

Least Distance Based Liver Segmentation Technique (LDBLST) For Liver Segmentation from CT Scan Images

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Abstract-Liver is a very important human organ. It is a human chemical processing plant. It receives thirty percent of human blood circulation. It removes harmful toxins with chemical reactions. Liver volume is assessed primarily via organ segmentation of computed tomography (CT) and magnetic resonance imaging (MRI) images. Due to the existence of high tissue homogeneity among visceral organs, to segregate or visualize the fine structural detail of liver image alone is difficult. This constraint is experienced by radio diagnostic experts and medical doctors. Automatic image processing and extraction techniques are gaining more attention. Though, several new algorithms or a combination of methods have been proposed in medical image processing, gaps exist between proposals and applications. This paper proposes a novel technique based on the least distance method called the Least Distance Based Liver Segmentation Technique (LDBLST) for Liver Segmentation from CT Scan Images. The aim of this paper is to provide a workable segmentation method for liver segmentation from CT scan images.

Keywords: Classification, Liver Segmentation, Least Distance, GLCM, Image Retrieval.

I. INTRODUCTION

Liver is one of the most important vital organs. Many biochemical, detoxification, destruction of red blood corpuscles are taking place, apart from the

secretion of digestive enzymes by hepatic cells of liver. Liver cirrhosis, hepatic carcinoma, liver jaundice, enlargement of liver lobes, bleeding in liver vessels and rupture of liver edges are some of the major diseases diagnosed by Hepatologist to initiate treatments. Anatomically liver is occupied in abdomen along with other gastro intestinal organs viz.: spleen, pancreas, kidneys and intestine. There is substantial increased death rate due to liver structural defects and functional complications worldwide. The recent advancement of science and technology has been resulted in findings of non-invasive scanned digital images for ruling out the diseased state of liver along with clinical laboratory biochemical investigations (Zakim and Boyer, 2002; Tortora and Bryan, 2008; Abdel *et. al.*, 2010).

Several computer scientists have been proposing new algorithms, combination of certain methods and system based steps for the medical image processing. Although many ways are suggested that accuracy of the prediction still requires modifications. Generally, the image features of Gray Level Co-occurrence Matrix (GLCM), texture and shape of the images are worked in MATLAB environment. However image segmentation and recapturing the image from a dataset has not been

well established till date for clinical application. There lies a lacuna for further innovation. In the light of above concept an attempt has been made in this present work for the segmentation of liver in visceral CT scan images as well as an automatic retrieval mechanism for capturing an equal image by the query image from dataset.

A. Scope of research work

- Development of new method for the segmentation of liver image out of abdominal CT scan images.
- User friendly image processing techniques for liver digital image analysis.
- Methodology for the interpretation of liver images on the regions of interest
- Ways for Individual interested points on structural details of liver images
- Expansion of image physical feature analysis by texture, shape and intensity
- Growth of the prediction accuracy by adapting confusion matrix.
- Provision of information on various stages of disease developments.
- Enlargement of Retrieval mechanism by Least Distance Method at nearest Zero
- Adaptation of new algorithm

B. Objectives

- To analysis the 800 abdominal CT scan images by shape, intensity and texture features.
- To segment the liver images from the 800 selected images.
- To preprocess the images by inverse image, edge detection and correction, SOBEL imaging for the segmentation of liver.
- To run the query image into the liver image dataset.
- To identify the identical image with all respects by Least Distance Method (LDM).
- To validate the retrieval by confusion matrix.

II. RELATED WORK

A review of earlier works particularly on liver image segmentation and the computer-based image quality processes is given in this section. Articles appear in reason years are looked back.

The abdomen is the body region where many organs are located. To overcome the burden of identification of specific organ and its defect in abdominal CT scan cut images, the boundaries and

shape of the visceral organs are analyzed. The selection process is known as segmentation technique. Different theoretical applications and statistical methods are employed for segmentation of liver image out of images formed for other organs (Lav Varshney, 2002).

Gray-level is more understandable and clear way in selection of character of image by extractions from image pools. To capture an image of interested object out of many digital images, the principle of gray-level is applied to identify the shape and boundaries of the desirable object. In many gray level procedures for image analysis normally algorithms are not used. It is a semi-automatic technique and requires role of user's operation. However it has its own demerits during the prediction of liver when the intensity is appeared as less between the object and background (Punia and Singh, 2013).

Morphological filters are used to ascertain the segmentation after employing threshold determination. The images obtained out of the farmer step are sensitive to noise. Therefore roundness and information of adjacent slices are also analyzed to reduce the burden of false detection (Abdel-massiehet.al., 2010).

III. METHODOLOGY

The achievement of perfect liver image segmentation out of multi organ CT scan abdominal image was done by sequential image processing steps. Various statistical and mathematical equations were applied to derive the qualities of images. In addition to this an automatic retrieval technique was also designed out of the image qualities determined. This section deals with those methods employed.

Although many ways under semiautomatic and fully automatic means for the liver segmentation are suggested, a new method is proposed in this research work. This includes various pre-processing of abdominal CT scan images and Smoothing Techniques. The various details of methods adopted are described below:

The working flow chart given below explains the various steps followed for liver segmentation (Figure 1).

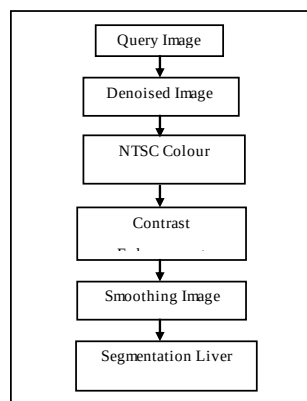


Fig1. Working flowchart for liver segmentation

A. Selection of query image

The database which contains images of 800 Abdominal CT scan digital pictures were utilized for the liver segmentation process. All the selected 800 images were subjected for the different methods of processing as described in the working flow chart. Some of the collected sample CT scan images are given in Figure2.



Fig 2. Furnished with some significant CT scan abdominal liver images under investigation.

B. Denoised image

The next step is denoising of the 800 CT scan images under present observation. The following paragraph explains the various steps involved for denoising. The main properties of a good image denoising model are that it will remove noise while preserving edges. In order to reconstruct and find the edges for liver segmentation, all the 800 abdominal digital images were processed for above denoising procedure (Figure 3).

Fig 3. A sample screen shot of abdominal CT Scan image after denoising

C. NTSC Colour format

The next step is NTSC colour format. In this step colouring to the desirable regions by enhancing red colour. The denoising process carried out in previous step develop some artifacts on the quality of the image. This can be improved by subjecting the image in NTSC colour format. The other two components of Hue and Saturation modify image with chrominance colour information (Figure 4).

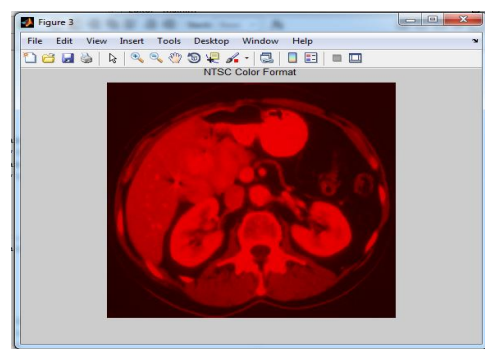


Fig 4. A sample screen shot of abdominal CT Scan image after NTSC colour format

D. Contrast enhancement

The next step was enhancement of contrast. It was employed to bring a quality of the images. Since contrast is an important trait for image quality. The contrast of any given image is revealed by its histogram. Therefore in the next step of image processing contrast enhancement treatment was given Figure 5.

$$\text{Contrast} = \sum_{i,j} i, j^2 p(i, j) \text{-----}(1)$$

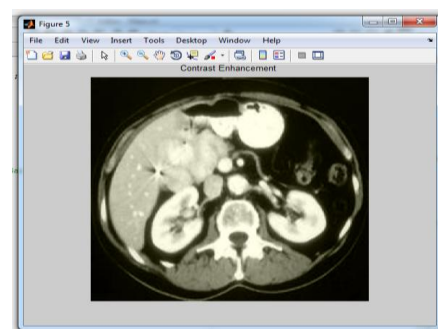


Fig 5. A sample screen shot of abdominal CT Scan image after contrast enhancement

E. Smoothing image

The smoothing method is based on the principle of filtering the information. After smoothing, the image gives a single significant value for the representation of the image under study. There is various types of filters, One of the common filters is the linear filter. While using the linear filter the output pixel value is determined as a weighted sum of input pixel values. This can be explained by the equation given below.

$$g(i, j) = \sum_{k,l} f(i+k, j+l) h(k, l) \text{-----}(2)$$

Where h, k, l are called kernel, which is nothing more than the coefficients of the filter.

The estimation of input filter values is important for the assessment of desirable regions picked from the overall image (Figure 6).

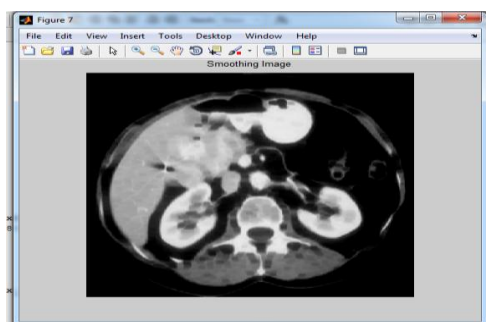


Fig 6. A sample screen shot of abdominal CT Scan image after smoothing

F. Segmentation of liver using DCT

The next step is the image segmentation or the classification and image compression. Normally for any image regional selection are done by a widely used method of Discrete Cosine Transform (DCT). The DCT coefficient reflects the image features as those used at pixel level. Thereby DCT coefficient can express the average intensity value in block of pixels/voxels.

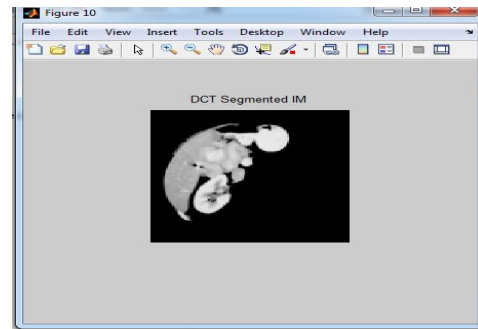


Fig7. A sample screen shot of segmented liver image

G. Methodology for image preprocessing and feature extraction

For image feature extraction all the images were undergone with preprocessing steps. The various steps of preprocessing are given in the work plan (Figure 8).

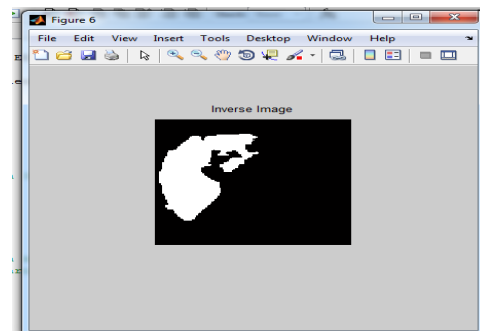


Figure 8. Steps adopted for image preprocessing

In order to achieve retrieval of liver image from the dataset, as a matter of study convenience a repository of 40 sample database consisting segmented liver images was set aside (DCT Segment). From this dataset a query image was allowed to run for recapturing the identical image. Therefore all the 40 segmented images and one query image were preprocessed for texture extraction. The following are various methodology of preprocessing undertaken in this study.

H. Inverse image

The first step adopted for the preprocessing is the inverse image (Figure 9). The inverse image is a

particular subset S of the co-domain of a function is the set of all elements of the domain that map to the members of S .

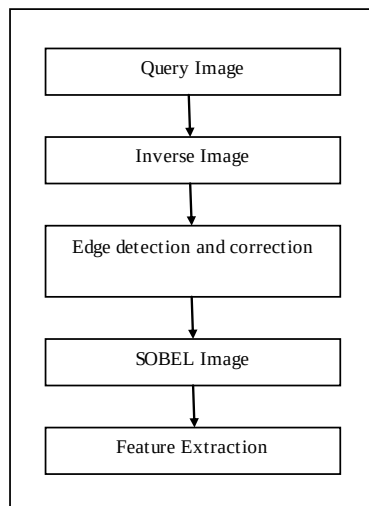


Fig 9. A sample screen shot of liver image after inverse image

I. Edge detection and correction

Edge detection is an image processing technique for finding the boundaries of objects within images. After the edge detection the circles are given for the enhancements of edges. This is known as edge correction, edge correction by only centering circles on points in the center portion of the study plot. Only points within the red rectangle (which is 75% smaller than the full plot; 12.5% per edge) are used to construct the circles, but all points are counted if they fall within a circle, regardless of whether they are inside or outside the red rectangle (Erdet.al., 2010) The following mathematical step was adopted (Figure 10).

$$P_y = \frac{e+d}{2d} \text{-----}(7)$$

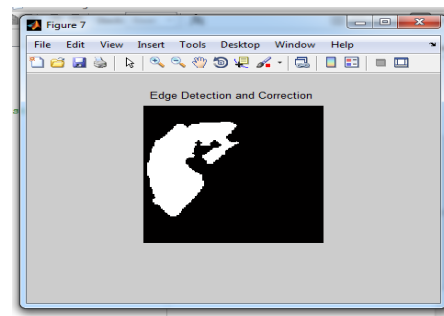


Fig 10. A sample screen shot of liver image after edge detection and correction

J. SOBEL image

Next step is SOBEL image processing. It is also called as the Sobel-Feld Man Operator or SOBEL filter. It is named after Irvin Sobel and Gary Feldman at the Stanford Artificial Intelligence Laboratory (SAIL). The idea of sobel image is to process isotropic 3x3 image gradient operation. Technically it is described as discrete differentiation operator, computing an approximation of the gradient of the image intensity function. In his present work SOBEL image operator was used for emphasizing the edges of segmented liver image from the abdominal CT scan pixels (Figure 11).

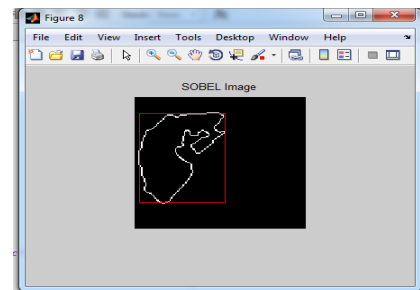


Fig 11. A sample screen shot of liver image after SOBEL image processing

K. Image dataset

In this paper work, an exclusively new database was created as described earlier part of this thesis. It is named as "DCTSEGMENT", The DCTSEGMENT database consist of 800 segmented CT scan liver images, each image size of 512x512 in the jpeg format. The database consists of images of varying area and contrast. 40 sample liver image of the process of image feature extraction exhibits. (Figure 12).



Fig 12. A sample liver image of all the process of image feature extraction

L.Gray level co-occurrence matrix

Gray-level co-occurrence matrix (GLCM) is the statistical method of examining the textures that considers the spatial relationship between the pixels. The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix.

$$\text{Offsets} = [0 \ 1; -1 \ 1; -1 \ 0; -1 \ -1;];$$

----- (10)

$$\text{gldm} = \text{graycomatrix}(\text{I}, \text{'NUMLEVELS'}, 8, \text{'G'}, [], \text{'Offset'}, [1 \ 0]); \text{-----} (11)$$

M. First order features (Shape, Intensity)

The different shape, Intensity feature viz: area, perimeter, roundness, solidity, Threshold were defined by statistical method. The formula for the same is listed in Table 1 and 2.

TABLE 1.
SHAPE BASED FEATURES

Shape features	Formula
Area	$A = n[1]; n[]$ represents the count of numberof the patterns within the parenthesis
Perimeter	$\sum Ed(L)$
Roundness	$C = \frac{P^2}{4\pi A}$
Solidity	Solidity = area/ convex area

TABLE 2.
INTENSITY BASED FEATURES

Intensity feature	Formula
Threshold	$\sum TH(L)$
Irregularity Index	$I = \frac{4\pi \times \text{Area}}{(\text{Perimeter})^2}$
Equivalent Diameter	$E_d = \frac{4 \times \text{Area}}{\pi}$
Pair wise Linear Function	$\sqrt{(\Delta x)^2 + (\Delta y)^2} = \sqrt{1 + \left(\frac{\Delta y}{\Delta x}\right)^2} \Delta x,$

N.Second order features (Texture)

There were 13 parameters of texture features. They were identified by the same way of using statistical means below is the outlines of the explanation and the formula applied for the same Table 3.

TABLE 3.
Details of 13 statistical parameters identified for the images and the formula used for the calculation

Texture feature	Formula
Correlation	$\frac{i - \mu_i \quad j - \mu_j \quad p \quad (i, j)}{\sigma_i \sigma_j}$
Contrast	$i, j \quad p(i, j)$
Energy	$p(i, j)^2$
Variance	$\sigma^2 = \frac{1}{N \times M} \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} (P(i, j) - \mu)^2$
Entropy	$E = - \sum_{i,j} P(i, j) \log P(i, j)$
Homogeneity	$\frac{p(i, j)}{1 + i - j }$
Prominence	$PROM = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \{i - j - \mu_x - \mu_y\}^4 \times P(i, j)$
Inertia	$INERTIA = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \{i - j\}^2 \times P(i, j)$
Shade	$SHADE = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \{i - j - \mu_x - \mu_y\}^3 \times P(i, j)$
Dissimilarity	$Dissimilarity = \sum_{i,j} i - j p(i, j)$

Texture feature	Formula
ASM	$ASM = \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} [\wedge_{p=i,j,d,\theta}]^2$
Sum Average	$AVER = \sum_{i=0}^{2G-2} i^p (i)$ $x-y$
Sum of Squares	$SSQ = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} (i-\mu)'P(i,j)$

O. Prediction

All the above described methods were adopted for the prediction of liver image / segmentation of the interested area in the image in question. The entire stepwise procedure is simplified and given in the flowchart (Figure 16).

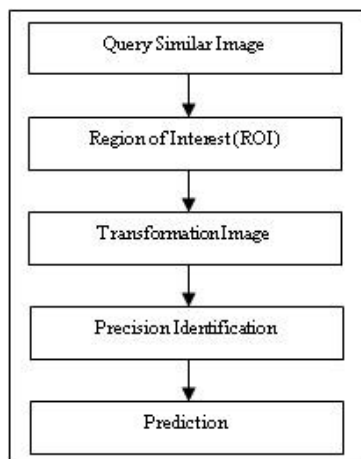


Fig 13. Process of prediction for liver segmentation

P. Region of Interest (ROI)

A region of interest (often abbreviated ROI), is a selected subset of samples within a dataset identified for a particular purpose. The concept of a ROI is commonly used in many application areas. For example, in medical imaging, the boundaries of a tumor may be defined on an image or in a volume, for the purpose of measuring its size.

Q. Transformation image

A function or operator that takes an image as its input and produces an image as its output, depending on the transform chosen, the input and output images may appear entirely different and have different interpretations. Fourier transforms, principle component analysis (also called Karhunen-Loeve analysis), and various spatial filters, are example of frequently used image transformation procedures.

This equation is considered

$$G(x,y) = T\{ f(x,y) \} \text{------(34)}$$

R. Validating of the result

The validations of automated detection of liver image, two measures are mostly used: sensitivity and specificity. Confusion matrix is used for measuring the sensitivity and specificity (Claude and Geoffrey, 2010)

True positives- Correctly identified abnormal liver image.

True negatives- Correctly rejected abnormal liver image.

False positives- Incorrectly identified normal liver image.

False negatives- Incorrectly rejected normal liver image.

Calculate accuracy using properties of actual positives which are correctly identified.

Accuracy

$$= \frac{\text{true positives} - \text{true negative}}{\text{true positives} - \text{true negatives} - \text{false positives} - \text{false negatives}}$$

Calculate error rate that probability of a negative tests given that the liver has no structural abnormalities.

IV. EXPERIMENTAL RESULTS

This chapter embodies the result of entire image process conducted for liver segmentation and development of retrieval technique. In addition the interpretation of the results for the achievements proposed objectives.

The preceding section of thesis describes the methodology followed for the liver segmentation and a new novel algorithm for the automatic retrieval technique. The results were obtained by adopting various new ways of image processing methods. They are exhibited by suitable tables and pictures where ever necessary.

As outlined earlier part, an exclusive database consisting of 800 abdominal CT scan images available from open source was developed as a

repository for investigation. A few such sample images (16 Numbers) which were served for the extraction of liver and retrieval process are shown below as representation. The first level of experiments on image was segmentation of clear liver image from abdominal image of multi organ.

A. Liver segmentation

Liver segmentation was achieved by undertaking a stepwise preprocessing. The sequential steps were denoisation, NTSC colour format, contrast enhancement and smoothing. Unwanted noises of images were eliminated by denoisation. After the removal of noises the images were appeared in good visual quality and edges of liver were clearly detected. The screen shot exhibited below shows a denoised image (Figure 18).

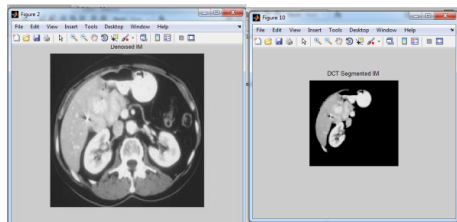


Fig 14. (a) Input Query Image (b) Segmented Liver image

B. Feature extraction

Once liver is perfectly segmented, the next objective is to extract the image features for knowing very finer details of the liver image. Few pre-processing ways are undertaken before initiation of feature+ extraction. The explanation and the results are presented in this section. The first initial preprocessing step is inverse image. This was done by statistical method. This gives a cryptographic attack on hash function. Thereby it prevents the unwanted details of the image.

Shape features such as area, perimeter, roundness and solidity were determined. The results of extraction of those features are presented in table 4. The table contains data for the only selective 40 abdominal CT scan images after post pre processes. An important point to be noted in this circumstance that presentation of data on feature extraction for the whole 800 abdominal images make a very large table which gives a strain to the reader as well as causing a hardship to provide an evidence on the result of automatic retrieval method. Hence only data for 40 images is furnished. The same 40 images are used

for all the rest of investigation and innovation of new algorithm for recapturing technique.

C. Results of retrieval process

The final pace of this present work is to design an algorithm for an automatic retrieval technique. This section describes the achievement of the above objective. The dataset which was developed after entire image processing and their unit values were used as repository to derive the equivalent image while the data for the selective quarry image run into the database. A novel new stepwise algorithm was introduced and employed for the recapturing of the resultant image from the dataset, when automatically computed with the image features data of the selected query image. For this purpose the principle of Least Distance Method (LDM) was adopted. This means the closest difference is at 0.

D. Algorithm followed for Least Distance Method

Input : Shape, Intensity, Texture Features Values
Output: LeasedDistance Method Measure nearest zero and similar image

Step 1: Initialize I = 0; D=0; L =0
 Step 2: Load features data set
 Step 3: Calculate Leased difference nearest 0 for feature i
 For i = 1:N

$$D = \text{abs} \left| \frac{f_i}{f_{j-}} \right|$$

End

N = No. of features

q = Query Image Features

f = Features Data Set

D = Difference

Step 4: Find nearest zero in f_i

If Min (D_i) is nearly zero

Assign L_i = Min (D_i)

L = Lease Distance Value zero

Step 5: Find L_i until all the features dataset reached.

Step 6: There is no match means the query image stored in a new image

The results of the execution of algorithm for recapturing the equivalent image by least distance method are explained in following paragraphs and in tables showing that which image has the least distance (i.e. at 0) by image identification number for each category of the image characteristics (shape, intensity and texture). It is denoted by bold numbers. Table 9 is presented with the findings on shape and intensity matching.

Summary of the above findings is provided in the table 10 given below. From the summary it was evident that No.35th image of segmented liver image data set was so similar with that of the image

characteristics of area, perimeter, equivalence diameter and pwl.

TABLE4.
Summary Table for Shape and Intensity Features

Shape features	
Feature Name	Image ID
Area	35
Perimeter	35
Roundness	38
Solidity	06
No. of Time occurrences	2/4
Intensity Features	
Threshold	18
Irregularity Index	10
Equivalence Diameter	35
Piece wise Linear Function	35
No. of Time occurrences	2/4

TABLE5.
Result of Image Retrieval Process at Different Orientation

Feature Set	Image ID in Different Angle			
	0°	45°	90°	135°
Correlation	35	12	35	27
Contrast	35	3	3	35
Energy	35	35	35	35
Variance	4	35	35	4
Entropy	35	35	35	35
Homogeneity	35	33	35	33
Prominence	35	35	35	35
Inertia	1	3	3	3
Shade	15	15	15	15
Dissimilarity	1	1	1	1
Sum Average	35	35	35	35
Sum of Squares	1	1	1	1
ASM	35	35	35	35
No. of Time Occurrences	8/13	6/13	8/13	6/13

The accuracy value was estimated by application of confusion matrix equation with the number of occurrences. The principle of classification is given in the table below. (Table 5)

TABLE6.
Results on the Predictive Accuracy after Confusion matrix analysis

Features	Accuracy	Error Rate
Shape	0.9691	0.0309
Intensity	0.9874	0.0126
Texture	0.9898	0.0102
Weighted Accuracy / Error Rate	0.9821	0.0179

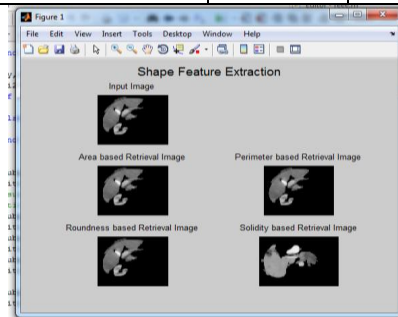


Fig 15. Resultant Image for Shape Feature

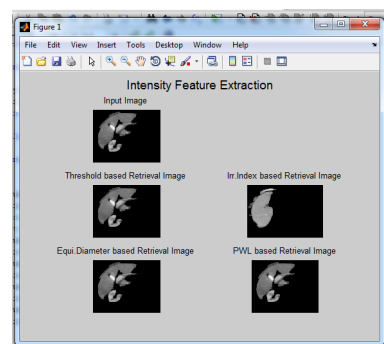


Fig 16. Resultant image for Intensity Feature

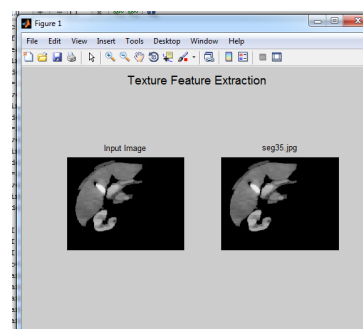


Fig 17. Resultant image for texture feature

V. CONCLUSION

In view of the above constrain, a study has been attempted in the present project work on clear segmentation of liver by adopting few preprocessing

techniques such as Denoising, NTSC colour format, contrast enhancement, smoothing, inverse image, Edge detection, SOBEL image, area, perimeter, roundness, solidity, threshold, irregularity index, equivalent diameter and pair wise linear function. A large dataset consisting of 800 abdominal CT scan images are utilized. Further a new novel algorithm with the principle of Least Distance Method (LDM) is followed for the development of liver image retrieval technique and the basis of physical numerical characteristics of pixels. The liver image texture feature analysis by high order statistical approach enabled to know the homogeneity and differentiations of image shape, intensity and texture. This information has served as a base for the development of predictive algorithm by the principle of least distance method. The proposed stepwise algorithm has shown significant retrieval speed and accuracy. The prediction resulted in a expected satisfaction. This is proved when the results are analyzed in confusion matrix equations. The accuracy rate is 98.84%.

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