Volume 5, Issue 8, August 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Segmentation of Liver using Hybrid K-means Clustering and Level Set

Ina Singh, Asst. Prof. Neelakshi Gupta
Amritsar College of Engineering and Technology
Punjab, India

Abstract: Liver Segmentation from Computed Tomography (CT) is a significant but challenging task. In the abdominal CT scan image the liver is seen 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 presents an efficient and fully automated liver segmentation technique. The proposed method uses Ant Colony Optimization technique along side K-Means and Level set to locate the liver region. Prior to the liver transplantation surgery the livers that belong to the living donor and the recipient are evaluated to spot liver region and determine the size mismatch. This knowledge helps to decide if the donor and recipient is good match or not. The essential problem in manual segmentation is that boundaries of liver may be identified differently by different radiologists and even by the same radiologist at a different time. Thus fully automated liver segmentation is important to analyze the liver effectively. The method was placed on CT datasets and the performance of the algorithm was measured using the receiver operating characteristics such as f-measure and sensitivity. Quantitative analysis suggests that this method can consistently segment liver images with high accuracy and efficiency.

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

I. INTRODUCTION

Medical Imaging is an important tool for diagnosis and treatment planning. Imaging modalities such as for example computed tomography (CT), magnetic resonance imaging (MRI) and digital mammography has greatly improved the possibility to examine the body without needing invasive methods. Image segmentation is a technique to partition an image into various non-overlap regions which are mutually exclusive and exhausted such that the pixels within a region are homogeneous based on certain criteria.

Liver is an essential organ with several vital functions such as for instance protein synthesis and detoxification. Additionally, it regulates biochemical reactions that include the synthesis or break down of complex and small molecules and produces bile, which is an alkaline compound that aids in digestion. Till date there is no device which can compensate for the absence of liver in human body. The only possible solution is liver transplantation which is a risky surgery. In liver transplantation, the liver from cadavers are the first choice of treatment but due to shortage of cadavers, transplantation from living donors has become the choice of treatment. Before the surgery planning, the livers of the recipient and donor are evaluated to find the volume, size mismatch, vascular structures and decide whether the transplantation can be performed or not [5]. Therefore, liver segmentation is a key step in liver transplantation surgery. Manual segmentation of liver has several problems such as the boundary of liver can be identified differently by different radiologists due to complex structure of human body and similar intensities of different organs present in the abdominal section of human body. Thus, in this study, a fully automated liver segmentation method which uses abdominal CT images for liver segmentation is proposed.

II. LITERATURE SURVEY

Simon Esneault et al. [5] suggested a fast and fully automated liver vessel segmentation method based on 3-D geometrical moment based detector of cylindrical shapes wthin minimum cut and maximum flow energy minimization framework. 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. Shi Na et al. [9] discussed the standard k-means clustering algorithm and analyzed the shortcomings of standard k-means algorithm. 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. Gambino, O. et al. [7] proposed an automatic texture based volumetric region growing method for liver segmentation. 3D seeded region growing was based on texture features with the automatic selection of the seed voxel inside the liver organ and the automatic threshold value computation for the region growing stop condition. Militzer A. et al [9] presented a novel system for automatic detection and segmentation of focal liver lesions in CT images. It utilized a probabilistic boosting tree to classify points in the liver as either lesion or parenchyma, thus providing both detection and segmentation of the lesions at the same time and fully automatically.

III. SEGMENTATION TECHNIQUES

The various segmentation techniques used in this proposed framework are listed below:

K-Means Clustering: K-means is among the simplest unsupervised learning algorithms that classify confirmed data set into certain quantity of clusters (assume k clusters) fixed a priori. The important thing idea is obviously to define k centroids, one for every single cluster. These centroids should really be put in an intelligent way, because different location causes different result. So, the greater choice is to put them around possible far from each other. The next step is obviously to take each point owned by confirmed data set and associate it to the nearest centroids. When no point is pending, the first step is completed and an in the beginning grouping is done. Again re-calculate k new centroids of the clusters (resulting from the last step). After having these k new centroids, brand new binding needs to be performed between the same data set points and the nearest new centroids. Repeat the strategy until centroids do not move any more. In the successive loops, the k centroids change their location step by step [20]. Eventually, a scenario is going to be reached where in fact the centroids do not move anymore. This signifies the convergence criterion for clustering.

Ant Colony Optimization: In the natural world, ants (initially) wander randomly, and upon finding food return for his or her colony while laying down pheromone trails. If other ants find this type of path, they're likely not to keep traveling randomly, but to instead follow the trail, returning and reinforcing it as long as they eventually find food. After a while, however, the pheromone trail starts to evaporate, thus reducing its attractive strength. The additional time it requires for an ant to see down the trail and rear, the additional time the pheromones need certainly to evaporate. A fast path, in comparison, gets marched over more frequently, and thus the pheromone density becomes higher on shorter paths than longer ones. Pheromone evaporation even offers the benefit of avoiding the convergence to a locally optimal solution. If there were no evaporation at all, the paths chosen by the original ants would are often excessively appealing to the next ones. Because case, the exploration of an ideal solution is space could possibly be constrained. Thus, when one ant finds a good (i.e., short) path from the colony to a food source, other ants are susceptible to follow that path, and positive feedback eventually leads to any or all or any the ants' carrying out a single path.

Level Set Method: The level set method is initially proposed to track moving interfaces and has spread across various imaging domains. It may be used to efficiently address the problem of curve/surface/etc. propagation within an implicit manner. Level Set Methods are based on curve evolution theory. According to which, the deformation of a curve is written by a Partial Differential Equation. The main benefit of Level Set approach is that the geometric properties of the contour could be obtained employing a level pair of the surface. The level set method is initially proposed to track moving interfaces and has spread across various imaging domains. It may be used to efficiently address the problem of curve/surface/etc. propagation within an implicit manner.

Hybridization of K-Means and Ant Colony Optimization

Hybrid Clustering Algorithm is based on the combination of ant colony optimization and K-means Clustering. The basic reason for our refinement is, in virtually any clustering algorithm the obtained clusters won't give 100% quality. You will have some errors known as misclustering. That is, a data item could be wrongly clustered. Most of these errors could be avoided by utilizing the refinement algorithm. Inside this method, just one ant can be used to refine the clusters. This ant is permitted to go for a random walk on the clusters. Whenever it crosses a cluster, it'll pick something from the cluster and drop it into another cluster while moving. The picking and dropping probabilities are calculated in terms of entropy. This Algorithm can avoid local optimization and results in global optimization.

Description of Hybrid Clustering Method: Hybrid Clustering Method is described as follows.

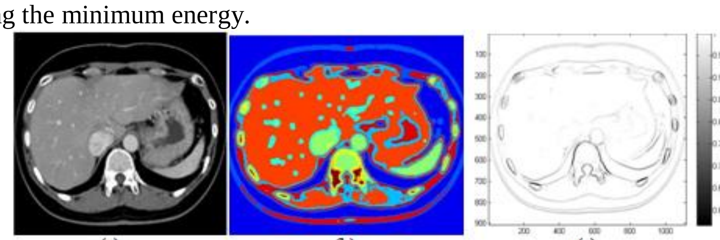
(a) The objects are clustered using K-Means Clustering using fixed number of clusters.
(b) From the k-clusters, Cluster centers are chosen.
(c) Each cluster is refined using Ant colony Optimization to optimize the wrongly selected k-clusters.
(d) Output the results.

IV. RESULTS AND DISCUSSIONS

In this paper, the performance of hybrid K-Means clustering and level set for liver segmentation from CT images were analyzed. The liver images were collected from various medical sites. The implementation of the framework is done in MATLAB. The performance metrics like F-Measure and Sensitivity 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 applied to 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 level set minimizes the gradient of the energy. Iterations occur till the energy is minimized and a final segmented image is obtained. From the figure it can be seen that the initial energy of the level set function is above zero. After applying the level set, the energy is minimized and drops below zero i.e. negative energy is obtained showing the minimum energy.



(a) (b) (c)

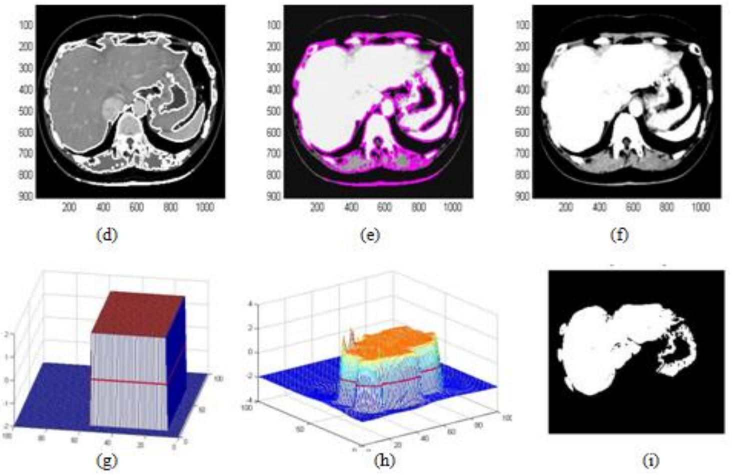


Fig 1: (a) Original image of abdominal CT, (b) Image after applying K-Means Clustering with k=4, (c) Image showing the edge detection function, (d) Image showing the initial contour, (e) Image showing initial level set function, (f) Image showing final level set function, (g) Image showing initial level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

The quantitative results are presented in tables which gives the comparison between the existing and proposed technique on basis of F-Measure and Sensitivity. The existing technique uses K-Means Clustering and level set method whereas the proposed technique uses ant Colony Based K-means Clustering with level set.

F-Measure Analysis:

Table1 shows the comparative output of the existing and proposed technique on basis of f-measure. The results were taken on fifteen CT images.

Image No.	Existing (K-Means & Level Set)	Proposed (K-Means, ACO & Level Set)
1	84.13	95.86
2	82.55	92.54
3	83.88	96.86
4	91.70	93.02
5	92.07	94.43
6	88.59	93.73
7	89.57	93.61
8	85.25	93.49
9	81.52	94.26
10	84.82	98.17
11	91.80	97.84
12	94.75	95.20
13	85.25	93.49
14	94.74	97.51
15	92.22	99.19

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.

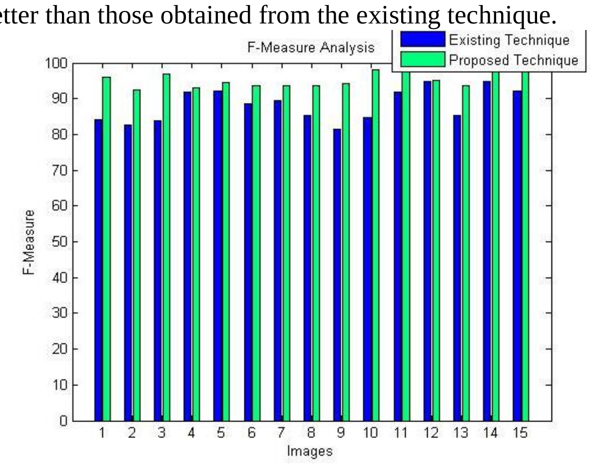


Fig 2: Graphical representation of existing and proposed technique in terms of F-measure.

Sensitivity Analysis:

Table 2 shows the comparative output of the existing and proposed technique on basis of sensitivity. The results were taken on fifteen CT images.

Image No.	Existing (K-Means & Level Set)	Proposed (K-Means, ACO & Level Set)
1	81.05	96.03
2	83.60	93.06
3	83.40	96.96
4	86.84	95.26
5	86.08	94.73
6	82.69	94.10
7	88.44	94.00
8	88.43	93.89
9	80.88	94.57
10	84.22	98.21
11	89.47	97.89
12	90.64	95.01
13	88.43	93.89
14	89.41	97.57
15	83.34	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.

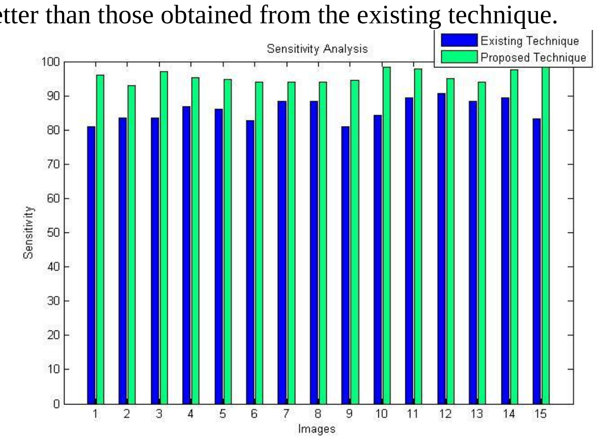


Fig 3: Fig 2: Graphical representation of existing and proposed technique in terms of Sensitivity.

V. CONCLUSION AND FUTURE SCOPE

In this work, a fully automated liver segmentation technique is described which means that this technique identifies the desired Region of Interest itself. The performance of k-means and level set, and proposed hybrid k-means and level set was evaluated on a number of CT images to segment the liver region. The segmentation requires prior anatomical knowledge of the abdominal Ct image to differentiate between different organs of human body. Both quantitative and qualitative analyses are in favor of hybrid k-means (k-means with ACO). The analyses resulted in high F-measure rate and sensitivity in all testing data. This technique can further be used on other modalities with different diseases, which will be helpful in surgeries. Also colored images can be used and implementation can be done in 3-D. the performance of proposed algorithm depends on choice of initial centroids as well as on proper selection of structural element.

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.

