Various Image Segmentation Algorithms: A Survey

Check for updates

Kurumalla Suresh and Peri Srinivasa rao

Abstract Image segmentation is a necessary method in image processing. It is nothing but partitioned an image into several parts called segments. It has applications like image compression; because of this type of application, it is unable to develop the entire image. In that, time segmentation technique is used, to segment the portions from the image for remaining processing. Already certain methods are existed, which divides the single image into multiple parts depending on some constraints like intensity value of the pixel, image color, size, texture, etc. These methods can be divided based on segmentation method. In this paper, author reviewed some algorithms, and finally their pros and cons are listed.

1 Introduction

An image is a mode of conveying details, and the image holds lots of effective information. Understanding the image and obtaining data from the image to achieve certain works is a principal area of application in digital image technology, and the main step in interpreting the image is called as image segmentation. Nowadays, image segmentation is popular and challenging field in image processing. Practically, it is often not interested in all parts of the image, but only for some certain areas which have the same characteristics. It is foundation for image processing. It is also an important basis for image recognition. It depends on certain measure to partition an input image into several numbers of the equal nature of group in order to bring out the area in which people are focused on. It is the foundation for image analysis and understanding of image feature extraction and recognition. The concept of image

K. Suresh (✉)
Jawaharlal Nehru Technological University, Kakinada, A.P, India
e-mail: kurumallasuresh@gmail.com

P. Srinivasa rao
CS&SE dept, Andhra University College of Engineering, Visakhapatnam, A.P, India
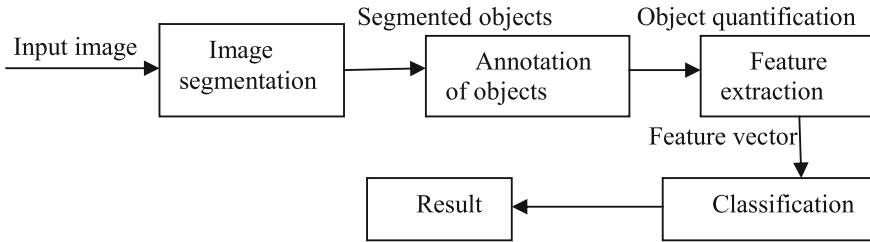e-mail: peri.srinivasarao@yahoo.com

Fig. 1 Image analysis pipeline

segmentation is simplification. It is the first and main step in image analysis and processing (Fig. 1).

Every algorithm in image segmentation has three characteristics. They are correctness, stability toward parameter choice, and stability toward image choice.

Correctness
Segmentation clearly finds the structure in the image. It is not too good or bad up to certain level of details.

Stability toward parameter choice
The aim is to generate a segmentation of uniform definiteness for a wide area of parameter choice.

Stability toward Image choice
The aim is to generate a segmentation of uniform correctness in a wide range of various images.

If any algorithm obeys these three characteristics, then only it will display the efficient expected result, which is incorporated into larger systems.

Image segmentation algorithms have two basic properties. They are discontinuity and similarity. Discontinuity is nothing but portioning an image based on edge intensity values, whereas similarity is nothing but portioning an image based on region methods like region growing and region splitting and merging.

2 Image Segmentation Techniques

Partitioning a single image into several parts is called image segmentation. It is based on multiple methods. They are threshold, edge-based, region-based, clustering-based, watershed-based, PDE-based, and ANN-based methods.

Threshold method
Thresholding method [1] is easy and efficient procedure for image segmentation. In this, image pixels are partitioned with the support of image intensity. This technique is mainly focused on how to separate front objects from background. It can be divided into three types. They are

(1) **Global thresholding**:
   It completely depends upon threshold value selection.

   (i) If pixel value > threshold, then it indicates one.
   (ii) If pixel value ≤ threshold, then the output indicates zero.

(2) **Variable thresholding**:
   In global thresholding, T value is fixed, but in this it varies through an image.

(3) **Multiple thresholding**:
   As the name itself, it indicates many threshold values from t_0 to t_n.

Region-based segmentation

In this method, grouping the smaller regions into big regions is done.
It can be divided into two parts [2].

 (i) Seeded region growing method and
(ii) Unseeded region growing method.

   In seeded region growing process, first start with a set of seeds. Then, the region is grown by adding remaining seeds which are having similar properties. After that, perform splitting and merging process.

   In unseeded region growing process, no need to select initial seeds for segmentation. Remaining process is same as seeded region growing method.

Clustering-based image segmentation

Clustering is another synonym for image segmentation. In this method [3], group the objects which are having similar characteristics. The techniques used for clustering same techniques are applicable for image segmentation.

Edge-based image segmentation

These are famous and advanced methods in image processing. It depends upon intensity change in the image. Single intensity value does not give the efficient result about image. In this, first we find the edges after connecting the edges with object boundaries to segment the image. Two methods are used here; they are gray histograms and gradient-based methods. The output is displayed as binary image. These techniques depend upon the discontinuity detection [4].

Watershed-based method

The watershed method [5] depends on topological interpretation approach. In this algorithm, intensity indicates with the basin containing holes where water comes into the outside. When the water reaches to basin boundary, then the adjacent regions are combined. These methods used the image gradients like topographic surface.

Partial Differential Equation Based Segmentation method

These methods are speed techniques of image segmentation. These are mainly used for crucial time applications. These are mainly divided into two types. They are (1) nonlinear isotropic diffusion filter and (2) convex non-quadratic variation restoration (It eliminates the noise). Then, the output displays a blurred image. The fourth-order

PDE is used mainly for decreasing noise of the image. Second-order PDE mainly identifies the edges [5].

Artificial Neural Network Based Segmentation method: [2]
The main aim of this method is decision-making. It is mainly used in medical fields to remove the background from the required image. It is independent of the partial differential equation based segmentation method.

There are regularly used image segmentation algorithms. This paper relates the following four algorithms for simple survey.

3   Related Work

Zhensong Chen et al.:
Zhensong Chen et al. developed an algorithm for image segmentation. It depends upon the DP clustering algorithm [6]. In this algorithm, there is no need of prior knowledge about cluster numbers. Only two parameters are considered for each point i. One is density ρ_i and the second one is distance δ_i.

$$\text{Density}\rho_i = \Sigma_j \exp -\frac{d_{ij}^2}{d_c^2} \tag{1}$$

d_{ij} indicates distance between i and j,
d_c indicates cutoff distance, and
ρ_i indicates points distribution around i.
distance δ_i can be calculated using the formulae

$$\delta_i = \begin{cases} \min_j(d_{ij}) & \rho_j > \rho_i \\ \max_j(d_{ij}) & \rho_i \text{ is the higher density} \end{cases} \tag{2}$$

Algorithm steps:

(1)   In this algorithm, first consider input image data to gain the indications in three color channels.
(2)   Find the distance and density using Eqs. (1) and (2). Then, compute the decision graph.
(3)   Select the points with high density and large distance. And then find the cluster number.
(4)   If $\rho_j > \rho_i$ and ρ_i has higher density, these two conditions are satisfied at the point x_i. Then, the points are assigned to the same label x_j.
(5)   Finally, segmentation depends on the label marks.

Digabel et al.: [7]
Digabel et al. proposed region-based image segmentation algorithm. It completely

depends upon the watershed geographical concept [8, 9]. In this first, figure out the segmentation function of the image. It is nothing but dark regions are considered as objects in the image. Then, identify foreground and background marks. Foreground markers are pixels which are part of any object. At the end, figure out the watershed transformation.

Suresh et al.: [10]
Suresh et al. proposed a new algorithm called efficient DBSCAN for image clustering. It depends upon the traditional DBSCAN approach. In this method, first consider an RGB image and then converted into the gray color image. If noise is presented in the gray image, remove the noise. Then, calculate the minpts and eps. Minpts are based on image size.

Let image size is $M * N$

Then, minpts are calculated using the formulae

$$\text{Minpts} = \frac{M * N}{256} \tag{3}$$

256 indicates the gray level value of the image, and $M * N$ indicates the pixel image size. Eps depends upon minpts and KNN algorithm. Then, apply the traditional DBSCAN approach [11, 12]. Using this clustering technique, the image is segmented and displayed as output.

Improved Fuzzy C-Means algorithm [13]
The famous clustering techniques like FCM [14, 15] and FLICM [16] are not suitable for segmentation with noise images. In both the algorithms, image gray values are taken into consideration. So IFCMA is introduced. It gives the efficient results with noise images also. For this, Euclidean distance measure is used to find the distance between pixels. In this algorithm, first compute the total number of clusters. Then, compute the center of cluster with the help of Euclidian distance and find the membership matrix. The values which are present in the matrix update the center of cluster with that values. Repeat the algorithm until Euclidian distance is greater than the matrix value.

Comparative Analysis of algorithms with advantage and Disadvantages
Table 1 shows the advantages and disadvantages of different image segmentation algorithms.

4 Research Challenges in Image Segmentation

After reviewing the above image segmentation algorithms, authors are identified some research challenges in this area. They are as follows:

Scalability
Majority of the image segmentation algorithms work effectively for small size images

Table 1 Comparative analysis of image segmentation algorithms

Algorithm	Methodology	Advantage	Disadvantage
Zhensong Chen et al.	Distance and density	• No need of prior knowledge about cluster number	• High time complexity • Less efficiency
Digabel et al.	Watershed geographical concept	• Used to separate foreground and background objects	• Need to specify number of clusters for segmentation function
Suresh et al.	Eliminating noise points	• Noise resistant	• It is expensive • It takes more time
Improved fuzzy C-means algorithm	Euclidean distance measure	• Effective results with noise images also	• Usage of membership matrix

only, but in real scenario images are vast in size. Hence, present algorithms are less effective to segment the image and even few algorithms unable to segment the images also. Hence, there is a scope for developing scalable algorithms to segment the images in present real world.

Quality

The proposed image segmentation algorithms are usually tested on well-known pixels of image or image segmentation with very small structure but those algorithms not tested the quality on large images. Hence, there is a scope for testing the algorithm with different benchmarks to reveal the quality of images in real-world networks.

5   Conclusion and Future Scope

In this survey, authors presented different image segmentation algorithms on small size images only. Majority of present algorithms works well on small size images but not suitable for large images. These image segmentation techniques are based on distance and density, watershed geographical concept, eliminating noise points, and Euclidean distance. The spatiality of this work is that it reveals the literature review of different image segmentation algorithms and provides a large amount of information under a single paper. After reviewing all the existing algorithms, this survey concludes that scalability and efficiency are the major factors affecting community detection.

References

1. Zhang, Y.J.: An overview of video and Image segmentation in the last 40 years. In: Proceedings of the 6th International Symposium Applications on Signal Processing, pp. 1441–1451 (2001)
2. Rajesh, R., Senthilkumaran, N.: Edge detection techniques for image segmentation- a survey of soft computing approaches. Int. J. Recent Trends Eng. **1**(2) (2009)
3. Yambal, M., Guptha, H.: Image segmentation using FCM clustering: a survey. Int. J. Adv. Res. Comput. Commun. Eng. **2**(7) (2013)
4. Kalyankar, N.V., Saleh, S., Khamitkar, S.: Image segmentation using edge detection (UCSE). Int. J. Comput. Sci. Eng. **02**(03) (2010)
5. Liang, R.R., Yang, Q.Q.: The comparative research on image segmentation algorithms. In: IEEE Conference on ETCS 2009, pp. 703–770
6. Dilpreet Kaur et al.: Various image segmentation techniques: a review. IJCSMC **3**(5), pp. 809–814 (2014)
7. Hui, S.M., Bhandarkar, Z.: Image segmentation using evolutionary computation. IEEE Trans. Evol. Comput. **3**(1), pp. 1–21 (1999)
8. Wang, D.: A multiscale gradient algorithm for image segmentation using watersheds. Patt. Recogni. **30**(12), 2043–2052 (1997)
9. Kim, J.B., Kim, H.J.: Multi resolution based watersheds for efficient image segmentation. Patt. Recogni. Lett. **24**, 473–488 (2003)
10. Kurumalla, S., et al.: K-nearest neighbor based DBSCAN clustering algorithm for image segmentation. J. Theor. Appl. Inf. Technol. **92**(2) (2016)
11. Mohamedt, R.F., ElBarawy, Y.M., Ghali, N.I.: Improving social network community detection using DBSCAN algorithm. In: 2014 World Symposium Computer Applications & Research (WSCAR). IEEE (2014)
12. Mehjabin., et al.: Community detection methods in social networks. I.J. Educ. Manag. Eng. **1**, 8–18 (2015). (http://www.mecs-press.net), https://doi.org/10.5815/ijeme
13. Li, L., Hu, X.: Improved F c-means algorithm for image segmentation. J. Electr. Electron. Eng. **3**(1), 1–5 (2015)
14. Dunn, J.C.: A fuzzy relative of the ISODATA process and its use in detecting compact well separated clusters. J. Cybern. **3**, 32–57 (1973)
15. Bezdek, J.C.: Pattern Recognition with F Objective Function Algorithms. Kluwer Academic Publishers (1981)
16. Chatzis, V., Krinids, S.: A robust of logical information C-means clustering algorithm. IEEE Trans. Image Process. **19**(5), 1328–1337 (2010)