ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 9, September 2015

Optimized Liver Segmentation using Ant Colony Optimization

Ina Singh
Amritsar College of Engineering and Technology

Neelakshi Gupta
Assistant Professor
Amritsar College of Engineering and Technology

Abstract
Liver Segmentation is a very essential task in planning of liver transplantation surgeries. In the abdominal CT scan image the liver is observed clearly nevertheless the physician needs the accurate boundaries and correct size measurement for the liver transplantation surgery. The boundaries of the various organs are nor clearly visible as a result of complex structure of the human body. This paper focuses on segmentation of liver using k-means and Ant Colony Optimization. Ant Colony Optimization is used to optimize the poorly selected k-clusters. The Computed Tomography images were used to segment the liver section. Quantitative analysis was performed on the basis of accuracy and specificity. High accuracy and specificity was achieved with hybrid Ant colony and K-means clustering which clearly suggests that the hybrid method is better than k-means clustering.

Keywords
Ant Colony Optimization, Computed Tomography, Image Processing, Liver Segmentation,

1. Introduction
Liver Diseases, which is one of the most common diseases, has affected and devastated many lives. According to International Agency for Research on Cancer (IARC), hepatocellular carcinoma (liver cancer) is the third most common cause of cancer-related deaths worldwide. Deaths from liver diseases have reached record levels, rising 25% in less than a decade. Liver performs numerous operations in the human body. Yet, no technique or device can compensate for the absence of the liver. The only real available option is liver transplantation, which is really a major and risky surgery. Although transplantation from cadavers utilized to be the very first choice, transplantation from living donors has turned into a range of treatment because of the shortage of cadaver donation in recent years. Prior to the surgical procedure, the livers that fit in with the living donor and the recipient are evaluated: to recognize the liver region, to determine the size mismatch, to measure liver volume, and to analyze the vascular structure. Knowledge obtained by the evaluation is necessary to decide whether the donor and recipient is a good match and when the transplantation ought to be performed.

2. Literature Survey
El-Masry, W.H. et al. [19] presented an automated liver CT image clustering approach based on evolutionary metaheuristic algorithm called invasive weed optimization is presented without any prior information about the number of naturally occurring groups in the images. Dharmendra K Roy and Lokesh K Sharma [10] presented a clustering algorithm based on Genetic k-means paradigm that works well for data with mixed numeric and categorical features. C.Immaculate Mary et al. [20] proposed Ant colony optimization to improve k-means clustering. Though the k-means is one of the best clustering algorithm, the quality is based on the starting condition and it may converge to local minima. Zhao Xiao Yuan et al. [6] presented an automatic liver segmentation algorithm centered on fast marching and improved fuzzy cluster methods, which can segment liver from abdominal MR images accurately. Priyadasrshini, S. and Selvathi D. [21] performed an extensive comparative analysis to illustrate the merits and demerits of various available techniques. This work also explores the applicability of the techniques in liver segmentation from Computed Tomography images. Abdalla Zidan et al. [18] evaluated a new combined approach intended for reliable CT liver image segmentation, to separate the liver from other organs, and segment the liver into a set of regions of interest (ROIs). The approach combines the level set with watershed approach used as post segmentation step to produce a reliable segmentation result. Youguo Li et al. [22] combined the largest minimum distance algorithm and the traditional K-means algorithm to propose an improved K-Means Clustering. This improved algorithm can make up the shortcomings for the traditional K-Means algorithm to determine the initial focal point.

ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 9, September 2015

3. Methodology

An experiment using MATLAB has been performed using a CT image. Segmentation from a CT image is one of the most difficult image processing operations because the images contain speckle and Gaussian noise and various attenuated artifacts. The procedure took for the implementation of the proposed technique is explained below:

Image Acquisition

For experimental purpose, abdominal CT scans of various patients were collected from different sources. The medical images have a unique format i.e. DICOM (Digital Imaging and Communication in Medicine). The DICOM files have a header which contains information of patient, type of scan and image dimensions. For research purpose, we have used files in PNG, TIFF and JPEG formats due to lack of portability of DICOM format. Images are stored in MATLAB and displayed as a gray scale image of 256*256. The entries of a gray scale image range from 0-255, where 0 shows total black color and 255 shows total white color. Entries between these ranges vary in intensity from black to white.

Applying ACO based K-Means Clustering

The K-Means Clustering algorithm is an unsupervised learning algorithm that classifies a given data set in certain number of clusters depending on fixed priori. The main idea is to define k centroids one for each cluster. The k-means method aims at grouping items in a cluster which is nearest to its centroids. Since no clustering algorithm gives 100% quality results, therefore ACO based refinement is done in which one ant is used to refine the clusters. Whenever it crosses a cluster, it picks an item from cluster and drops it into another. This hybrid technique helps in defining the area to be segmented.

Applying preprocessing steps

The preprocessing performs background noise removal, intensity inhomogenity correction and removal of irrelevant organs such as kidney, spleen, gallbladder automatically from abdominal images to suppress their interference in the segmentation process. The most commonly present noise is Gaussian noise which occurs during image acquisition. This type of noise is removed using Gaussian filter or spatial filter. In this adaptive thresholding is used to separate foreground from background with non-uniform illumination. Pre-processing also detects and removes kidney, spleen, heart, gallbladder and spine automatically from abdominal images, to suppress their interference in the liver segmentation process. These organs are first detected using anatomical knowledge and morphological operations are applied on these detected structures. Binary morphological image reconstruction is applied with an appropriate marker image on the organ. The required mask for image reconstruction is obtained by choosing the cluster that shows the organ, after clustering of the original image with Gaussian mixture model.

Compute Signed Pressure Force (SPF) Function

The SPF function is measured using the intensity values inside and outside of the active contour. If the values inside and outside the contour are close to each other then the contrast of the image is low. Then the difference of minimum average intensity and the pixel value is used for the curve evolution. Such type of edge detection gives good results even at weak boundaries.

Compute Gradient

The gradient of the energy functional is calculated by taking absolute of the gradient of the convolved image with Gaussian noise. But the Gaussian filter is incapable in preserving edges along with removal of noise. Therefore instead of using convolution of the Gaussian kernel, the gradient is computed using SPF function as described above. The gradient is given as:

$$G = SPF(I(x)) + \nabla SPF(I(x))$$

Energy Minimization

To obtain the minimum value of the energy functional, steady state solution of gradient is found by taking the gateaux derivative of energy function $E(\phi)$. The gradient flow equation is given as:

$$\partial\phi \,/\, \partial t = - \partial E \,/\, \partial\phi$$

Where $\partial\phi / \partial t$ is the gateaux derivative of $E(\phi)$.

Once the energy gradient is minimized then the final segmented output liver image is obtained. If the gradient is not minimum then the weight values are computed again and gradient is computed till is reaches the minimum value.

4. Performance Metrics

The analysis of the above technique was done on the basis of accuracy and specificity which are calculated as follows:

Accuracy = TN + TP / TP + TN + FP +FN

Specificity = TN / TN + FP

Where,

TP (True Positive) = No. of pixels that are classified correctly as foreground in the foreground region.

TN (True Negative): No. of pixels that are classified correctly as background in the background region.

FP (False Positive): No. of pixels that are classified as foreground in the background region.

FN (False Negative): No. of pixels that are classified as background in the foreground region.

5. Results and Discussions

In this paper, the performance optimized k-means clustering using Ant Colony Optimization from CT images was analysed. The liver images were collected from various medical sites. The implementation of the framework is done in MATLAB. The performance metrics like Accuracy and Specificity are computed for quantitative comparison.

For qualitative analysis, output images of the implemented framework are shown in Fig 1(a)-(i). The images show the original image, then k-means clustering is put on the image using 4 clusters which helps to generate an initial contour of the CT image. Then level set and ACO are applied which help in optimizing the k-clusters. The particular level set minimizes the gradient of the energy. Iterations occur till the energy is minimized and your final segmented image is obtained. From the figure it can be seen that the first energy of the particular level set function is above zero. After applying the particular level set, the energy is minimized and drops below zero i.e. negative energy is obtained showing the minimum energy.

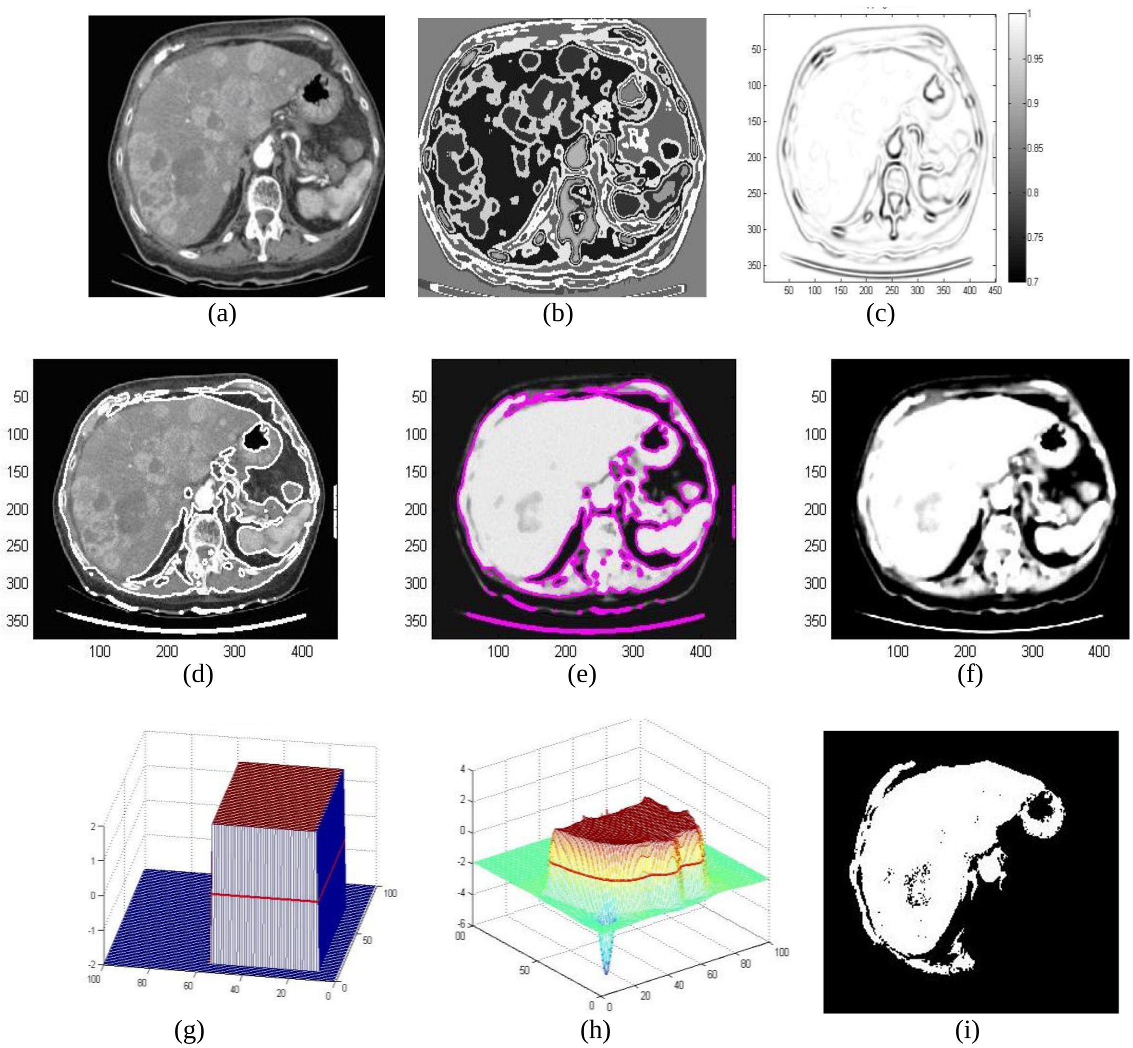

Fig 1: (a) Original image of abdominal CT, (b) Image after applying K-Means Clustering with k=4, (c) Image showing the edge detection function, (d) Image showing the initial contour, (e) Image showing initial level set function, (f) Image showing final level set function, (g) Image showing initial level set energy, (h) Image showing Final level set energy, (i) Final segmented image after applying K-means, level set and ant colony optimization.

Quantitative Analysis

The quantitative results are presented in tables which gives the comparison between the existing and proposed technique on basis of Accuracy and Specificity. The results were taken on 15 CT scan images.

Accuracy Analysis:

Table below shows the comparative output of the existing and proposed technique on basis of Accuracy. The results were taken on fifteen CT images.

Image No.	Existing	Proposed
1	81.10	94.05
2	81.54	89.95
3	82.21	95.80
4	89.28	92.63
5	89.36	91.45
6	85.23	90.35
7	88.40	91.62
8	86.14	92.52
9	79.27	91.90
10	84.82	98.17
11	90.34	97.19
12	83.45	92.04
13	86.14	92.52
14	92.72	97.54
15	88.80	98.74

The figure below shows the graphical implementation of the above table. The graph clearly depicts that the results of the proposed technique are much better than those obtained from the existing technique.

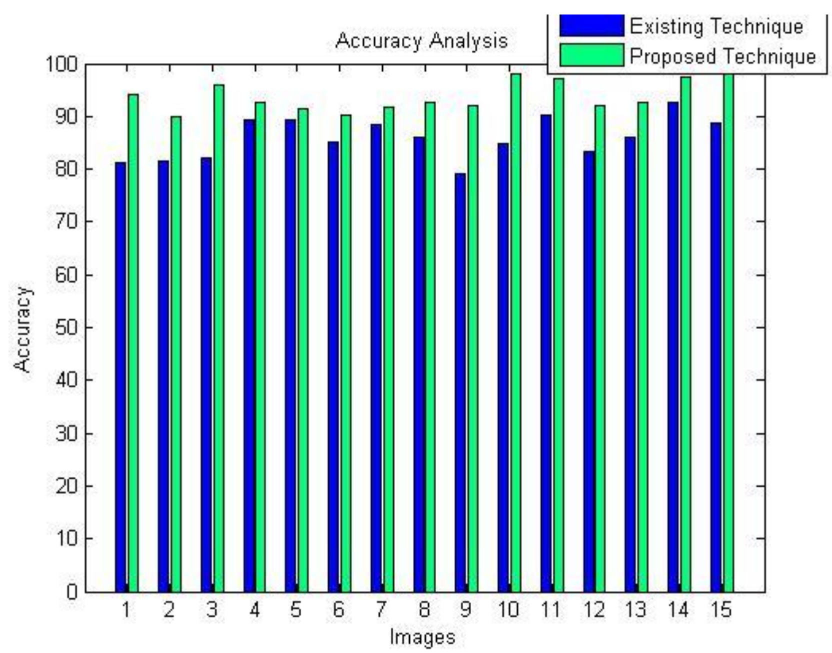

Fig 2: Graphical representation of existing and proposed technique in terms of Accuracy.

Specificity Analysis:
Table below shows the comparative output of the existing and proposed technique on basis of specificity. The results were taken on fifteen CT images.

Image No	Existing	Proposed
1	76.62	95.86
2	80.41	92.55
3	80.15	96.86
4	84.85	95.02
5	83.90	94.43
6	79.07	93.73
7	86.94	93.62
8	86.92	93.49
9	76.39	94.26
10	81.41	98.17
11	88.31	97.84
12	89.68	94.75
13	86.92	93.49
14	88.16	97.51
15	80.03	99.20

The figure below shows the graphical implementation of the above table. The graph clearly depicts that the results of the proposed technique are much better than those obtained from the existing technique.

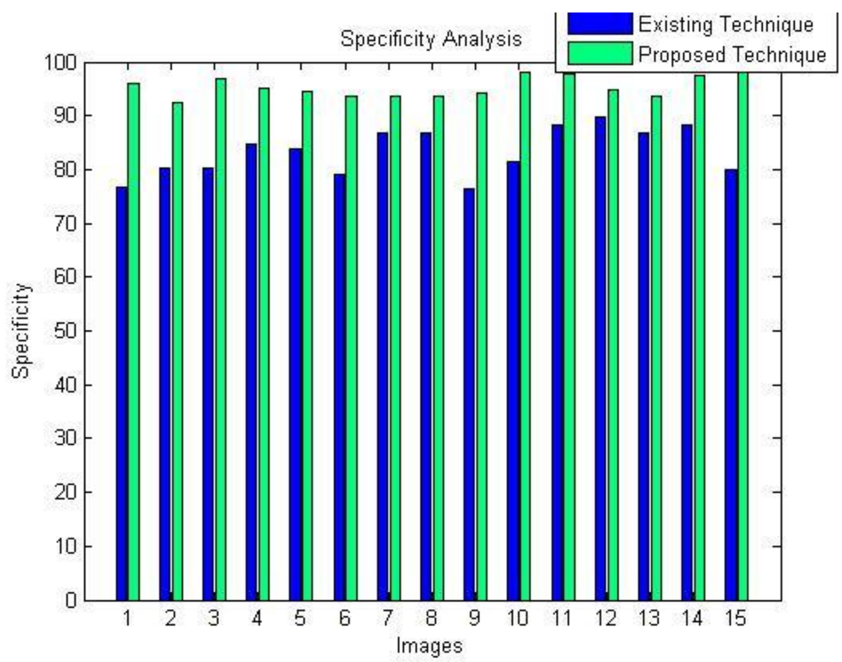

Fig 3: Graphical representation of existing and proposed technique in terms of Specificity.

6. Conclusion and Future Scope

In this work, an automated segmentation technique using optimized k-means clustering has been proposed. It employed k-means and Ant Colony Optimization to extract the liver area from CT image automatically. The Level Set method was incorporated to refine the edges and contours for better visualization. The experimental result shows high accuracy (98.74) and high specificity (99.20) in various testing data. Compared with standard k-means, this method is fully automatic and achieves better segmentation even if boundary is not clear. The future work focuses on implementing tis technique on various other organs of human body and on other imaging modalities.

References

[1] Laurent Massoptier and Sergio Casciaro, " A new fully automatic and robust algorithm for fast segmentation of liver tissue and tumors from CT scans", European Radiology, Vol. 18, 1658-1665, Springer 2008.

[2] Haibin Ling et al., " Hierarchical, learning based automatic liver segmentation", IEEE 2008.

[3] Amir H. Forouzan et al., "Liver Segmentation by intensity analysis and anatomical information in multi-slice CT images", Springer 2009.

[4] Gang Chen and et al., " Improved level set for liver segmentation and perfusion analysis in MRI's", Information Technology in Biomedicine, Vol.13, 94-103, IEEE 2009.

[5] S.Esneault, "Liver Vessel Segmentation using a Hybrid Geometrical Moments/Graph Cuts Methods", Biomedical Engineering, Vol.57, 276-283, IEEE 2010.

[6] Zhaoxiao Yuan and et al., " A novel automatic liver segmentation technique for MR images", Image and Signal Processing, Vol. 3, 1281-1286, IEEE 2010.

[7] O. Gambino and et al., " Automatic Volumetric Liver segmentation using Texture based region growing", Complex ,Intelligent and Intensive Systems, 146-152, IEEE 2011.

[8] A. Militzer and et al., "Automatic detection and segmentation of focal liver lesions in contrast enhanced CT images", Signal, Image and Video Processing, Vol.7, 163-172, IEEE 2010.

[9] N. Shi, "Research on K-Means Clustering Algorithms: An improved K-Means Algorithms", Intelligent Information Technology and Security Informatics, 63-67, IEEE 2010.

[10] Dharmendra K. Roy and Lokesh Sharma, " Genetic K-Means Clustering algorithm for mixed and categorical data sets", IJAIA 2010.

[11] Madhu Yedla and et al., "Enhancing K-Means Clustering Algorithm with Improved initial center", Vol.1, 121-125, IJCSIT 2010.

[12] Chumning Li and et al., " Distance Regularised Level Set Evolution and its application to image segmentation", Image Processing, Vol. 19, 3243-3254, IEEE 2010.

[13] Ahmed M. Mharib, "Survey on liver CT image segmentation methods", Artificial Intelligence Review, Vol.37, 83-95, Springer 2011.

[14] A.K. Mishra, "Decoupled Active Contour for Boundary Detection" ,Pattern Analysis and Machine Intelligence, Vol. 33, 310-324, IEEE 2011.

[15] S.S. Kumar and et al., "Automatic liver and lesions segmentation: a primary step in diagnosis of liver diseases", Pattern Recognition, 2524-2527, Springer 2011.

[16] Shweta Gupta and Sumit Kumar, "Variational Level Set Formulation and Filtering Techniques on CT Images", IJEST 2012.

[17] Priyadarshini S. et al., "Survey on segmentation of liver from CT images", IEEE 2012.

[18] Abdalla Zidan, "Level Set based CT liver image segmentation with watershed and artificial neural networks, International conference on hybrid intelligence systems, 96-102, IEEE 2012.

[19] El Masry and et al., "Automatic liver CT image clustering based on invasive weed optimization algorithm", Engineering and Technology, 1-5, IEEE 2014.

[20] C.Immaculate et al., "Refinement of clusters from K-Means with Ant colony optimization", 28-32, Journal of Theoretical and Applied Information Technology 2013.

[21] Priyadarshini S. et al., "Survey on segmentation of liver from CT images", IEEE 2012.

[22] Youguo Li et al., " A clustering method based on K-means Algorithm", Physcs Procedia 25, 1104-1109, Elsevier 2012.