norm	289.1	278.4	232

7. DISCUSSION

As we have reviewed the wavelet transforms are far better than the FFT and DCT, as wavelet based feature extraction provides around 20% overall accuracy than the FFT and DCT methods. DWT based on mother wavelets regularly outperformed both the other feature extraction techniques. As features extracted from DWT provides superior capabilities for any type of image processing application. The classification accuracy can be greatly achieved by variation of the mother wavelets. As HAAR is commonly used mother wavelet as it is easy to implement, but we have used Daubechies-4 wavelet which will probably provide the better classification accuracy. The following tables show, some feature for sample medical images which are extracted from the decomposition of images at 3rd level using 2D-DWT. These extracted features provide the localized information of the respective images that is being proved helpful in much medical imaging application to get the ROI.

Table 2
Extracted Features from the Approximated Image at level 2

Features/Images (Approximation at level 2)	*Image 1*	*Image 2*	*Image 3*
Minimum	–31.37	–6.502	18.19
Maximum	249	281.7	231.9
Mean	51.44	125.9	62.13
Median	8.39	134.7	35.59
Standard Deviation	65.71	86.48	50.14
Median abs Dev.	8.39	84.81	5.77
Mean abs Dev.	58.11	77.29	40.36
Max norm	249	281.7	231.9

Table 3
Extracted Features from the Approximated Image at level 3

Features/Images (Approximation at level 3)	*Image 1*	*Image 2*	*Image 3*
Minimum	–6.813	–7.745	19.07
Maximum	244.2	275.6	232.7
Mean	51.41	125.6	62.13
Median	8.248	136.3	35.57
Standard Deviation	65.42	85.44	50.09
Median abs Dev.	8.248	81.46	5.683
Mean abs Dev.	57.97	76.15	40.36
Max norm	244.2	275.6	232.7

As depicted from the tables, the clear difference is shown, that level 3 provides much efficient values than the level 1 and level 2. But some feature values vary for specific region at different level of approximation which shows the variation in histograms of approximated images.

8. CONCLUSION

To pick the potential, it is mandatory to utilize the high performance solution in image processing. Extraction of statistics features is one of the chosen parts which provide the immense solution. For the purpose of analysis we have taken 4 medical images and obtained the features by decomposing these sample images at level 3 using Daubechies-4 wavelet. The obtained histograms of approximated images of all level 3 have also been differentiated using MATLAB in the end. So as to get the more efficient future work or to get the 100% classification accuracy probably, the indented work will be performed by using the Daubechies mother wavelet of extended level.

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