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A COMPARATIVE STUDY OF SEVERAL IMAGE SEGMENTATION TECHNIQUES

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Abstract- Image segmentation play an important role for many image video and computer vision applications and still is a relevant research area due to its wide usage in the field like medical, remote sensing and image retrieval. Over the last few decades, many segmentation methods have been proposed. Paper is divided in three sections. First section contains introduction for image segmentation and importance for various image applications. In second section paper enumerates and review main segmentation algorithms, problems being encountered, related issues and usage of techniques in different areas. Finally, in third section conclusion is drawn that summarizing commonly used techniques for segmentation and their complexities in application.
Keywords- Image segmentation, Objective thresholding, Edge detection, Region based, Laplacian of Gaussian

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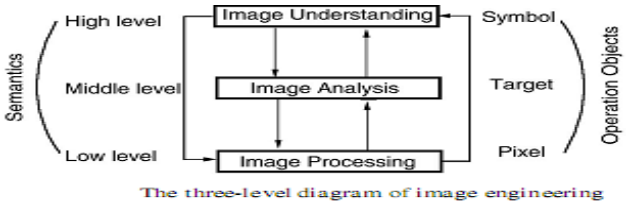
Introduction

Image segmentation is a key process in many image, video, and computer vision applications. The main goal of segmentation is domain independent partitioning of an image into a set of disjoint regions that are visually different, homogeneous and meaningful with respect to some characteristics or computed properties, such as grey level, texture or color that makes image analysis (object identification, classification and processing) easy [6].The importance of segmentation has long been recognized, but in the last few decades the lack of good segmentation methods was just one of many roadblocks towards making a number of applications feasible. In the applications like content based image/video retrieval, computer vision and object and content-based image/video compression, segmentation has become one of the major problem that must be solved for successful results[5].

Innumerable image segmentation methods have been proposed, exploiting a wide variety of image features and characteristics, to obtain more accurate and effective segmentation result.

Fig. 1 shows the relationship between Image processing, image analysis and image understanding. Image analysis mainly focuses to monitor and measure the interested targets in the image in order to get its objective information [3]. Image processing is relatively low-level operations and mainly operated on the pixel-level. Next is Image analysis that enters at the middle-level, it focuses on measuring, expression and description of target. Image Understanding is mainly high-level operation, it focus on the operation and illation of data symbol which abstracts from the description [3]. In other words Image understanding is one of the fundamental step in many research where the main



The three-level diagram of image engineering

Fig. 1

Objective is to understand the component of an image and interpret its semantic meaning. Image component recognition is basic building block of most image processing based research that involves image understanding. What comprise an image must be first identified before we analysis an image any further. For example in medical image processing identification of a tumor is

enough and no further processing is needed. On the other hand, in some cases we need to identify image object as a pre processing step.

we can define the image segmentation as follows[6]:

$$\text{Let the image domain be } \Omega \text{ and } P_i \text{ be partitions of } \Omega$$

$$\text{Such that } P_i \subset \Omega \text{ , } \Omega = \cup_{i=1}^{n} P_i \text{ , } H(P_i) = true \ \forall m,$$

$$H(P_i \cup P_j) = false \quad \forall P_i \, and \, P_j \, adjacent$$

$$\text{where } P_i \cap P_j = \Phi \text{ for } i \neq j \text{ , and each } P_i \text{ is connected.} \qquad (1)$$

Discontinuity and similarity/homogeneity are the two basic properties of pixels in relation to their local neighborhood used in many segmentation methods. The segmentation methods that are based on discontinuity property of pixels are considered as boundary or edges based techniques and that are based on similarity or homogeneity are region based techniques[6]. Unfortunately, segmentation is a complex problem with no exact solution. Research into better segmentation methods invariably encounters two problems [5]:

i. Inability to effectively compare the different segmentation methods or even different parameterizations of any given segmentation method.
ii. Inability to determine whether one segmentation method or parameterization is best for all images or classes of images (e.g. natural images, medical images, etc).

The application of image segmentation is also very wide and almost appeared in all areas of image processing as well as involved various types of image. For example Locate objects in satellite images (roads, forests, etc.), Face recognition, Iris recognition, Fingerprint recognition, Machine vision, medical imaging(Locate tumors and other pathologies, Measure tissue volumes, Computer-guided surgery, Diagnosis, Study of anatomical structure etc) Agricultural imaging – crop disease detection etc.

Segmentation techniques

Edge based

An edge is a set of linked pixels lying on the boundary between different regions, where there are intense discontinuities such as gray change, color distinctness, texture variety and so on [7]. Image can be segmented by detecting such types of discontinuities. Edge detection can be a challenging problem in low level image processing. It becomes more challenging when color images are considered because of its multi dimensional nature. Color images provide accurate information about the object which will be very useful for further operations than gray scale images[8]. There are many challenges in the edge detection method such as (a) Change in lighting condition, (b) Image background is dynamic, (c) Noise have a great impact on the shaping the edge,(d) False Edge Detection(detecting edge where it does not exist) (e) Dislocated edge(Detected edge to be shifted from its true location).

Classification of Edges And Its Detection Methods

The classification of the edge detection algorithms based on the behavioral study of edges with respect to the operators.

a. Classical or Gradient based edge detectors (first derivative)
b. Zero crossing (second derivative)
c. Laplacian Of Gaussian (LOG)
d. Gaussian edge detectors
e. Colored edge detectors

a. Classical Edge Detectors

It contains classical operators and uses first directional derivative operation, Sobel (1970), Prewitt (1970), Krisch (1971), Robinson(1977), Frei-Chen(1977). Detection of edges and their orientation is the main advantage of such types of edge detectors. Disadvantage of these types of edge detectors is that they are sensitive to noise.

b. The Roberts Detection

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point[16]. The operator consists of a pair of 2X2 convolution kernels as shown in Figure 2.In Robert cross algorithm the horizontal and vertical edges bring out individually and then they put together for the resulting edge detection [8].

+1	0
0	-1

Gx

0	+1
-1	0

Gy

Fig. 2- Mask used for Robert operator

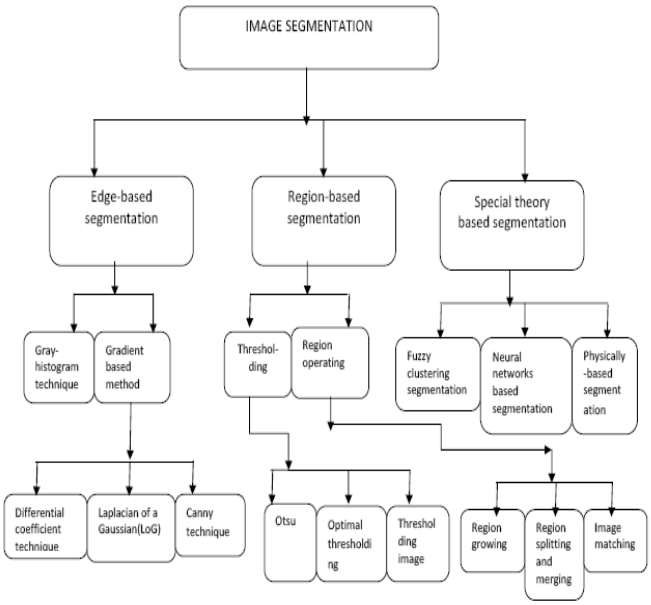


Fig. 3- Hierarchy of image segmentation techniques

c. Sobel Edge Detection

The classical operator such as sobel uses first derivative has a simple calculation to detect the edges and their orientations but has inaccurate detection sensitivity in case of noise. This method is similar to that of the Roberts Cross operator, despite the design of sobel and Robert are common, the main difference is the kernels that each uses to obtain the image is different. The sobel kernels are more suitable to detect edges along the horizontal and vertical axis and the Roberts's operator able to detect edges run along the vertical axis of 45◦and 135◦[8] .In theory at least, the operator con-

sists of a pair of 3x3 convolution kernels as shown in Figure 4. One kernel is simply the other rotated by 90◦.

+1	+2	+1
0	0	0
-1	-2	-1

-1	0	+1
-2	0	+2
-1	0	+1

Fig. 4- Masks used by sobel operator

d. Zero Crossing

Zero crossing use the second derivative and it includes Laplacian operator. It is having fixed characteristics in all directions but drawback is that it is sensitive to noise. Haralick proposed use of zero-crossing of the second directional derivative of the image intensity function.

e. **Laplacian Of Gaussian (LOG)**

It was invented by Marr and Hildreth in 1980. Laplacian of Gaussian (LOG) operator is represented as another type of edge detection operator that uses second derivative. The Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively[8]. Disadvantages are malfunctioning at the corners, curves and where the gray level intensity function varies. Not finding the orientation of edge because of using the Laplacian filter [16].

f. Gaussian Edge Detectors

This is the another type of edge detection operator Gaussian edge detectors such as Canny, Shen, Castan operators which are using probability for finding error rate and localization. It is symmetric along the edge and reduces the noise by smoothing the image and gives better result in noisy environment. It is time consuming and very complex for computation.

g. Canny Edge Detector

The popular edge detection algorithm Canny first presented in 1986, and it is known to many as the optimal edge detector. The problem with this type of traditional edge detection approach is that a low threshold produces false edges, but a high threshold misses actual edges. First requires that the image be smoothed with a Gaussian mask, which reduced the noise within the image, then the image is run through the sobel algorithm. Lastly, the pixel values are chosen based on the angle of the magnitude of that pixel and its neighboring pixels [8]. Unlike Roberts Cross and much like sobel, the canny operation is not very susceptible to noise. Canny edge detector performance is good, the only drawback is that it takes more time to compute and it is more complex.

Table 1- Comparison of edge detection methods

Method	Advantages	Disadvantages
Robert	Simplicity	Highly susceptible to noise
sobel	Simplicity of the method	Sensitive to noise and inaccurate
Zero crossing	Detection of edges and their orientations. Having fixed characteristics in all directions	Sensitive to noise
Laplacian of Gaussian (LoG)	Finding the correct position of edges by testing wider area around the pixel	Malfunctioning at the corners, curves and where the gray level intensity function varies.
Gaussian Edge Detectors	Better result in noisy environment	Time consuming and complex
Canny	Performance is good, Using probability for finding error rate,	More complex

Canny edge detector is known as an optimal edge detector because having low error rate, good localization of edge points, and a single response to a single edge pixel[16].

Region-Based Segmentation

Thresholding Method:

Thresholding technique for the image segmentation is one of the old, simple and popular method, widely used in the field of image segmentation. When only one threshold value is used for the entire image it is called global thresholding, on the other hand when the image is partitioned into subregion and a threshold value is determined for each subregion it is called local thresholding[1]. Image segmentation based on thresholding techniques aims to partition an input image into pixels of two or more values through comparison of pixel values with the predefined threshold value T individually;

$$\text{Let } I(i,j) \text{ be an image,}$$

$$I(i,j) = \begin{cases} 0, & p(i,j) < T \\ 1, & p(i,j) \geq T \end{cases}$$

Where p(i, j) refer to the pixel value at the position (i, j)
Comparison of several thresholding techniques

Table 2- Comparision of thresholding methods

Method	Advantage	Disadvantage	segmentation effect
Minimum Thresholding	Low complexity	Narrow in application	normal
Iterative thresholding	Average complexity	Image details are fuzzy	good
Entropy based thresholding	Complexity is very low	Sensitive to noise	normal
Otsu thresholding	Complexity is very high	Combine with other algorithm to improve its performance	good

i) Global Thresholding: When a Threshold value T depend only on the f(x,y)(only on gray level values) and the value of T solely relates to this character of the pixels, this thresholding techniques is called as global thresholding techniques[7]. A number of global thresholding techniques such as: minimum thresholding, otsu, optimal thresholding
iterative thresholding and so on.

ii) Local thresholding: If threshold value T depend on both f(x,y) and p(x,y) this thresholding is called local threshold[7]. Local thresholding techniques are simple statistical thresholding, 2-D entropy based thresholding, histogram transformation thresholding etc

Region Operating

(a) Region splitting and merging: Rather than choosing seed points, users can divide an image into a set of arbitrary, unconnected regions and then merge and/or split the regions in an attempt to satisfy the conditions of reasonable image segmentation [7]. Split and merge techniques consist of the two basic steps. First one is, the whole image is considered as one region. If this region does not satisfy a homogeneity criterion the region is split into four quadrants (sub-regions) and each quadrant is tested in the same way, this process is recursively repeated.

(b) Region growing: As name implies, region growing is a process that groups pixels or sub regions into larger regions based on predefined criteria. Region growing algorithms are based on the growth of a region whenever its interior is homogeneous according to features as intensity, color or texture. The approach goes on like this, firstly set a group of seed points in original image, then grow regions by appending each seed to those neighboring pixels that have similar properties of the seed (like gray level or color)[7].

Conclusion and Summary

In this survey, the aim has been to investigate and discuss different traditional and popular image segmentation techniques. Fundamental properties and methodologies of different techniques have been highlighted. The merits and demerits of methods discussed in short. Although various techniques are available, each technique works on specific concept hence it is important which image segmentation techniques should be used as per application domain. With this survey we conclude that segmentation algorithms has been proposed in the literature but there is no single algorithm that works well for all types of images, but some work better than others for particular types of images suggesting that improved performance can be obtained by selecting appropriate algorithm or combination of appropriate algorithms or techniques.

References

[1] Nikhil R. Pal, Sankar K. pal (1993) *pattern recognition,* Vol. 26, No. 9 pp. 1277-1294.

[2] Pooja Mishra et al (2008) *Int. J. Comp. Tech. Appl.,* Vol 2 (3), pp.704-708.

[3] Jun Tang (2010) *Second International Conference* vol. 6 pp. 634-637.

[4] Zuo yong Li, Chuancai Liu, Guangha, Liu Yong Cheng, Xibei Yang (2011) *Int. J. Electron. Commun.(AEU¨)*vol. 64 pp.1137–1147.

[5] Hui Zhang, Jason E. Fritts and Sally A. Goldman (2003) *An Entropy-based Objective Evaluation Method for Image segmentation*.

[6] Tranos Zuva, Oludayo O. Olugbara, Sunday O. Ojo and Seleman M. Ngwira (2011) *Canadian Journal on Image Processing and Computer Vision* Vol. 2, No. 3,pp.20-29.

[7] Wen-Xiong Kang, Qing-Qiang Yang, Run-Peng Liang (2009) *ETCS* pp. 703-709.

[8] Lakshmi S., Sankaranarayanan V. (2010) *CASCT,* pp.35-41.

[9] Hassana Grema Kaganami and Zou Beiji (2009) *Fifth International Conference on Intelligent Information Hiding and Multimedia Signal Processing IEEE,* pp.1217-1221.

[10] Dey Y. Zhang, Zhong M. (2010) *IAPRS,* Vol. XXXVIII, Part 7A.

[11] Ho S.Y. and Lee K.Z. (2003) *"Design and Analysis of an efficient evolutionary image segmentation algorithm"* vol. 35, pp. 29-34.

[12] Shital Raut, Raghuvanshi M., Adarsh Raut, Dharaskar R. (2008) *International Conference on Advanced Computer Control, IEEE* pp. 420-424.

[13] Senthilkumaran N., Rajesh R. (2009) *International Conference on Advances in Recent Technologies in Communication and Computing IEEE* pp. 844-846.

[14] Mehmet Sezgin Bulent Sankur (2004) *Journal of Electronic Imaging* 13(1), pp.146–165.

[15] Mohamed Roushdy (2006) *GVIP Journal,* Vol. 6, Issue 4, pp. 17-23.

[16] Raman Maini and Dr. Himanshu Aggarwal (2002) *International Journal of Image Processing*, Vol 3, Issue 1 pp. 1-12.

[17] Freixenet J., Munoz X, Raba D., Martı J., and Cuf X. (2002) *Springer LNCS* 2352 pp. 408-422.

[18] Catalin amza (2000) *"A review on neural network-based image segmentation techniques"* pp.1-23.

[19] Jun Tang (2010) IEEE.

[20] Alan Bovik (2006) *Handbook of Image and Video Processing (Second Edition),* pp.429–468.

[21] segmentation using wavelets and watersheds (2003) *"IEEE Computer Graphics and Image Processing, SIBGRAPI XVI Brazilian Symposium,* pp.278–284.