

# Segmentation of Liver and Retrieval Procedure by Feature Extraction for CT-Scan Abdominal Image Processing

K.A.M. Sajad Hyder, M. Vanitha

**Abstract:** Liver is an important vital organ. In these days medical professionals utilize CT scan abdominal images for the diagnosis of liver disorders. There arise the problem of liver segmentation and image processing for recapturing the matching image of predetermined image of liver ill state. In this present work a new way of methodology has been introduced for the pulling out liver image in a large dataset of abdominal scanned images. Further the segmented liver images are preprocessed for the feature extractions of Shape, Intensity and Texture. An automatic system of Least Distance Method (LDM) is used for the recalling of image is run into the system. There is a significant speed and accuracy have been notified by this LDM. The above results are discussed with earlier related works and concluded with the application in clinical practice.

**Keywords:** Automatic retrieval technique, Digital image processing, Liver Segmentation, Least Distance method for recapturing matching image.

## I. INTRODUCTION

Diagnosis of diseases by non-invasive methods is attracting medical professionals since the revolution of science and technology resulted in the findings of abdominal image capturing biomedical equipments. Each patient has a unique structural defect. Prediction of diseased state is case sensitive. Voluminous image data has been accumulated for future references. Above and beyond to pull a definite diagnostic conclusion out of this large image collection is a difficult task. Moreover medical experts do not find enough time to go through the entire data and unaware of image features. The advancement of computer automatic image processing may mitigate this burden of heavy time consuming as well as a way for accurate prediction. Liver is an important vital organ, There are many structural and functional defects occur in liver. Liver is situated in the abdominal region. In abdomen along with liver other organs like spleen, pancreas, kidneys and intestine are located. Tissue homogeneity of their organs way develop less dissimilarities in image formation.

This causes a hardship to segment the image of liver alone in abdominal CT scan images. Therefore extraction of liver image followed with image processing is mandatory for the prediction of liver disorders through CT scan image analysis. Nevertheless automatic retrieval of diseased liver image from the prediagnosed image dataset would also be helpful to the health professional to initiate treatments.

The gray-level based procedure involves direct utilization of characteristics of images. These methods are often entertained in clinical practice. The drawback in this image processes mean depends on the developments of grey-level of liver targets. When grey-level is not stable the extraction speed is get minimized. Histogram comparisons are also considered in some methods. In some grey-level method manual analysis or rough segmentation is also be made. The methods those are devoid of using prior knowledge the accurate prediction may fail when percentage of liver image low. The notable merit of the above method is that they are more sensitive to boundaries of the digital images. Above and beyond they are more close to capture boundaries since the single individual image has numerous boundaries. Sometimes this may lead to an under or incomplete segmentation. The adding of neural-network and manual involvement may refine the gray-level methods to overcome many issues [1].

The structure base methods are concern with the unclear image of the liver and using prior knowledge. The limitation of the method is that they require large instruction data to cover all the aspects of liver texture [2]. On the other hand the texture methods are more complex and the involvement of human eye sight to do segmentation. The main advantage is more details of features are considered at a specified time and interpretation of results by manual segmentation. Nevertheless even when the liver boundaries are not clear, texture based method extraction beneficial for best results. Studies for the improvements are on and machine learning plus pattern identification with less processing are looked for [3]. In view of the above context an attempt has been made in this present work to develop a computer automatic technique to segment liver image in abdominal CT scan image data repository. Further an automatic speedy computer aided liver image retrieval process also designed.

## II. MATERIALS AND METHODOLOGY

Eight hundred abdominal CT scan images and for try segmented liver digital images are the materials utilized for this study.

Revised Manuscript Received on 30 September 2016.

\* Correspondence Author

K.A.M. Sajad Hyder\*, Research Scholar PG & Research, Department of Computer Science, J.J College of Arts and Science, Pudukkottai (Tamil Nadu)-622422, India.

Dr. M. Vanitha, Ph.D. and Research, Assistant Professor, Department of Computer Application, Alagappa University, Karaikudi (Tamil Nadu)-600006, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>

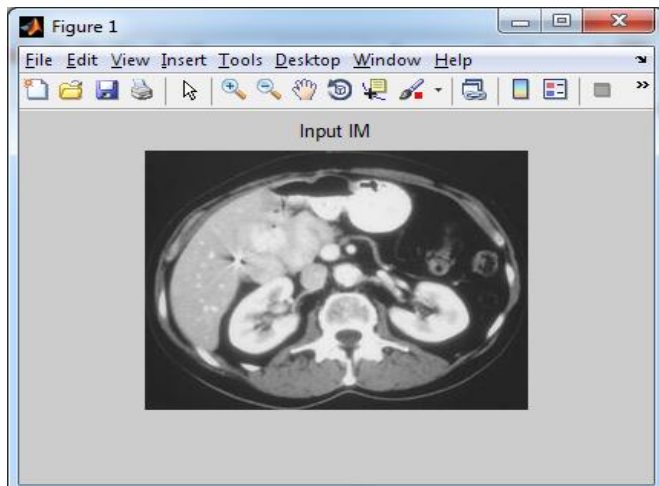
**2.1. The Procedure adopted for Liver Segmentation**

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 details of methods adopted are described below:

The following is a sample query image, which was processed by the proposed segmentation and feature extraction.

**2.1.1 Sample Dataset abdominal CT Scan Image**

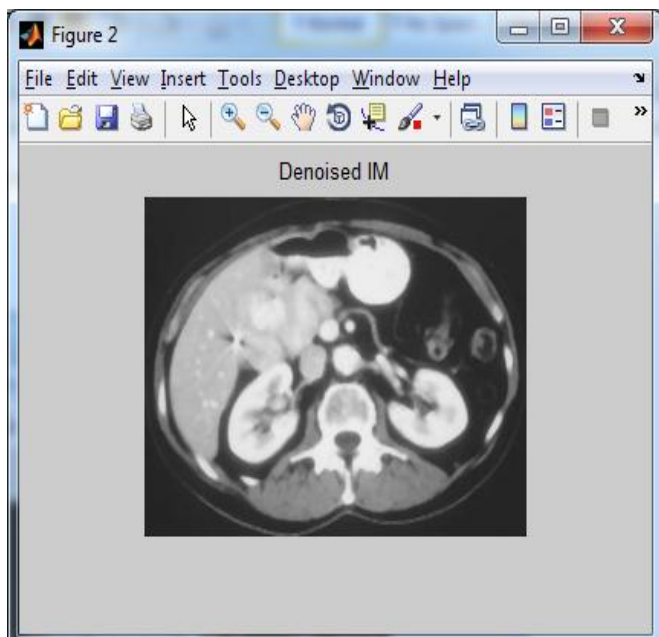
The photograph of sample abdominal CT scan image.



**Fig 1. Sample abdominal CT scan image**

**2.1.2. Denoising**

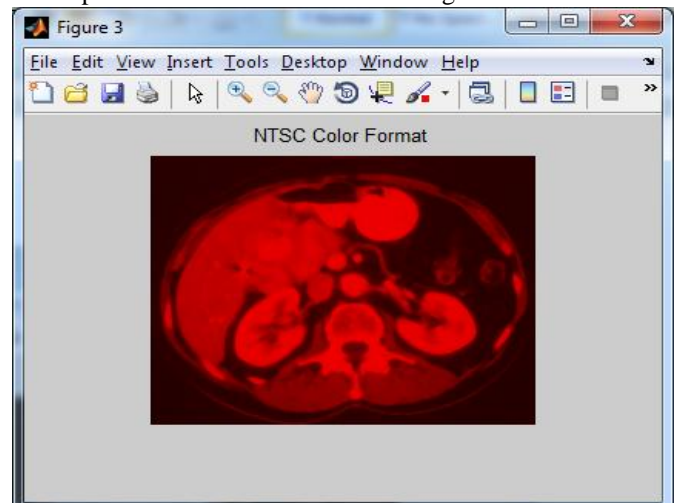
Denoising of the images was done by mean square error and peak signal noise ratio. This method was adopted by earlier workers to denoise the images at considerable level. The following mathematical steps were followed to calculate the ratio.



**Fig 2. Denoised Image**

**2.1.3 NTSC Color Format**

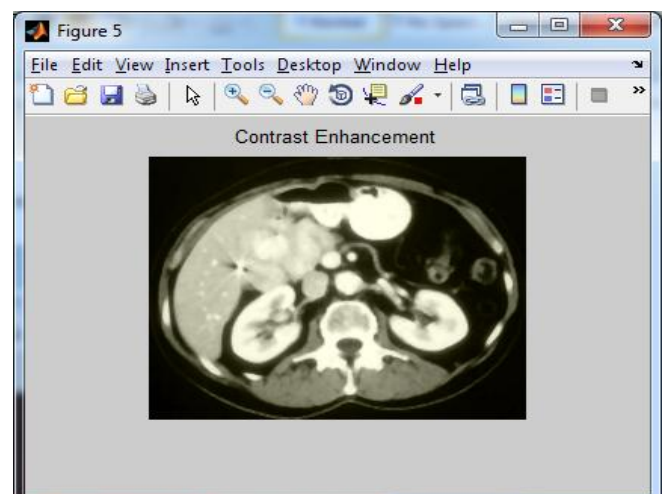
The next step was NTSC based colour format. To determine the accurate contrast of an image the colour format was applied. The Principle of this method is red colour is enhanced in red, green and blue combination. Once red colour is well pronounced the contour of an image is visualized well.



**Fig 3. NTSC Color Format**

**2.1.4 Contrast Enhance Image**

The image processed after contour enhancement was subjected for the next step of increasing the contrast. Here “Hue” and skewness values were raised. This was resulted an increase of contrast in the image under examination.



**Fig 4. Contrast Enhancement**

**2.1.5 Inverse imaging**

In this step the more brightness were given to the region of bright areas. Similarly excess dullness were also given to the dull fields. By this way “Skewness” and edges of the images were corrected.

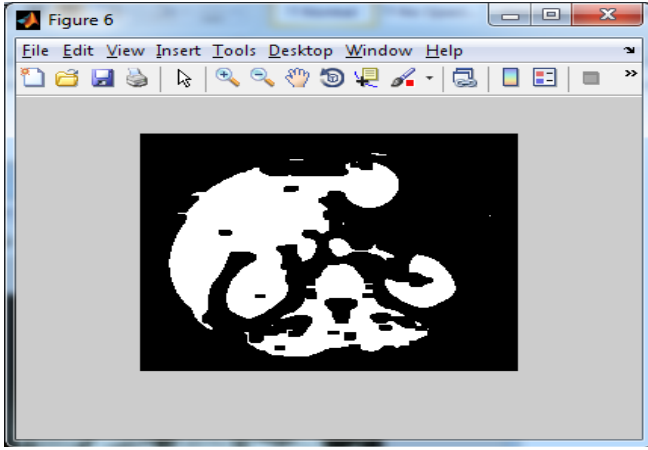


Fig 5. Inverse Image

2.1.6 Smoothing Techniques

By smoothing techniques all the edges were corrected. Since even after inverse imaging there were some uncorrected edges.



Fig 6. Smoothing Image

2.1.7 Segmentation of Liver

Finally Discrete Cosine Transform (DCT) algorithm was followed to extract liver accurately from the scanned digital image. The detailed steps of the utilized algorithm is given below

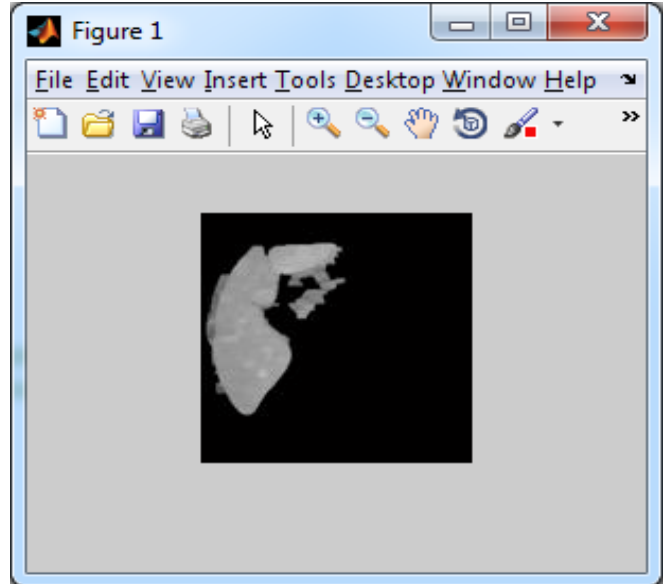


Fig 7. Segmented Liver Image

2.2 Image Feature Analysis for Retrieval

The Second Phase of examination was the analysis of image features in extracted liver image arrived at the query image first phase observation. In Phase II and Pre Processing of segmented liver was done by following heads.

2.2.1 Query Image

After the first phase was over the same image was processed for the feature extraction. Before initializing the feature extraction a preprocessing steps were undertaken. Given below is the different method of preprocessing carried in phase II experiments.

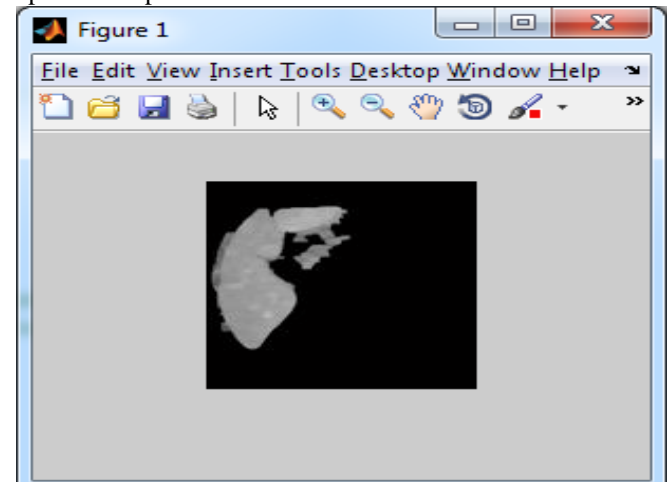


Fig 8. Query Image

2.2.2 Inverse Image

During this method "Skewness" and edges were corrected. The same method was followed as that of segmentation of liver from abdomen CT Scan images. The Principle was given elsewhere. The brightness regions were increased into more brightness and the dull areas were also raised to more dullness. Thereby edges were looked clearly.

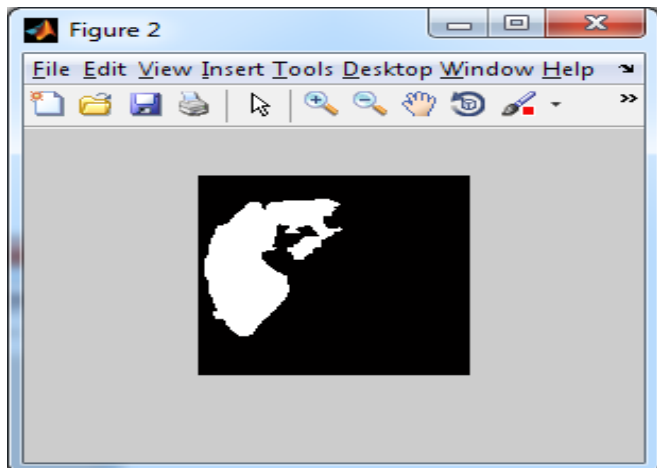


Fig 9.Preprocessed Inverse image

2.2.3 Edge detection

The edges of images which were selected by inverse image processing were subjected for all vector calculations. The formula all the steps are detailed below

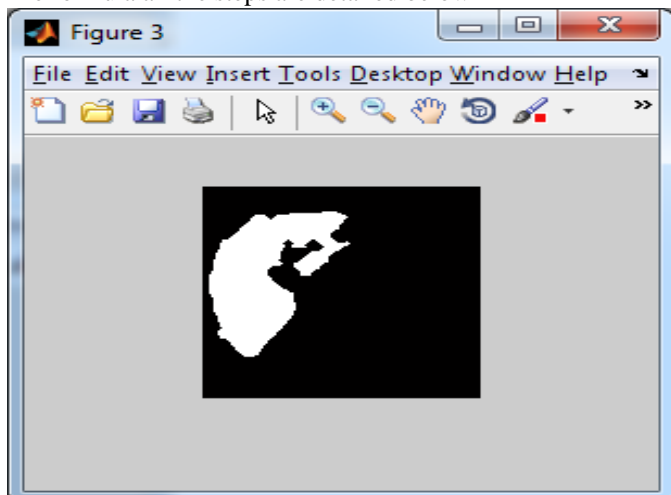


Fig 10.Edge Detection for Query Image

2.2.4 SOBEL Method

A marker was given for the location of targeted area on the liver image. A square marker was made to encircle the region of liver image under observation.

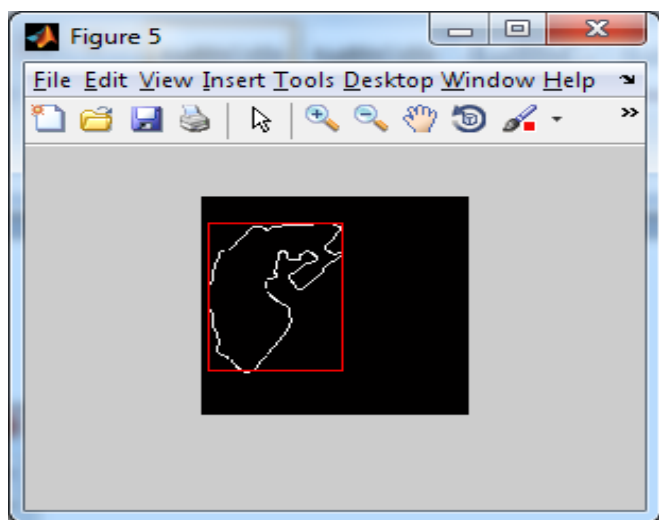


Fig 11 SOBEL Image

2.2.5 Feature Extraction

The query image and the data set were analyzed by image features. The image features of shape, intensity and texture at four different degrees of 0°, 45°, 90° and 135° were determined and tabulated. The method of GLCM was utilized in MATLAB. The mathematical derivative steps are explained below.

```
Offsets = [0 1; -1 1; -1 0; -1 -1];
glcm= graycomatrix (I, 'NUMLEVELS', 8, 'G', [],
'Offset', [1 0]);
```

2.2.6 Retrieval Technique

The odd query image was run into the data compiled by the above described image processed for the data set. The distance between query and the retrieval image were very nearer to zero in all features at lowest distance. This recaptured image was appeared on the screen. Thereby the predetermined liver defect was assumed for the query liver image too.

III. IMPLIMENTATION

Fig 12 is the representation of the dataset for the 800 images of abdominal CT scan.

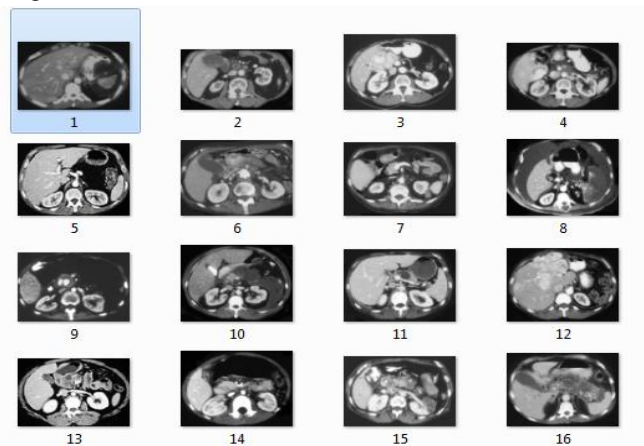


Fig 12.Sample Dataset

The process of segmentation of liver out of the dataset consisting 800 abdominal images was yielded images with clear segmented liver. Fig. 13



Fig. 13. Sample photographs of 40 segmented liver images

Among these images 40 images are selected for the automatic retrieval procedure and image feature extraction for the convenience of the present study. These images were processed after the smoothing technique.

The same procedure adopted for the query image was also followed for the entire sample dataset of segmented liver images (Fig.9).

Figure 10 is showing edges of liver processed after the correction of skewness and edge detection as that of query image explained in preprocessing. The same image is subjected to the next step of the SOBEL method. Figure 11 is showing marked liver area in the segmented image. The resultant image is further analyzed for various feature extraction. All the images are processed by the same way.

The results of different image features such as shape, intensity and texture at different degrees 0°, 45°, 90° and 180° are given in Tables 1, 2 and 3. The table is also furnished with details of various characters of shape, intensity and texture features and their formula.

**Table 1. Shape based Features**

Area	$A = n [1]; n [ ]$ represents the count of number of the patterns within the parenthesis
Perimeter	$\sum Ed(L)$
Roundness	$C = \frac{P^2}{4\pi A}$

**Table 2. Intensity based Features**

Threshold	$\sum TH(L)$
-----------	--------------

**Table 4. Shape and Intensity Feature Extraction**

Image ID	Shape Features Extraction			Intensity Feature Extraction		
	Area	Perimeter	Roundness	Threshold	Irregularity Index	Equivalent Diameter
1	7883	190	0.72004	0.258824	2.744064	100.1846
2	3963	186	0.655583	0.235294	1.439488	71.03413
3	4898	230	0.749388	0.333333	1.163518	78.97042
4	5910	155	0.831926	0.305882	3.091249	86.74587
5	3593	171	0.569865	0.32549	1.544098	67.6369
6	2727	127	0.606	0.333333	2.124651	58.92473
7	2152	119	0.647998	0.345098	1.909669	52.34512
8	4813	249	0.6228	0.262745	0.975499	78.28219
9	4663	131	0.779766	0.215686	3.414544	77.05268
10	4036	176	0.527582	0.286275	1.637328	71.68539
11	2098	99	0.682276	0.258824	2.689955	51.6842
12	3597	108	0.685535	0.270588	3.875277	67.67453
13	2857	196	0.548579	0.262745	0.934562	60.3129
14	1364	119	0.462687	0.305882	1.210404	41.67372
15	1553	111	0.815651	0.433333	1.583928	44.4673
16	2380	149	0.57697	0.345098	1.347145	55.04825
17	2912	137	0.779026	0.243137	1.949665	60.89067
18	2419	152	0.602041	0.321569	1.315705	55.49745
19	2963	185	0.63312	0.278431	1.087923	61.42157
20	1519	94	0.64147	0.317647	2.160289	43.97785
21	3964	138	0.647712	0.305882	2.615684	71.0431
22	2761	123	0.675226	0.305882	2.293327	59.29093
23	3880	160	0.666438	0.356863	1.904591	70.28634

Irregularity Index	$I = \frac{4\pi \times \text{Area}}{(\text{Perimeter})^2}$
Equivalent Diameter	$E_d = \sqrt{\frac{4 \times \text{Area}}{\pi}}$

**Table 3. Texture based Features**

Correlation	$\sum_{i,j} \frac{(i - \mu_i)(j - \mu_j) \overline{p(i,j)}}{\sigma_i \sigma_j}$
Contrast	$\sum_{i,j}  i,j ^2 p(i,j)$
Energy	$\sum_{i,j} p(i,j)^2$
Variance	$\sigma^2 = \frac{1}{N \times M} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (P(i,j) - \mu)^2$
Entropy	$E = - \sum_i \sum_j P[i,j] \log P[i,j]$
Homogeneity	$\sum_{i,j} \frac{p(i,j)}{1 +  i - j }$

The results of difference between the odd query image and images compiled in dataset are presented in following tables (4-9).

24	2216	108	0.711168	0.243137	2.387438	53.11778
25	3088	148	0.737521	0.298039	1.771592	62.70378
26	3227	147	0.732078	0.278431	1.876611	64.09949
27	4496	124	0.724577	0.254902	3.674454	75.66033
28	2500	158	0.744048	0.345098	1.258449	56.41896
29	2551	124	0.726781	0.298039	2.08486	56.99153
30	4395	160	0.821035	0.309804	2.157391	74.80567
31	2208	121	0.62585	0.290196	1.895126	53.02182
32	1891	108	0.76404	0.272549	2.037295	49.06828
33	1698	107	0.614105	0.211765	1.863717	46.49689
34	2491	113	0.750301	0.337255	2.451471	56.31731
35	3675	144	0.698006	0.266667	2.227113	68.40435
36	5427	207	0.734967	0.32549	1.591582	83.12563
37	2245	112	0.598667	0.258824	2.249004	53.46422
38	1281	78	0.636048	0.32549	2.645878	40.38589
39	1760	134	0.573664	0.32549	1.231723	47.33816
40	1035	64	0.743534	0.188235	3.17534	36.30156

Table 5. Query Image: Shape and Intensity Feature Extraction

Query Image ID	Shape Feature Extraction			Intensity Feature Extraction		
	Area	Perimeter	Roundness	Threshold	Irregularity Index	Equivalent Diameter
Seg46	2562	150	0.7678	0.2863	1.4309	57.1143

Table 6. DIFFERENCE: Shape Feature

Image ID	Shape Features			Intensity Features		
	Area	Perimeter	Roundness	Threshold	Irregularity Index	Equivalent Diameter
1	2.0768	0.2666	0.0621	0.0958	0.9177	0.7541
2	0.5468	0.24	0.1461	0.1780	0.1442	0.2437
3	0.9117	0.5333	0.0239	0.1643	0.1868	0.3826
4	1.3067	0.0333	0.0835	0.0684	1.1603	0.5188
5	0.4024	0.14	0.2577	0.1369	0.0791	0.1842
6	0.0644	0.1533	0.2106	0.1643	0.4848	0.0316
7	0.1600	0.2066	0.1559	0.2054	0.3346	0.0835
8	0.8786	0.66	0.1888	0.0821	0.3182	0.3706
9	0.8200	0.1266	0.0156	0.2465	1.3863	0.3490
10	0.5753	0.1733	0.3128	0.1232	<b>0.0060</b>	0.2551
11	0.1811	0.34	0.1113	0.0958	0.8799	0.0950
12	0.4039	0.28	0.1070	0.0547	1.7082	0.1848
13	0.1151	0.3066	0.2854	0.0821	0.3468	0.0560
14	0.4676	0.2066	0.3973	0.0684	0.1540	0.2703
15	0.3938	0.26	0.0623	0.5136	0.1069	0.2214
16	0.0710	0.0666	0.2484	0.2054	0.0585	0.0361
17	0.1366	0.0866	0.0146	0.1506	0.3625	0.0661
18	0.0558	0.0133	0.2158	<b>0.0</b>	0.0804	0.0283
19	0.1565	0.2333	0.1753	0.0273	0.2396	0.0754
20	0.4071	0.3733	0.1644	0.1095	0.5097	0.2300
21	0.5472	0.08	0.1563	0.0684	0.8280	0.2438
22	0.0776	0.18	0.1205	0.0684	0.6027	0.03811
23	0.5144	<b>0.0066</b>	0.1319	0.24657	0.3310	0.2306
24	0.1350	0.28	0.0737	0.15068	0.6684	0.0699
25	0.2053	0.01333	0.0393	0.04109	0.2381	0.09786
26	0.2595	0.02	0.0464	0.02739	0.31149	0.1223
27	0.7548	0.1733	0.05623	0.109589	1.5679	0.32471

28	0.0241	0.05333	0.03087	0.205479	0.12051	0.012174
29	0.4344	0.173333	0.05336	0.04109	0.45703	0.19767
30	0.71545	0.06666	0.06939	0.08219	0.50772	0.3097
31	0.13817	0.193333	0.18483	0.01369	0.32443	0.07165
32	0.2619	0.28	0.17154	0.04794	0.4237	0.1408753
33	0.3372	0.286666	0.20012	0.26027	0.30248	0.18589
34	0.02771	0.246666	0.022734	0.178082	0.7132479	0.01395
35	<b>0.00429</b>	0.04	0.090848	0.068493	0.5564520	<b>0.00214</b>
36	1.11826	0.38	0.042706	0.136986	0.112301	0.455426
37	0.1237	0.253333	0.220237	0.095890	0.571750	0.063907
38	0.5	0.48	<b>0.00483</b>	0.13698	0.84911	0.29289
39	0.31303	0.1066666	0.25280	0.13698	0.139191	0.17116
40	0.59601	0.5733333	0.031547	0.3424657	1.2191	0.36440

Table 7. Texture Feature Extraction for Correlation

Image ID	0°	45°	90°	135°
1	0.965321	0.948139	0.974436	0.951429
2	0.96203	0.953476	0.97011	0.93377
3	0.974902	0.959598	0.9757	0.955367
4	0.972968	0.970789	0.983607	0.965009
5	0.969381	0.961051	0.979288	0.951729
6	0.972989	0.962097	0.979919	0.957211
7	0.967159	0.963244	0.984536	0.953487
8	0.972182	0.951251	0.97123	0.952706
9	0.976723	0.971881	0.980574	0.95589
10	0.967654	0.957599	0.976398	0.948687
11	0.968549	0.955254	0.981453	0.96339
12	0.974148	<b>0.97219</b>	0.986829	0.964092
13	0.966568	0.953226	0.973501	0.94547
14	0.958133	0.930018	0.956558	0.920798
15	0.964005	0.961897	0.976247	0.935492
16	0.968365	0.951081	0.979748	0.959962
17	0.970198	0.955879	0.976896	0.95595
18	0.96802	0.95918	0.978244	0.947701
19	0.974907	0.961827	0.977692	0.957852
20	0.960254	0.949971	0.98413	0.953689
21	0.976715	0.968261	0.981807	0.964181
22	0.969366	0.96678	0.980543	0.948471
23	0.970255	0.959459	0.979205	0.953658
24	0.97157	0.969674	0.986694	0.961234
25	0.975404	0.964633	0.978675	0.957843
26	0.969071	0.956918	0.980254	0.957808
27	0.978348	0.971656	0.982914	<b>0.967076</b>
28	0.963681	0.95337	0.974903	0.942431
29	0.973351	0.966961	0.981731	0.955715
30	0.975942	0.969301	0.979887	0.958368
31	0.961499	0.952361	0.979121	0.946499
32	0.968045	0.963245	0.971509	0.936156
33	0.965103	0.957784	0.983039	0.954854
34	0.973495	0.96936	0.986768	0.962995
35	<b>0.978573</b>	0.960372	<b>0.97739</b>	0.955362
36	0.972741	0.961979	0.977926	0.953673
37	0.960482	0.952192	0.979116	0.945799

38	0.976336	0.972062	0.987276	0.965696
39	0.965567	0.952625	0.975339	0.946584
40	0.960455	0.946868	0.979829	0.955771

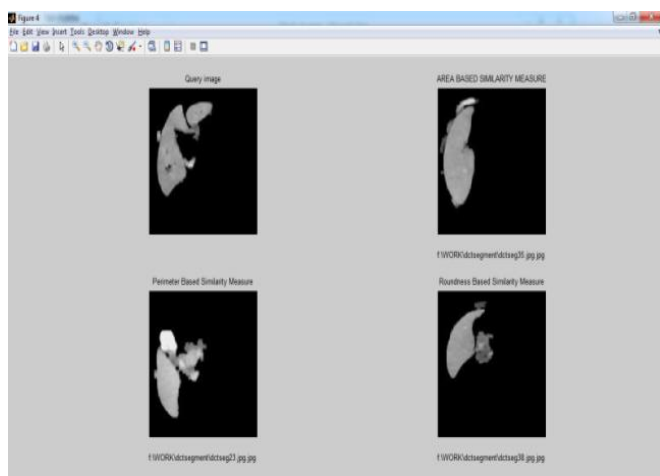
Table 7 is presented with the data of feature extraction after the calculation of correlation under texture characteristics. In this same way the data for all the remaining features results are explained in the different tables for reference. Due to the constraint of page consumption the above said table 7 is given as representative sample table for all the data.

**Table 8. Difference findings for Texture Features**

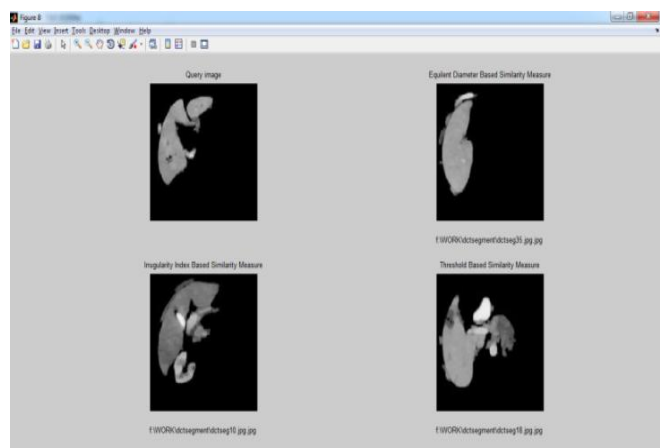
Feature Set	0°	45°	90°	135°
Correlation	1.559461	1.58283	<b>1.548966</b>	1.59456
Contrast	0.194609	0.136549	0.240547	<b>0.119334</b>
Energy	1.457335	1.471407	<b>1.454274</b>	1.475278
Variance	1.966507	1.954332	1.966507	<b>1.954332</b>
Entropy	1.815941	1.739614	1.840625	<b>1.721473</b>
Homogeneity	1.552643	1.564193	<b>1.550544</b>	1.567797

**Table 9. Result of Image Retrieval Process at Different Orientation**

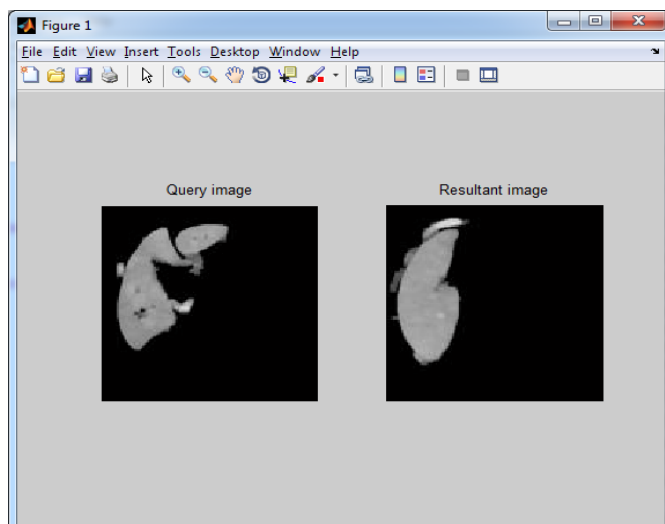
Feature Set	Image ID			
	0°	45°	90°	135°
Correlation	<b>35</b>	12	<b>35</b>	27
Contrast	23	3	3	<b>35</b>
Energy	<b>35</b>	<b>35</b>	<b>35</b>	40
Variance	40	<b>35</b>	<b>35</b>	<b>35</b>
Entropy	1	37	36	<b>35</b>
Homogeneity	<b>35</b>	<b>35</b>	<b>35</b>	<b>35</b>
<b>No. of Time Occurrences</b>	<b>3/6</b>	<b>3/6</b>	<b>4/6</b>	<b>4/6</b>



**Fig 14. Resultant Image for Shape Feature**



**Fig 15. Resultant image for Intensity Feature**



**Fig 16 Resultant image for Texture Feature**

The 35<sup>th</sup> image was resulted as an image which had nearer to 0 differences. From the forgoing results of image processing it would be suggested that the 35<sup>th</sup> image is a retrieved image from the dataset. It is also be presumed that the query odd liver image has all the image features as equal that of 35<sup>th</sup> image of the dataset.



It is evident that the present automatic image process effectively segmented the liver region and the selection of defective liver from the predetermined diseased cases of liver images. This would help the medical experts to draw the diagnostic conclusion by using this automatic computer process.

#### IV. DISCUSSION

Medical image segmentation has been given more attention and attraction for the prediction accuracy for the past decades. Many workers have been studied segmentation of interested organ image by numerous automatic computer image processing methods. In this present work the segmentation of liver image from a large dataset consisting of 800 abdominal real CT scan images. This large dataset is used for the efficiency and development of new method for the application of liver image extraction. In this attempt a sequential steps of Denoising, NTSC colour, increasing contrast, correction of skewness and edge correction means are used to isolate an obvious liver image without any arbitraries from the dataset. Finally liver image is marked by Discrete Cosine Transformation (DTC algorithm).

The grey-level procedure is normally adopted and shown by many workers in this line of research for the liver segmentation. [4,5,6]. However when single image of liver has numerous boundaries. This may lead to artifact or incomplete segmentation. Most likely the texture methods are also having some issues and require manual involvement. The other common method of structure bound analysis also have some problems on pulling out the liver image [7,8,9]. Although structural analysis is effective, combinations of other techniques are also suggested to obtain accuracy of 75% and above.

The proposed method which is followed in this present work covers all the aspects and without any constrains in liver image segmentation. It could also be noted that speed of process is highly significant and not manual processing is needed. In the next phase of experiments the groups of 40 segmented liver images are subjected for the feature extraction and for mining the correlation of suspected liver image. The pre processing steps are including image, edge detection, and SOBEL means. Then the various features of image like shape (Area, Perimeter, and Roundness), intensity (Threshold, Irregularity Index) and Texture (Autocorrelation, contrast, prominence and energy) are determined by statistical derivation in MATLAB. The above image process is successfully capture an equal image of zero difference between the query image and the resultant image of dataset. The proposed algorithm of Least Distance Method (LDM) is a new kind in this field. The results have disclosed the minimg efficiency of the above new algorithm. Therefore in the light of liver segmentation and retrieval of an image from the dataset the present proposed procedure and algorithms (LDM) are best suitable for practical applications in clinical domain.

#### V. CONCLUSION

Liver segmentation in abdominal CT scan pixel pictures and automatic recapturing of liver defective picture from the dataset pave a way for quick diagnosis of liver diseases. It reduces the diagnostic time and cost effective in medical

practice. Much more clear observations are needed to investigate involving various image processing methods and combinations of certain procedures to achieve cent present efficiency. This research area is open for new venture and application in medical profession.

#### ACKNOWLEDGMENTS

The author (K.A.M. Sajad Hyder) is grateful to Prof. Dr .K. Jayapraksh, Head, Research and Development, Department of Biotechnology, KVCET, Chennai for his critical review of the subject.

#### REFERENCES

1. R. Punia and S. Singh, "Review on Machine Learning Techniques for Automatic Segmentation of Liver Images," International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 3, No. 4, 2013, pp. 666-670
2. M. Erdt, et al., "Fast Automatic Liver Segmentation Combining Learned Shape Priors with Observed Shape Deviation," Computer-Based Medical Systems, 2010, pp. 249-254
3. M. Sammouda, et al., "Tissue Color Images Segmentation Using Artificial Neural Networks," Biomedical Im-aging: Nano to Macro, 2004
4. G.G. Rajput and Anand M.Chavan (2016) "Atomic Detection of Abnormalities Associated with Abdomen and Liver Images : A survey on Segmentation methods", International Journal of Computer Applications, Volume 140-No.4, pp. 1 to 8
5. Lav R.Varshney (2002), "Abdominal Organ Segmentation in CT-Scan Images : A Survey", International Journal of Information Technology, Volume 100. pp. 200 to 215
6. Luo et. al., (2014), "Review on the methods of Automatic Liver Segmentation from Abdominal Images" Journal of Computer and Communications, 2, pp. 1-7
7. X. Zhang, et al., "Automatic Liver Segmentation Using a Statistical Shape Model With Optimal Surface Detection," IEEE Transaction on Biomedical Engineering, Vol. 57, No. 10, 2010, pp. 2611-2626
8. M. Erdt, et al., "Fast Automatic Liver Segmentation Combining Learned Shape Priors with Observed Shape Deviation," Computer-Based Medical Systems, 2010, pp. 249-254
9. H. Badakhshannoory and P. Saeedi, "A Model-Based Validation Scheme for Organ Segmentation in CT Scan Volumes," IEEE Transaction on Biomedical Engineering, 2009, pp. 2681-2693