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ANALYTICAL STUDY OF TRANSFORM BASED TECHNIQUES ON MEDICAL IMAGES

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Abstract

In medical image processing, recognition of disease on medical image using feature extractions of medical image is a challenging task. Several methods have been proposed by using transform based techniques in medical images for diseases detection, identifying hardwood species, biometrics, these applications could be great use of transform based techniques. Biomedical image processing is growing and widely acceptable field. Transform based techniques allow us to identify the smallest defect or abnormalities in human body image. The main objective of medical image processing techniques is to extract meaningful and accurate information from the images with minimum error [39]. In this paper presents an analytical study of features extraction using different transform based techniques by using simulated toolkit MATLAB wavelet analyzer at command line version of MATLAB R2019a, and also this paper deals with survey of segmentation techniques based on feature extractions techniques.

Keywords: Image Processing, diseases detection, medical image processing, feature extraction.

1. Introduction

Beghdadiet. al. (2013) proposed a medical image processing is an interdisciplinary scientific field that deals with the use of information and communication technologies and for clinical health care[1], for accurate and faster service to people. Interest in medical image processing area: improvement of pictorial information for human interpretation, and scene data for autonomous machine perception [2]. Sarode T. K et. al. (2016) proposed the cell detection bone narrow of first application of image processing techniques was used in improving digitized newspaper pictures sent by between London and New York[3]. The field of digital image processing has growing very rapidly [4]. In addition to application in medical field, biomedical image processing techniques now are used to solve a variety of problem. Sudarvizhi .D et. al. (2015) defines most of the problem in medical image processing requires method capable of getting information from biomedical image for human interpretation and decision support[5]. Jyotsna.N et. al (2017) in medicine, for instance, biomedical image processing to help enhance the capability of features extraction from X-rays, MRI and CT image and other biomedical image [6]. Medical practitioners use the same or similar techniques to study biological patterns from medical image [7,35,50].

Features extraction and pattern recognition procedures are used for solving medical problem [8, 35, 50]. Transform based methods are successful design , implementation and validation of complex medical system requires a good level of interdisciplinary collaboration between physician and engineer because poor image quality leads to problematic feature extraction, segmentation and pattern recognition in medical application [9, 35]. There is plenty of study has been proposed, till it is geared towards improvement of features extraction techniques and pattern recognition[10, 50, 35]. Transform based techniques which playing a leading role in the improvement of image quality, image compression and features extraction from medical image and interpretation in modern biomedical imaging area [11].

The application based on transform techniques is good tool for physician investigating a vast number of medical problems for which are better than other method [12]. Biomedical image analysis can be conducted through a highly intelligent cognitive process that requires special medical knowledge and experience [13]. It could not found any absolute technique which is fulfill to the medical image is for the highly intelligent investigating about medical image, but relatively low level features such as shapes, texture, and other pixel based statistics can be used for recognition [14]. In this paper we used different type of image like X-rays, MRI and CT on transform based techniques for features extraction simulated with the various proposed techniques by using MATLAB R2019a[15].

This paper is organized with the section 2 feature extraction methods, section 3 deals with the various segmentation techniques of medical images and section 4 ends with the conclusion and future enhancements.

2. Feature Extraction Methods

Feature extraction is the process of acquiring or gathering discriminating data from the image. In machine learning used sample cognizance and in image processing, characteristic extraction starts off evolved from a preliminary set of measured statistics and builds derived values (features) supposed to be informative and non-redundant, facilitating the subsequent getting to know and generalization steps, and in some instances leading to better human interpretations. Feature extraction methodologies consider objects and photographs to extract the most necessary features that are representative of the number training of objects. Feature extraction techniques are useful in various picture processing purposes such as photograph enhancement, noise disposing of classification, segmentation, detection, focus and evaluation of the clinical images.

2.1 Discrete Wavelet Transform [2, 3]

Gilbert B.K and Harris L.D (1980) present wavelet based disease recognition from medical image. Medical image contain component of different shapes and texture used in Nanni. L and Melucci. M (2016)[16]. With help of wavelet feature which is extracted from digital medical image develop disease detection system [17]. It is automatic disease detection system from medical image using discrete wavelet transform method [18]. There are several steps in the proposed method [19]. In this paper [20] discrete wavelet transform are used to extract feature from medical images from LL1, HL2, HH3, LH4, LL2 and LL3 extractions as shown in Fig.1 [15].

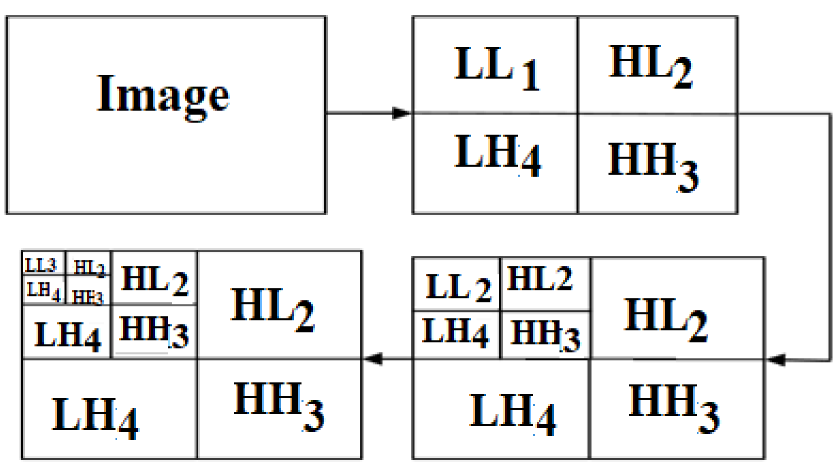

Fig.1: Block Diagram of Discrete wavelet Transform [2,3].

To simulate discrete wavelet transform by using MATLAB wavelet transform window has two dimensions 1-D, 2-D extractions and produce wavelets as shown Fig.2.

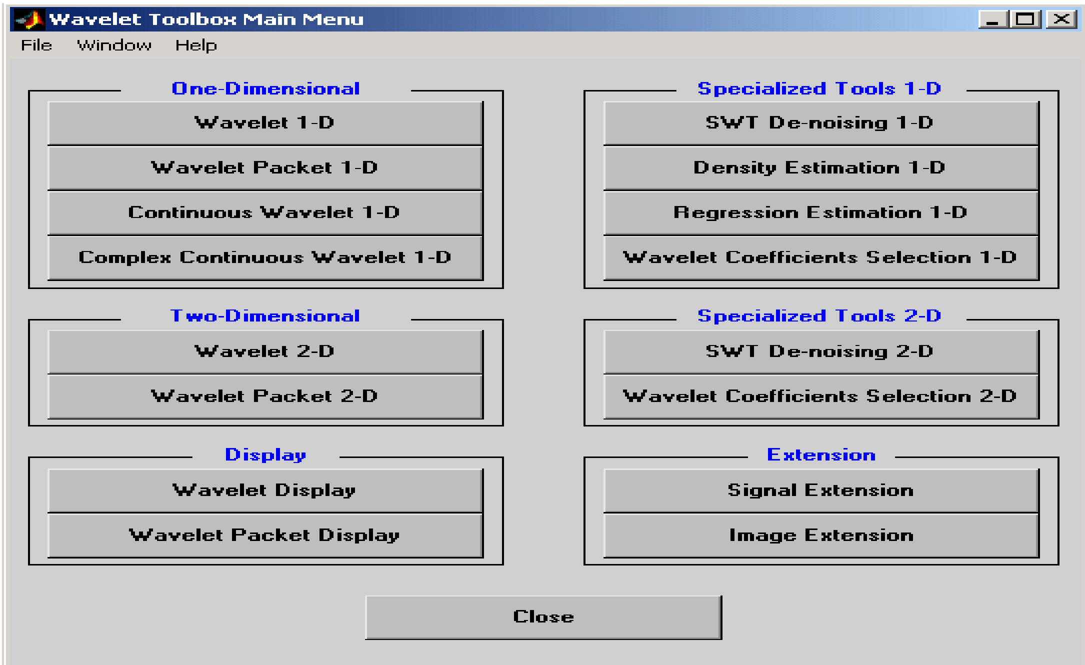

Fig.2: MATLAB Wavelet Analyzer [26].

Advantages: In this method no need to divide input coding non-overlapping block. It allows good localization in time and frequency domain. [11].

Limitations: It has poor directional selectivity. It is not a time invariant. [25].

Applications: It can be used noise removing, signal coding data compressions and also applicable where scalability tolerable degrade are important. [11, 25] .

2.2 HAAR Transform *[3,4]*

Gilbert B.K and Harris L.D (1980) proposed the method to cancerous cell recognition in bone marrow smear using haar wavelet base transform technique. Jiang. J et. al. (2013) bone marrow cell detection system to select proper features to represents a cancer cell under different condition[21]. The cancerous cell is prepared for preprocessing and detected using haar wavelet method. Coefficient matrix used to get the features from bone marrow image to detect the cell [16]. Haar wavelet transform is very widely used method of image processing, feature extraction, denoising and compression [22]. Decease Detection is used in many applications like as biometric, system interaction and security system [23].

Priyanka A (2016) used Haar transform for feature extractor in image processing [24]. Haar function $h_k(z)$ is basic of haar transform technique. Which is are defined over the continuous, closed interval z-[0,1] where k=0,1,2,……N-1 and $N=2^n$. The first step in generating the haar transform is to note that the integer k can be define uniquely as

$$k = 2^p + q - 1 \qquad (1)$$

Where $0 \le p \le n-1$, q=0 or 1 for p=0 , and $1 \le g \le 2^p$ for $p \neq 0$. For example.if N=4 , k,q and p have the following values:

k	**p**	**Q**
0	0	0
1	0	1
2	1	1
3	1	2

With this back ground, the haar functions are defined as

$$A_4 = \frac{1}{\sqrt{4}}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$$

$$\text{and } H_0(Z) = h_{00}(Z) = \frac{1}{\sqrt{N}}(2^{\frac{p}{2}}) \qquad when\ \frac{q-1}{2^p} \le Z \le \frac{q-1/2}{2^p} \qquad (2)$$

$$H_0(Z) = h_{00}(Z) = \frac{1}{\sqrt{N}}(-2^{\frac{p}{2}}) \qquad when\ \frac{q-1}{2^p} \le Z \le \frac{q-1/2}{2^p} \qquad (3)$$

$$H_k(Z) = h_{00}(\mathrm{Z}) = 0 \qquad \text{otherwise} \quad \mathrm{z} \in [0,1]$$

These results allow derivation of haar transformation matrices of order N×N by formation of the i^{th} row of a haar matrix from element of $h_i(z)$ for z= 0/N, 1/N, 2/N ……(N-1)/N. For instance, when N=2, the from Eq (2) , $h_0(z)$ is equal to $\frac{1}{\sqrt{2}}$, independent of z, so the first row of the matrix has two identical $\frac{1}{\sqrt{2}}$ elements. The second row is obtained by computing $h_1(z)$ for z=0/2,1/2. When k=1, p = 0 and q = 1 from Eq. (1). Thus , from Eq .(3) , $h_1(0) = 2^0/\sqrt{2} = 1/\sqrt{2}$ and $h_1(1/2) = -2^0//\sqrt{2} = -1/\sqrt{2}$. The 2×2 Haar matrix is

$$A_2 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

Following a similar procedure yield the matrix for N=4:

$$A_4 = \frac{1}{\sqrt{4}}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$$

Advantages: It is discrete function. Analysis of signals with sudden transition such as monitoring of tool failure in machine.

Limitations: It is not continuous function.

Applications: This method can be used in many areas of image processing such as denoising, edge detection, edge preserving smoothing or filtering.

2.3 Daubechies Transform [5, 6]

Sudarvizhi. D (2016) introduces the framework based on low level features extraction using Daubechies Wavelet Transform[5]. Francisco M (2018) used Daubechies Wavelet TransformIts objective is to retrieve images from huge database which are all related to a query image [26,39]. During image analysis, first good feature are identified from the images from the both database image and query image and analyze the query image features against feature of database [27]. There are many research have been contributed on image retrieval in last decades. Day by day database of images are growing very fastly. So without good techniques analysis of images is more tedious and less complex. So there is need for efficient and feasible retrieval system. Medical domain, digital library, Games and animation , keyword based retrieving video content, images based internet searching are area of content based image Retrieval system[33].

Jyotsna (2017) using Daubechies wavelet transform [6] are define same as the Haar wavelet transform by computing running averages and differences via scalar product with scaling signals and wavelets. The only difference between them consists in how these scaling signals and wavelet defined. For the Daubechies wavelet transform, the scaling signal and wavelets have slightly longer support [35]. They produce averages and difference using just a few more values from the signal. This slight change, however provide a tremendous improvement in the capabilities of these transform [36]. They provide us with a set of powerful tools for performing basic signal processing task. These tasks include compression and noise removal for audio and images and include image enhancement and image recognition [37].

Daubechies wavelet transform is defined in essentially the same way as the Haar wavelet transform. If a signal f has an even number N of values, then 1-level transform is the mapping $f \xrightarrow{D1} (a^1 \mid d^1)$ from the signal f to its first trend sub signal a^1 and first fluctuation sub signal d^1. Each value is of $a_m = (a_1 .... a_{N/2})$ is equal to scalar product:

$$a_m = f.V_m^1$$

Off with a 1- level scaling signal V_m^1 .Likewise, each value dm of $d^1=(d_1,.....,d_{N/n})$ is equal to a scalar product;

$$D_m = f.W_m^1$$

Off with a 1-level wavelet w_m^1 .

Haar Wavelet [7]: Any dialogue of wavelets starts with Haar wavelet, the first and simplest. The Haar wavelet is discontinuous, and resembles a step function as shown in Fig.4. It represents the same wavelet as Daubechiesdb1[7].

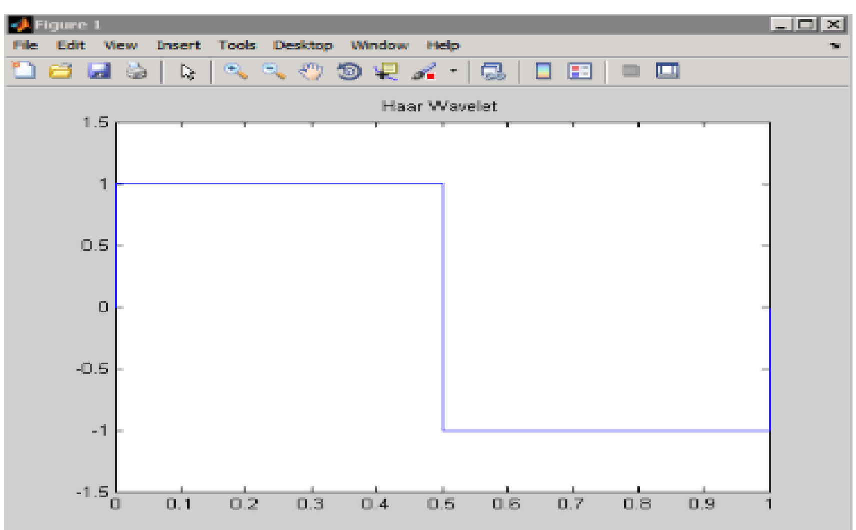

Fig. 4: Haarwalet Step function db1[7].

Ingrid Daubechies, one of the brightest stars in the world of wavelet research, invented what are known as compactly supported orthonormal wavelets therefore making discrete wavelet evaluation practicable [5]. The names of the Daubechies family wavelets are written dbN, where N is the order, and db the "surname" of the wavelet [6]. The db1 wavelet, as stated above, is the identical as Haar wavelet [38].

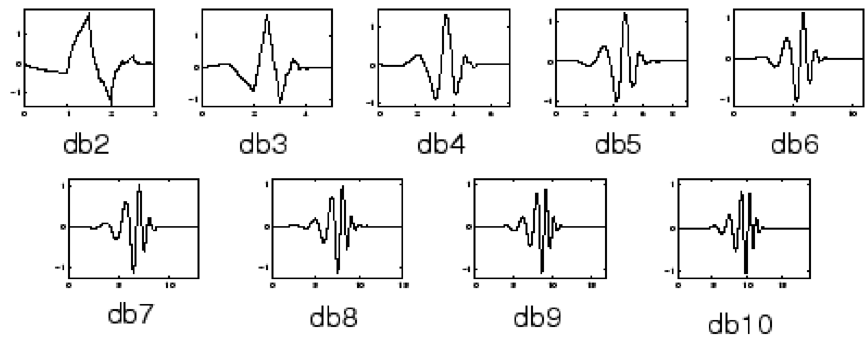

Fig. 5: Daubechies Wavelets db2 on the Left and db10 on the Right [6].

Here are the wavelet functions psi of the subsequent 9 contributors of the family as shown in Fig.5 [7]. Gibbs phenomenon relies upon on the fee assigned to the given function f(t) there, they use the flexibility to define for any $f(t) = \alpha f(t-0) + (1-\alpha) f(t+0)$ where $\alpha \in (0,1]$ as shown in Fig.6 Then they look at the magnitude and region of the maximum Gibbs ripples for every cost of α. For example, with a unit step characteristic f(t), the ripples are inconsiderable for $\alpha \approx 0.365$ and $\alpha \approx 0.27$ for the cases of the Shannon (wavelet) and Meyer's wavelet sampling series, respectively [22].

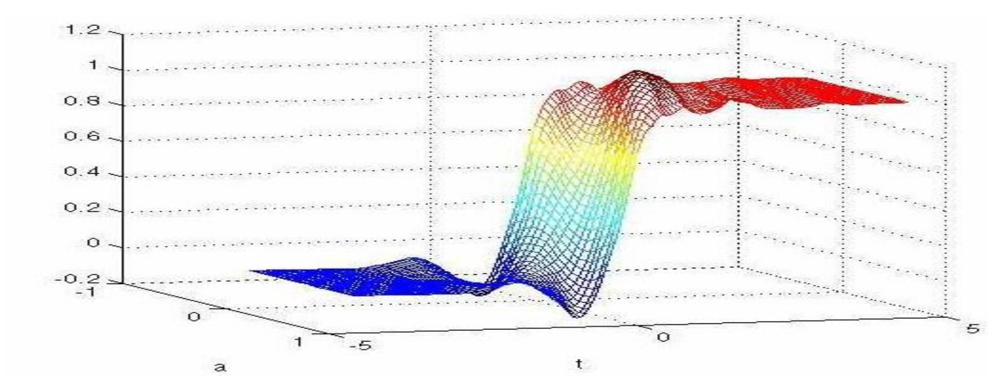

Fig. 6: Gibbs function of Daubechies Wavelet where N=4[22].

Advantage: It has scaling function and generates an orthogonal multiresolution analysis [9].

Disadvantage: Due to the redundancy, and the quantity of available wavelets, they could appear a little less efficient for the analysis of medical images [25].

Applications: It applies to compression and noise removal for audio signals and for images and include image enhancement and image recognition [10].

2.4 Morlet Transform [8]

Zhonghua L.Z.L and Bibo L.B.L (2010) introduce an iris detection method based on the imaginary coefficient of Morlet wavelet transform. For ensures the effective iris area, first step to locate the iris after it makes normalization to the image and get 512 columns multiplying 64 rows rectangular iris image. Second step, apply one dimension Morlet transform row by row and get a series of imaginary coefficients of wavelet transform at different scales and get the distribution figure of these coefficients of different scale [33].In the third step, according to imaginary coefficient of different scale and figure for making binary code. At last, recognition the iris pattern after sorting the different iris patterns and pattern matching method [50]. The recognition rate to detect the iris image is 99.641%. There are many advantage and distinct property to detect iris like uniqueness, stability, may-gathering etc. Iris detection has the higher accuracy compare with face [52], sound and other non-contacting status identification methods. All biometric statistics of iris detection has the minimum error rate. It algorithms Daugman is acceptance at present, but algorithm need of the texture and increase the feature extraction time. The wavelet feature need to be rectangular integrable and band skip (have no power at zero frequency). We used a real Morlet wavelet, which holds the above houses and has the following form:

where sigma is the approximate bandwidth and f0 is the center frequency of MATLAB command as shown in Fig. 11 indicates examples of the Morlet wavelet function at three distinct scales, along with the corresponding frequency domain information.

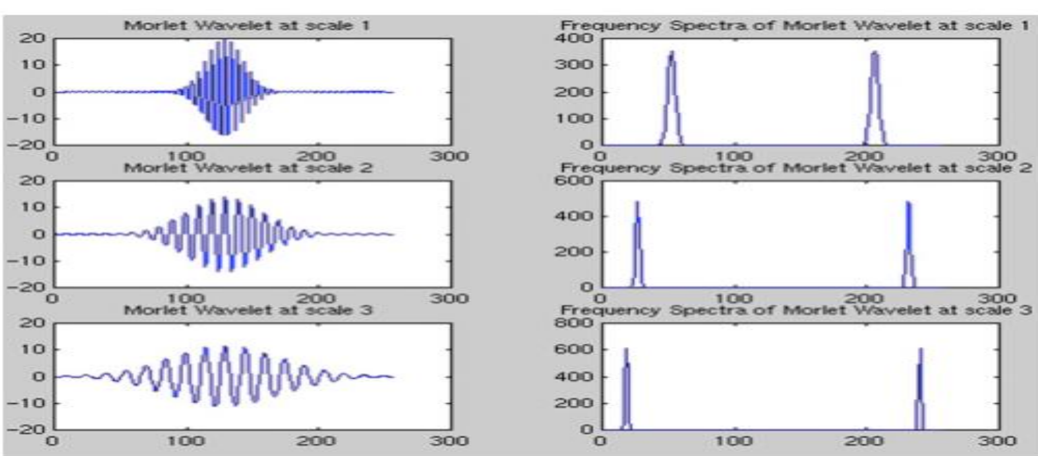

Fig.11: The Morlet Wavelet [24]

Advantage: This wavelet is very much related to human perception, both hearing and vision [11].

Disadvantage: For superior analysis, it becomes computationally intensive [25].

Applications: The application of the Morlet wavelet is used to categorize abnormal heartbeat behavior in the electrocardiogram (ECG) and image analysis [11] .

3. SURVEY OF SEGMENTATION TECHNIQUES IN MEDICAL IMAGES

Daliri M.R and Jin.Z (2015) have made a survey on the segmentation techniques used for biomedical images[44]. In this section we have describes that include many approaches along with a number of the published segmentations techniques where some hybrid techniques are used and others are modified version of its.

i. Mitra.S and B. Uma Shankaet. Al (2015) [12]

Techniques: Natural computing in medical image analysis. Fuzzy sets, Artificial neural network (ANN) [34], evolutionary computing genetic algorithm [51], swarm intelligence (ant colony optimization, artificial bee colony), support vector Machine (SVM), Immunocomputing, Rough Sets, Wavelet, membrane computing, harmony search, simulated annealing [45].

Invention: Breast, skin, lung Prostate image, Tumor detection, Lesion detection, Tumor identification or stage, Tumor tissue, characterization, Brain disease identification [41,37], Melanoma detection, Variegated coloring identification.

Limitations: pixel intensity outlier, missing feature sensor error, spatial inaccuracies, inter-image variability, Estimation of speed using parallel computing, Imaging Accuracies , efficient detection , organ and tissue structure.

ii. Le, U. Kurkure, and I. A. Kakadiaris et. al (2014) [13]

Techniques: Computerized Medical imaging and Graphics. DAISYDO, DAISY 3D, SIFT-3D, n-SIFTS

Invention: The detection of the anatomical point landmarks in mouse brain gene expression image [41,37].

Limitation: High memory requirement.

iii. Welikala R. A et al (2015) [14]

Techniques: Computerized Medical imaging and Graphics, Support vector machine (SVM), Genetic Algorithm [51].

Invention: The detection and classification of proliferative diabetic retinopathy. Limitation: Further enhancement of the classifier [49].

Limitation: Further enhancement of the classifier.

iv. El-Dahshan E.-S. A., H. M. Mohsen, K. Revett, and A.-B. M. Salem (2015) [15]

Techniques: Expert System with Applications: Feedback pulse-coupled neural network (FPCNN), Discrete Wavelet transforms (DWT), principle component analysis (PCA), Artificial neural network (ANN).

Invention: Brain tumor detection [41,37].

Limitation: The acquisition of large database from different institution with various image qualities for clinical evaluation and improvement in the CAD system, Improve the classification accuracy by extracting more efficient features and increasing the training data set [40].

v. Nanni. L and M. Melucci et. al.(2015) [16]

Techniques: Neurocomputing, Global approach, a bag-of-feature approach, Support Vector Machine (SVM)

Invention: Image classification [49].

Limitation: Use large database and memory requirements.

vi. Singh.A, M. K. Dutta, M. ParthaSarathi,et. al (2015) [17]

Techniques: Computer methods and program in Biomedicine [44], Discrete wavelet transforms (DWT), Principle component analysis (PCA), ANN, k-NN, SVM, Random forest classifier, Native byes classifier [49].

Invention: The Detection glaucoma from fundus

Limitations: Accuracy and efficiency.

vii. Choi W.J and T. S. Choi, et. al (2015) [18]

Techniques: Genetic algorithm template matching technique (GATM), Scale invariant feature transform (SIFT), Massive training artificial neural network (MTANN), Linear discriminant analysis (LDA) classifier, Support vector machine.

Invention: The detect pulmonary nodule in early stage.

Limitation: Accuracy and efficiency.

viii. Chen. Z, H. Wang, L. Xu, and J. Shenet. al (2014) [19]

Techniques: Optics and Laser Technology, Machine learning base adaptive weight estimation, it is brute force algorithm,

Invention: To detect under water object [36,39].

Limitations: Biological mechanism modeling [38]. Future work will continue to focus on the vision system of underwater animals to improve our bionic model for underwater image processing [36, 43].

ix. Murguía J.S, A. Vergara, C. Vargas-olmos, and T. J. Wong (2013) [20]

Techniques: Discrete wavelet transform, Support Vector machine (SVM)

Invention: To uniquely analyze the physicochemical characteristics of two distinct porous silicon optical gas sensors in solving a complex chemo-sensing task.

*Limitations:*classification[49].

x. Jiang. J, Y. Wu, M. Huang, W. Yang, W. Chen, and Q. Feng,(2013) [21]

Techniques: Computerized Medical Imaging and Graphics: Active Contour Model/Snake (ACM) and Level sets [42], Machine learning classification techniques, including super-vised(KNN , SVM) and unsupervised (clustering or fuzzy clustering), Back ground of graph-cut method.

Invention: The Tumor Detection, High-dimensional features and Real-Adaboost technique are used for voxel classification [51,52]. Information from all modalities is effectively used for distinguishing lesions and normal tissues [47].

Limitation: To improves the segmentation accuracy [38]. This is semi-automatic method. The most time-consuming stage is the training of the global classifier

4. Conclusion

In this a paper describes the analytical study of biomedical image processing which allows scientist and physician to get fast and accurately information for their decision support. With the growing of computational intelligence and machine learning techniques, the transform based techniques and segmentation techniques play a vital role. Now days it has become one of the major research area in medical imaging and diagnostic radiology [47-52]. In this paper provides an analytical study of different transform based techniques, and tested with the

MATALAB simulated toolkit and observed that all techniques are beneficial to the physicians and patients with various aspects and quickly recognize the various deceases. The transform based techniques is powerful tool for features extraction [27]. The use of transform based techniques is particularly appropriate since it give information about the image both in frequency and time domains.

In future scope of algorithms that could also be applied to biomedical image and provide effective results to the medical practitioner using emerging technologies like Internet of Things and cloud computing[27-33].

Conflict of interest: Authors would like to declare that they have no conflict of interest.

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