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A Survey on Radiological Image Processing

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ABSTRACT: The human bone is multiphase material consisting of collagenous matrix inter spread with mineral crystals. Now a days bone image is available in the form of X-Ray image. Image segmentation can be defined as in which we divide the image into multiple parts in the form of pixels. In segmentation, we simply represent the image into more understandable form. Segmentation basically used to detect the objects, boundaries and other relevant data in the digital images. Pixels in the image corresponds to some characteristics of image like colour, texture etc The aim of this paper is to give a review of digital image segmentation techniques With the growing research on image segmentation, it has become important to categorise the research outcomes and provide readers with an overview of the existing segmentation techniques in each category.

KEYWORDS: Bone; Edge Detection; Image Segmentation; Texture Analysis.

I. INTRODUCTION

The basic systems for image enhancement with a set of basic functions is capable of doing a number of general processing tasks, such as adapting the grey; using a; adjusting the contrast by equalizing the histogram; optimizing the image noise; etc. This type of software first emerged from 1985-1990; it is still supplied today in combination with CR and DR. But to get a good result with these elementary software systems, you will usually need to do manual post-processing for each individual image.

The systems currently available on the market can be broadly classified into three groups:

a) basic image processing systems;

b) conventional systems with multi-resolution image enhancement;

c) sophisticated, automated systems with multi-resolution image enhancement.

Image processing technique for texture analysis:

The X-ray images of bone will be obtained. In the first step, applying pre-processing techniques such as RGB to grayscale conversion and enhance them by using filtering algorithm to remove the noise from the image. Then the image is segmented. After segmentation, texture analysis is performed. The flow diagram of proposed system for detecting the bone fracture in X-ray images is shown below in Fig 2

Fig 1: (a) Raw Image (b) Processed image

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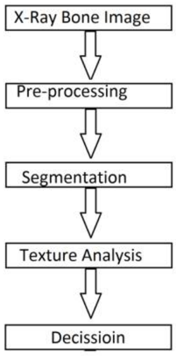

Fig. 2. Image processing flow

A) IMAGE PRE-PROCESSING

In computer-aided diagnosis of the medical images, image processing tools for noise removal, image segmentation and feature extraction play an important role in the success of such systems.

B) SEGMENTATION

Image segmentation is an important topic in the field of digital image processing. The purpose of image segmentation is to partition the image into essential regions with respect to the appropriate locations. For the segmentation we need the Images. But the images are either in form of black and white or colour. Colour images are due to the grey level . As the grey level contrast changes the color of color image also changes. Image segmentation plays important role in segmentation of medical images. Medical images play vital role in assisting health care which provides health care access patients for treatment. For the medical images, segmentation is crucial

Segmentation is the process of dividing the given image into regions homogenous with respect to certain features as colour, intensity etc. It is an essential step in image analysis and locates object & boundaries.

C)TEXTURE ANALYSIS

Gray-Level Co-occurrence Matrix is used for feature extraction and selection. GLCM is main tool used in image texture analysis. Textures of an image are complex visual patterns that are composed of entities or regions with sub-patterns with the characteristics of brightness, colour, shape, size, etc. GLCM is a statistical way to indicate image texture structure by statistically sampling the pattern of the grey-levels occurs in relation to other grey levels. The Gray Level Co-occurrence Matrix (GLCM) method is used to extract textural features such as entropy, contrast, correlation, homogeneity.

II. RELATED WORK

A. CATEGORIZATION OF SEGMENTATION

The abundance of literature on image segmentation makes the categorisation both necessary and challenging. Image segmentation is categorised as :

1. Image driven approach
2. Mode driven approach
3. Homogeneity measure

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B. TECHNIQUES OF IMAGE SEGMENTATION

There are different image segmentation techniques as shown in the figure below

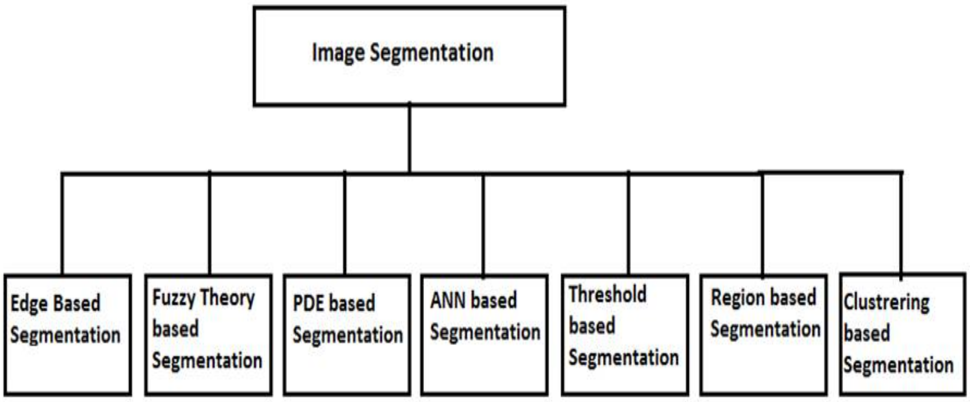

Fig. 3. Image segmentation techniques

i. Edge Based Segmentation

Edge can be defined as the boundary between two regions with definite properties of grey level. Edge detection can be defined as that each object is surrounded by a closed border, which is visible and can be detected in the intensity value of the image. It plays very important role in image analysis and pattern recognition as it describes the physical extent of objects. Edge detection methods are following:

a) Roberts Edge Detection: Roberts edge operator is used in image processing for edge detection. It was proposed by Lawerence Roberts in 1963. It was the first edge detector. The Roberts operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial gradient which often correspond to edges. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point.

+1	0
0	-1

(a)

0	+1
-1	0

(b)

Roberts cross convolution masks

b) Sobel Edge Detection: Sobel edge detector named after Irwin Sobel and it sometimes called as Sobel filter. Sobel edge detector is having two masks, one is vertical and other is horizontal. These masks are generally used 3*3 matrices. Standard Sobel operators, for a 3×3 neighbourhood, each simple central gradient estimate is vector sum of a pair of orthogonal vectors. Each orthogonal vector is a directional derivative estimate

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multiplied by a unit vector specifying the derivative's direction. The vector sum of these simple gradient estimates amounts to a vector sum of the 8 directional derivative vectors. Thus for a point on Cartesian grid and its eight neighbours having density values as shown: [5]

a	b	c
d	e	f
g	h	i

Density values [5]

c) Prewitt Edge Detection: Prewitt Edge Detector is used with edge detection algorithms in image processing. It is also called as Discrete Differentiation operator. It is used to calculate the gradient of the image intensity function. The Prewitt Edge filter is use to detect edges based applying a horizontal and vertical filter in sequence. Both filters are applied to the image and summed to form the final result. The two filters are basic convolution filters of the form: [6]

1	1	1
0	0	0
-1	-1	-1

Fig. 6(a) Horizontal Filter

-1	0	1
-1	0	1
-1	0	1

Fig. 6(b) Vertical Filter

ii. *Fuzzy Theory Based Image Segmentation*

Liu Yucheng [8] proposed a new fuzzy morphological based fusion image segmentation algorithm. Algorithm has used morphological opening and closing operations to smooth the image and then perform the gradient operations on the resultant image [9]. It also save the information details of image and improve the speed as well. SyojiKobashi [11] used scale based fuzzy connected image segmentation and fuzzy object model to segment the cerebral parenchyma region of new born brain MRI image. RefikSamet [12] proposed a new Fuzzy Rule based image segmentation technique to segment the rock thin segment images. They take RGB image of rock thin segment as input and give segmented mineral image as output. Fuzzy C Means is also applied on rock thin images and results are compared of both techniques. Muhammad RizwanKhokher [13] presented a new method of image segmentation using Fuzzy Rule based system and Graph Cuts. Authors have

firstly segmented the gray scale, color, and texture images

using Graph Cuts. Weights are assigned to the features of image using Fuzzy Rules. Their algorithm works by firstly extracting the features of image, calculate the constants using fuzzy rules, calculate the weighted average of constants to find the similarity matrix, partition the graph using Normalized Graph Cut method [14], and finally get the segmented image from partitioned graph. Berkley database is used to evaluate the algorithm.

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iii. Partial Differential Equation (PDE) Based Image Segmentation

Jinsheng Xiao [15] proposed a new non-linear discontinue partial differential equation (PDE) that models the level set method of gray images. A discrete method is also proposed to find numerical solution and to implement the filter. Fengchun Zhang [16] presents a variation model using 4th order PDE with 2nd order PDE for finger vein image de-noising. Midpoint Threshold segmentation technique is used to extract the region of interest accurately. 4th order PDE has reduced the noise very well, whereas 2nd order PDE has approximated the boundaries effectively. Chun Yuan [17] proposed a new segmentation model for colour images. This model is based on Geodesic Active Contour (GAC) model. But GAC is only restricted to gray scale images. Therefore their model is an extension of GAC model, and known as color-GAC model. It uses the expression of the Gradient of color image.

iv. Artificial Neural Network (ANN) Based Image Segmentation

Wencang Zhao [18] proposed a new image segmentation algorithm based on textural features [19] and Neural Network [20] to separate the targeted images from background. Dataset of micro-CT images are used. De-noising filter is used to remove noise from image as a pre-processing step, Feature extraction is performed next, and then Back Propagation Neural Network is created, and lastly, it modifies the weight number of network, and save the output. Lijun Zhang [21] proposed a new neural network based image segmentation system for colour images. They combined the Wavelet Decomposition and Self Organizing Map (SOM) to propose a new method, i.e., SOM-NN. Voting among child pixels selected the parent pixel. After initialization, ANN found the segmentation result which satisfies all levels. Wavelet decomposition is performed to remove noise. Hence wavelet decomposition and SOM-NN are combined to perform segmentation. Shohel Ali Ahmed [22] proposed Image Texture Classification technique based on Artificial Neural Networks (ANN). Firstly, image is captured and pre-processing is performed, after it, feature extraction [23] is performed, whereas, ANN classifier [24] is used for texture classification, Clustering is performed to separates background from sub-images. Trained ANN combines the input pixels into two clusters which give results. It produces the texture classification and segmentation of image.

v. *Threshold based Segmentation*

Threshold method is the mostly used technique in image segmentation. It is used to discriminate foreground from background. In this method, a grey scale image is converted into binary image. The binary image contains the whole necessary data regarding location and shape of the objects. Conversion to binary image is useful because it reduces the complexity of data. Threshold methods are following:

a) Global Thresholding In the global thresholding , the intensity value of the input image should have two peak values which correspond to the signals from background and objects. It tells the degree of intensity separation between two peaks in an image. Global thresholding, using an appropriate threshold T:

$g(x,y) = 1$, if $f(x, y) > T$

0, if $f(x, y) \leq T$ [27]

b) Variable Thresholding In variable thresholding, we separate out the foreground image objects from the background based on the difference in pixel intensities of each region. Variable thresholding, if T can change over the image. Local or regional thresholding, if T depends on a neighbourhood of (x, y). Adaptive thresholding, if T is a function of (x, y). [27]

c) Multiple Thresholding Multiple thresholding can be defined as that segments a grey level image into several distinct regions. It defines more than one threshold for the given image and divides the image into certain brightness regions and it corresponds to the background and several objects. Multiple thresholding:

$=a$, if $f(x, y) > T2$ $g(x,y)$

$= b$, if $T1 < f(x, y) \leq T2$

$=c$, if $f(x, y) \leq T$

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vi. *Region Based Segmentation*

Region Based segmentation can be defined as that in which we segment the similar image into various regions. It is used to determine the region directly. Portioning is done by using grey values of the image pixels. Two basic techniques of region based segmentation are following:

a) Region Growing Methods Region growing is a technique that groups pixels or sub regions into larger regions based on predefined criteria. The pixels aggregation starts with a set of seed points in a way that the corresponding regions grow by appending to each seed points those neighboring pixels that have similar properties like grey scale, color, texture, shape etc. [28]

b) Region Splitting And Merging in case of region splitting, the whole image is taken as a single region and then this region is being break into a set of disjoint regions which are coherent with themselves. Region merging opposes Region Splitting. A merging technique is used after each split and compares adjacent regions and merges them. It starts with small regions and merge the regions which have similar characteristics like grayscale, variance etc.

vii. *Clustering Based Image Segmentation*

Clustering based image segmentation is used to segment the images of grey level. Grey level methods can be directly apply and easily extendable to higher dimensional data. Clustering is also applicable in colour and multispectral images. There are two main methods in clustering:

a) K-Means the k-means methods of clustering are obtained based on the principle of minimization of the sum of squared distances from all points in each cluster domain to the cluster centre. This sum is also known as the within cluster as opposed to the between cluster distance which is the sum of distance between different cluster centre and the global mean of the entire data set. [29]

b) Fuzzy K-Means The Fuzzy K-means method is a two stage process involving a "coarse" segmentation followed by a "fine" segmentation. The "coarse" segmentation involves smoothing the histogram of each of the color components and using the first and second derivatives of the smoothed histograms to find the valleys which will then be the thresholds. A safe area surrounding the thresholds is then determined, and every pixel not falling into any safe area is assigned to a cluster based on its red, green and blue values and cluster centres are calculated. The "fine" segmentation involves assigning each pixel which belongs to a safe area to its closest cluster by calculating fuzzy membership functions. [29]

C. TEXTURE CLASSIFICATION

Assigning a sample unknown image to one of a set of know texture classes is referred to as texture classification. Texture analysis has four problem domains

1. Texture classification
2. Texture segmentation
3. Texture synthesis
4. Shape from texture

Fig7 shows the general fame work used for texture classification.

Texture classification process comprises of two phases: the learning phase and the recognition phase.

To build a model for the texture content of each texture class present in the training data, which generally involves images of known class labels. The texture content of the training images is captured with the chosen texture analysis method, which yields a set of textural features for each image. These features, which can be scalar numbers or discrete histograms characterize given textural properties of the images, such as spatial structure, contrast, roughness, orientation, etc. this is called as learning phase. In the recognition phase the texture content of the unknown sample is described with the same texture analysis method and then the textural features of the sample are compared with the training images with a classification algorithm, and then the sample is assigned to the category with the best match. The unknown sample can be rejected, if the best match is not sufficiently good according to some predefined criteria.

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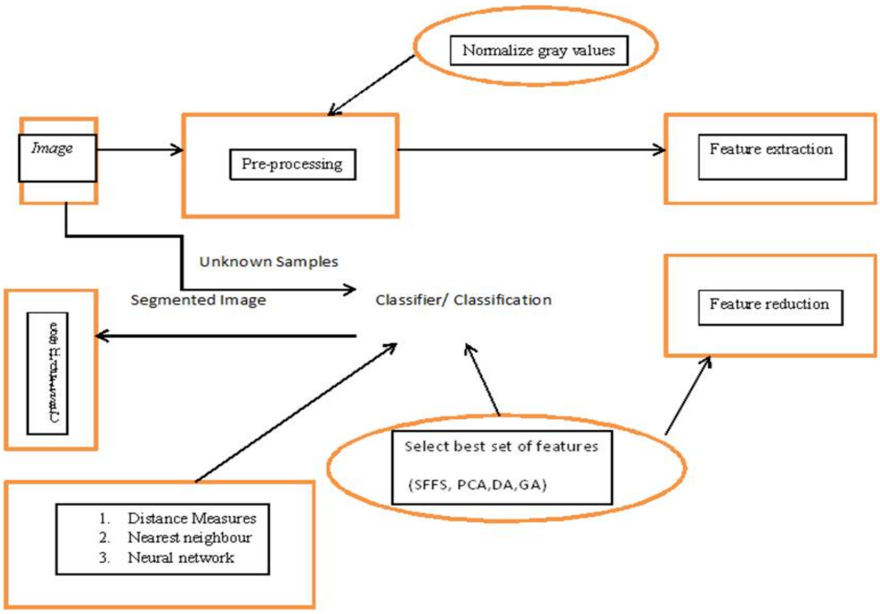

Fig 7: Framework for texture classification

D. TEXTURE ANALYSIS

One common approach used to characterize spatial information of an image is to extract features for classification which measure the spatial arrangement of gray tones within a neighbourhood of a pixel. This feature extraction method is referred to as texture analysis [31]. It includes a large number of possible features that have been developed to describe image texture. The discernment of texture is a function of spatial and radiometric scales. Mathematical procedures for texture characterization are classified into four categories, statistical, geometrical, model based methods and signal processing methods and include Fourier transforms, convolution filters, co-occurrence matrix, spatial autocorrelation fractals, etc. [31] Because texture has so many different dimensions, there is no single method of texture representation that is adequate for a variety of textures.

i. Statistical method:

Statistical methods analyse the spatial distribution of gray values, by computing local features at each point in the image, and deriving a set of statistics from the distributions of the local features. Depending on the number of pixels defining the local feature statistical methods can be further classified into first-order (one pixel), second-order (two pixels) and higher-order (three or more pixels) statistics. The basic difference is that first-order statistics estimate properties (e.g. average and variance) of individual pixel values, ignoring the spatial interaction between image pixels, whereas second- and higher-order statistics estimate properties of two or more pixel values occurring at specific locations relative to each other. The most widely used statistical methods are co-occurrence features and gray level differences [30]

ii. Model Based method:

Model-based methods hypothesize the underlying texture process, constructing a parametric generative model, which could have created the observed intensity distribution. The intensity function is considered to be a combination of a function representing the known structural information on the image surface and an additive random noise sequence Geometrical method Geometrical methods consider texture to be composed of texture primitives, attempting to describe the primitives and the rules governing their spatial organization. The primitives may be extracted by edge detection with a Laplacian-of-Gaussian or difference-of- Gaussian filter Once the primitives have been identified, the analysis is completed either by computing statistics of the primitives (e.g. intensity, area, elongation, and orientation) or by deciphering the placement rule of the elements The structure and organization of the primitives can also be

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presented using Voronoi tessellations [31] Image edges are an often used primitive element. Harlick et al. [30] generalized co-occurrence matrices, which describe second order statistics of edges. An alternative to generalized co-occurrence matrices is to look for pairs of edge pixels, which fulfil certain conditions regarding edge magnitude and direction. Properties of the primitives (e.g. area and average intensity) were used as texture features

iii. Signal Processing Method:

Signal processing methods analyse the frequency content of the image Spatial domain filters, such as Law's masks, local linear transforms proposed by Unser and Eden (1989), and various masks designed for edge detection are the most direct approach for capturing frequency information Rosenfeld and Thurston (1971) introduced the concept of edge density per unit area: fine textures tend to have a higher density of edges than coarse textures.

Texture Analysis methods:

i. Auto correlation and Fourier method:

As we know that the texture is property in which intensity of an image varies region to region. This prompts us to calculate the variance of intensity over the whole region of a texture. However most of the time this will not provide enough description which is most of time needed. Especially when texels are well defined or where there is high degree of periodicity in texture. Then it is natural to consider the use of Fourier analysis. Moreover Fourier method is difficult to apply to an image which is to be segmented for texture analysis Autocorrelation shows the local intensity variation as well as repeatability of the texture. It is use full for distinguishing short range and long range order in the texture. Auto correlation is not a good discriminator. in natural textures. Hence Co-occurrence matrix introduced by Harlick et al [30] became a large degree of standard.

ii. Pixel Based Models:

In pixel based models texture is described by statistics of distribution of grey levels or intensities in the texture. Most widely used pixel based model is Grey Level Co-occurrence model (GLCM). This is first introduced by Harlick et.al [30].

Grey Level Occurrence matrix (GLCM):

The fundamental concept behind these matrices is spatial distribution of grey level elements. In this approach a set of matrices are created that show the probability that a pair of brightness values (i,j) will occur at a certain separation from each other (Δx,Δy). The assumption is that the textural dependence will be at angles of 0°, 45°, 90° or 135° (with 0° being to the right and 90° above) from the original pixel that means four GLCM matrices would have to be created. Consider an image to be analysed has Nx resolution horizontally and Ny resolution vertically. Grey tone appearing in each resolution cell is quantized to Ng levels. The set LxXLy is the set of resolution of an image ordered in row and column. An image I can be represented as function which assigns some grey tone in G. we assume that texture context information in an image I is contained in overall or average spatial relationship which the grey tones in image I have to one another. Texture-context information is more adequately specified by matrix relative frequencies Pij with which two neighbouring pixels are separated by distance of d occur in an image such matrices of grey tone spatial dependency matrices are function of angular relationship between neighbouring cells as well as the distance between them. Since all texture information is present in grey tone spatial dependence matrices. Hence all texture features are extracted from these matrices. There are total 14 set of features of measures. But still it is difficult to say which measure describes which feature of texture. Following are 3 features out of 14 which define the textural characteristics. They are Angular Second Moment (ASM), Contrast(CON) and Correlation(COR) These metrics are calculated for each pixel for each using each of the four GCLMs and then a final texture value is usually calculated as an average of all four. It is obvious that these measurements can be computationally expensive especially as the quantization level becomes large. For many applications it may be beneficial to quantize the image into a smaller number of gray levels prior to creating the GLCMs

i. Local Binary Patterns

The local binary pattern (LBP) texture operator was first introduced as a complementary measure for local image contrast. The first incarnation of the operator worked with the eight-neighbours of a pixel, using the value of the centre pixel as a threshold. An LBP code for a neighbourhood was produced by multiplying the threshold values with weights given to the corresponding pixels, and summing up the result Fig 8.

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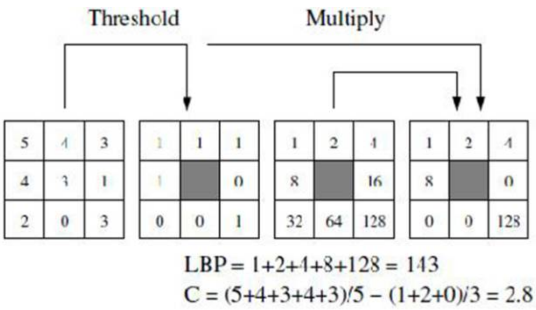

Fig 8: Calculating the original LBP code and a contrast measure

Calculating the original LBP code and a contrast measure TopiM¨aenp¨a¨a&MattiPietik¨ainen[32] have explained LBP as follows, The LBP method can be regarded as a truly unifying approach. Instead of trying to explain texture formation on a pixel level, local patterns are formed. Each pixel is labelled with the code of the texture primitive that best matches the local neighbourhood. Thus each LBP code can be regarded as a micro-texton. Local primitives detected by the LBP include spots, flat areas, edges, edge ends, curves and so on. Some examples are shown in Fig. 9 with the LBP8,R operator.

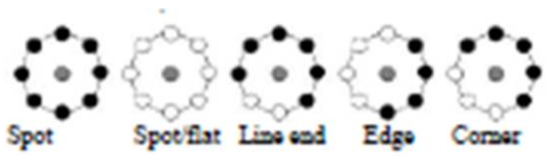

Fig 9: Different Texture Primitives detected by LBP

In the figure, ones are represented as white circles, and zeros are black. Spot Spot/flat Line end Edge Corner Fig 3. Different Texture Primitives detected by LBP. The LBP distribution has both of the properties of a structural analysis method: texture primitives and placement rules. On the other hand, the distribution is just a statistic of a nonlinearly filtered image, clearly making the method a statistical one. For these reasons, it is to be assumed that the LBP distribution can be successfully used in recognizing a wide variety of texture types, to which statistical and structural methods have conventionally been applied separately. Ojala et.al [33].

How to choose an algorithm for Texture analysis:
While choosing an algorithm for texture analysis we have to consider a number of aspects [34]:
1. Gray scale invariance;
Sensitivity of the algorithm changes in gray scale.
2. Spatial scale invariance;
Whether the algorithm can manage if, the spatial scale of unknown samples is different from that of training data.
3. Rotation invariance;
Effect of changes in rotation of image with respect to the viewpoint of algorithm.[34]
4. Projection invariance (3-D texture analysis);
The algorithm may have to sustain with changes in tilt and slant angles.
5. Robustness with respect to noise;
To what extent the algorithm tolerates noise in the input images.
6. Robustness with respect to parameters;
Does a given set of values apply for a large range of textures.
7. Computational complexity;
8. Generativity; Regenerating the texture that was captured using the algorithm.
9. Window/sample size;
How much large sample is required by the algorithm for being able to produce a useful description of the texture content.

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E. FEATURE EXTRACTION:

Feature extraction (or detection) is a type of dimension reduction that efficiently represent interesting parts of image as a compact feature vector. These regions can be defined in global or local neighbourhood and differentiated by shapes, textures, sizes, intensities, statistical properties, and so on. Local feature extraction methods are further classified as intensity based and structure based. Intensity-based methods analyze local intensity patterns to find regions that satisfy desired uniqueness or stability criteria. Structure-based methods detect image structures such as edges, lines, corners, circles, ellipses, and so on.

Feature Extraction Methods:

SerkanHutipoglu, and Sunjit K. Mitra[36] suggested two different methods for texture feature extraction, Quadratic teager filter and Singular value decomposition(SVD). Quadratic teager filter is used to find the local energy values. SVD values are used for feature extraction that represents the low frequency property of an image texture.

III. PROPOSED ALGORITHM

This paper, gives us the detailed knowledge of segmentation techniques used for the purpose of image analysis. The result of image segmentation depends upon many factors, i.e., pixel color, texture, intensity, similarity of images, image content, and problem domain. Therefore, neither we can use only one method for all type of images nor all methods can be used for a particular image. Hence, it is advised to use combination of multiple methods for image segmentation problem.

For recognising an image, one of the most important parameter is texture of image which starts with a surface that have local roughness or a surface which is then projected to form a textured image. Such image will consist of both regulation and randomness to different level of degrees. However, the key feature of randomness of that image have to be characterized by statistical techniques, and recognized using statistical classification procedures. Techniques that have been used for this purpose have been seen to include autocorrelation, co-occurrence matrices, texture energy measures, fractal-based measures, Markov random fields, and so on.

Combining this sufficiently obtained knowledge of image segmentation and texture analysis will be useful for radiological image analysis.

REFERENCES

1. Wang, T.; Burr, D.B.. "Shear Strength and Fatigue Properties of Human Cortical Bone Determined from Pure Shear Tests". Calcified Tissue International 69 (6): 373–378. doi:10.1007/s00223-001-1006-1,2001
2. Levrero, F.; Margetts, L.; et al. . "Evaluating the macroscopic yield behaviour of trabecular bone using a nonlinear homogenisation approach". Journal of the Mechanical Behavior of Biomedical Materials 61: 384–396. doi:10.1016/j.jmbbm.2016.04.008,2016
3. Bone Curriculum Educational resource materials by the "American Society for Bone and Mineral Research"
4. Mrudula S. Kulkarni, S.R. Sathe, "Experimental Determination of Material Properties of Cortical Cadeveric Femur Bone", Trends Biomater. Artif. Organs, Vol 22(1), pp 9-15 , Received 8 August 2007; published online 1 July 2008.
5. INSTRON 5582 UNIVERSAL TESTER, “Fat Tony”.
6. P. Mohanaiah, P. Sathyanarayana, L. GuruKumar, "Image Texture Feature Extraction Using GLCM Approach", International Journal of Scientific and Research Publications, Volume 3, Issue 5, May 2013, ISSN 2250-3153 .
7. Jennifer A Tripp, Maria E Squire, Julie Hamilton, Robert E M Hedges, " A NondestructivePrescreening Method For Bone Collagen Content Using Micro Computed Tomography "
8. L. Yucheng and L. Yubin, "An algorithm of image segmentation based on fuzzy mathematical morphology," in International Forum on Information Technology and Applications, IFITA'09, pp. 517-520,2009.
9. W. Haider, M. Sharif, and M. Raza, "Achieving accuracy in early stage tumor identification systems based on image segmentation and 3D structure analysis," Computer Engineering and Intelligent Systems, vol.2, pp. 96-102, 2011.
10. M. S. A. Shahzad, M. Raza, and K. Hussain, Enhanced watershed image processing segmentation," Journal of Information & Communication Technology, vol. 2, pp. 1-9, 2008.
11. S. Kobashi and J. K. Udupa, "Fuzzy object model based fuzzy connectedness image segmentation of newborn brain MR images," inProc. IEEE International Conference on Systems, Man, and Cybernetics (SMC), pp. 1422-1427, 2012.
12. R. Samet, S. E. Amrahov, and A. H. Ziroglu, "Fuzzy rule-based image segmentation technique for rock thin section images," in Proc. 3rd International Conference on Image Processing Theory, Tools and Applications (IPTA), pp. 402-406, 2012.
13. M. R. Khokher, A. Ghafoor, and A. M. Siddiqui, "Image segmentation using fuzzy rule based system and graph cuts," in Proc. 12th International Conference on Control Automation Robotics & Vision (ICARCV), pp. 1148-1153, 2012.
14. M. Sharif, S. Mohsin, M. J. Jamal, and M. Raza, "Illumination normalization preprocessing for face recognition," in Proc. International Conference on Environmental Science and Information Application Technology (ESIAT), pp. 44-47, 2010.
15. J. Xiao, B. Yi, L. Xu, and H. Xie, "An image segmentation algorithm based on level set using discontinue PDE," in Proc. First International Conference on Intelligent Networks and Intelligent Systems, ICINIS'08., pp. 503-506, 2008.

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ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

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16. F. Zhang, S. Guo, and X. Qian, "Segmentation for finger vein image based on PDEs denoising," in Proc. 3rd International Conference on Biomedical Engineering and Informatics (BMEI), pp. 531-535, 2010.
17. C. Yuan and S. Liang, "Segmentation of color image based on partial differential equations," in Proc. Fourth International Symposium on Computational Intelligence and Design (ISCID), pp. 238-240, 2011.
18. W. Zhao, J. Zhang, P. Li, and Y. Li, "Study of image segmentation algorithm based on textural features and neural network," in International Conference on Intelligent Computing and Cognitive Informatics (ICICCI), pp. 300-303, 2010.
19. M. Sharif, M. Y. Javed, and S. Mohsin, "Face recognition based on facial features," Research Journal of Applied Sciences, Engineering and Technology, vol. 4, pp. 2879-2886, 2012.
20. M. Yasmin, M. Sharif, and S. Mohsin, "Neural networks in medical imaging applications: A survey," World Applied Sciences Journal, vol.22, pp. 85-96, 2013.
21. L. Zhang and X. Deng, "The research of image segmentation based on improved neural network algorithm," in Proc. Sixth International Conference on Semantics Knowledge and Grid (SKG), pp. 395-397,2010.
22. S. A. Ahmed, S. Dey, and K. K. Sarma, "Image texture classification using Artificial Neural Network (ANN)," in Proc. 2nd National Conference on Emerging Trends and Applications in Computer Science (NCETACS), pp. 1-4, 2011.
23. M. Sharif, M. Raza, S. Mohsin, and J. H. Shah, "Microscopic feature extraction method," Int. J. Advanced Networking and Applications, vol. 4, pp. 1700-1703, 2013.
24. I. Irum, M. Raza, and M. Sharif, "Morphological techniques for medical images: A review," Research Journal of Applied Sciences, vol.4, 2012.
25. Muhammad Waseem Khan, A Survey: Image Segmentation Techniques," International Journal of Future Computer and Communication, Vol. 3, No. 2, April 2014", DOI: 10.7763/IJFCC.2014.V3.274, 89-93
26. AmanpreetKaur, A Review Paper on Image Segmentation and its Various Techniques in Image Processing," International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064", Volume 3 Issue 12, December 2014,12-14
27. Stefano Ferrari, universitadeglistudi di Milano, "Image Segmentation", a.a 2011/12
28. http://www.di.ubi.pt/~agomes/cvm/teoricas/07-regionsegmentation.pdf
29. SiddheswarRay, rose H.Turi and peter E. tischer, Clustering- based colour Image Segmentation: An Evolution Study.
30. Harlick and Shanmugam, "Textural feature for image classification", IEEE 1973
31. MihranTuceryan, Anil K. Jain, "Texture Analysis", The Handbook of Pattern Recognition and Computer Vision (2nd Edition), by C. H. Chen, L. F. Pau, P. S. P. Wang (eds.), pp. 207-248, World Scientific Publishing Co., 1998.
32. Topi M¨aenp¨a¨a&MattiPietik¨ainen "Texture Analysis With Local Binary Patterns", WSPC,2004
33. TimoOjala, MattiPietikaÈinen, "Multi resolution Gray-Scale and Rotation Invariant Texture Classification with Local Binary Patterns", IEEE Transactions on Pattern Analysis and Machine intelligence, vol. 24, no. 7, July 2002
34. T Ojala and M Pietikäinen, Texture classification,1998
35. FRANK Y. SHIH, "Image processing and pattern Recognition Fundamentals and Techniques", Image Processing and Pattern Recognition, IEEE 2010.
36. SerkanHutipoglu, and Sunjit K. Mitra, "Texture Feature Extraction Using Teager Filters And Singular Value Decomposition",IEEE 1998