

Comparative Analysis of Threshold Based, K-means and Level Set Segmentation Algorithms

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Abstract

Image segmentation algorithms provide a mean to segment the images of different formats. The beauty of an algorithm lies within the quality of segmentation it performs. The large number of segmentation algorithms are available, analysis of algorithms is emerging as an interesting field. A number of algorithms are available for segmenting an image but there is not a single algorithm which performs better for all applications. In this paper, the comparative analysis of level set, K-means and Thresholding based algorithms has been presented for standard Lena and Cameraman image. The performance of the algorithms measured in form of white pixel ratio and processing time.

Keywords

Image Segmentation, Performance Evaluation Parameters, Processing Time, White Pixel Ratio

I. Introduction

Over the last few years image processing has been playing an important role in the analysis of various types of images acquired both in visible band of Electromagnetic (EM) spectrum and remaining of the EM spectrum band. Finding out the exact position of the object in the image requires segmentation. Numerous segmentation and algorithms have been proposed for this purpose. Consequently there was a need for the comparison of different segmentation algorithms based on some parameter instead of taking into account the perceptual quality of the segmented image, which would take into account some other attribute of the segmentation algorithm. The algorithms taken for comparative study are Level set algorithm, K-means algorithm and Thresholding based algorithm. For the judgment of quality of a segmented image several parameters have been propounded by different scholars. These methods evaluate the performance of the segmented image and provide a way for the selection of an optimal technique for image segmentation. Now a day, there are cutting edge algorithms available which provide a very good segmentation of the images. So some parameter, different from the perceptual quality of the segmented image, has to be taken into account to evaluate segmentation algorithms. The task of evaluation becomes difficult when the performance matches to a great extent. So some parameter which compares the performance of the segmentation algorithms in terms of processing time is an interesting idea. Everything in this universe is bounded by time and space. In the context of segmentation algorithms, time may be considered as an important parameter to be taken into account. Here time may be regarded as a parameter in the sense that different algorithms take different time to segment the same image. We may call this parameter as processing time. Apart from processing time, another parameter taken into account for the comparative analysis of different algorithms is White Pixel Ratio (WPR). This ratio indicates the proportion of white pixels within a segmented image. The paper is organized as follows. Section II, describes level set, K-means and Thresholding based algorithms. Section III, deals with segmentation evaluation parameters. Section IV, discusses the related work. Experimental results are discussed in

Section V, while Section VI, expounds conclusion.

II. Different Algorithms Taken for Comparison

Three algorithms have been taken for comparison purpose which are as following:

- Level set Algorithm
- K-means Algorithm
- Thresholding based Algorithm

A. Level Set Algorithm

This algorithm is region-based active contour model (ACM) proposed by Kaihua Zhang et. al [1]. A Gaussian smoothing kernel has been used to regularize the algorithm. A region-based signed pressure force (SPF) function is used in the algorithm to effectively stop the contours at weak or blurred edges. The exterior and interior boundaries can be automatically detected with the initial contour being anywhere in the image. The algorithm can perform selective local or global segmentation. The level set function can be easily initialized with a binary function. The computational cost for traditional re-initialization can also be reduced. The algorithm can be efficiently implemented by the simple finite difference scheme. The algorithm is more efficient and accurate over Chan–Vese (C–V) active contours [2] and geodesic active contours (GAC) [3, 4].

B. K-means Algorithm

K-mean clustering algorithm was first proposed by Stuart Lloyd [5] in 1957 as a technique for pulse code modulation, though it wasn't published until 1982. It is one of the most commonly used clustering algorithms. Clustering based on k-means is closely related to a number of other clustering and location problems. There are a number of variants to this algorithm.

C. Thresholding Based Algorithm

This is a very simple intensity dependent Thresholding algorithm. Here the pixels of the image having intensity level less than a particular threshold value are assigned some other intensity level say binary '0' and pixels having intensity above that threshold level are assigned other intensity level say binary '1'. Some intermediary slabs of intensity levels may also be included for which a second threshold may be specified.

III. Segmentation Evaluation Parameters

Several parameters have been propounded by different researchers which evaluate the performance of segmentation algorithms. These parameters may be classified into three main categories namely analytical methods, goodness methods and discrepancy methods [5]. Analytical methods make use of algorithms for segmentation directly by considering principles, requirements, utilities & complexity, of algorithms. Most of the segmentation algorithms take a priori knowledge into consideration [6-7]. The goodness methods evaluate the performance of algorithms indirectly by judging the segmented images according to human intuition. So no prior knowledge of the correct segmentation is required for the segmented image. Goodness methods have been proposed to

cover different aspects of an “ideal” or a “good” segmentation. The discrepancy methods take into consideration the difference between an actually segmented image and a correctly or ideally segmented image (reference image). The reference image is also known as also gold standard or ground truth [8].

IV. Related Work

Original and segmented images are shown as below.



Fig. 1: (a) (b)



Fig. 2: (a) (b)



Fig. 3: (a) (b)



Fig. 4: (a) (b)

Experiments were performed with standard images of Lena and Cameraman by implementing Level set, K-Mean & Threshold based algorithms in MATLAB. In the above shown images, Fig. 1(a) is standard Lena image while fig. 1(b) is standard cameraman image. Fig. 2(a) and (b) are corresponding segmented images by thresholding based algorithm. Fig. 3(a) and (b) are corresponding images segmented by K-means algorithm while fig. 4(a) and (b) are corresponding images segmented by level set algorithm. Flow chart for the work done is shown as below.

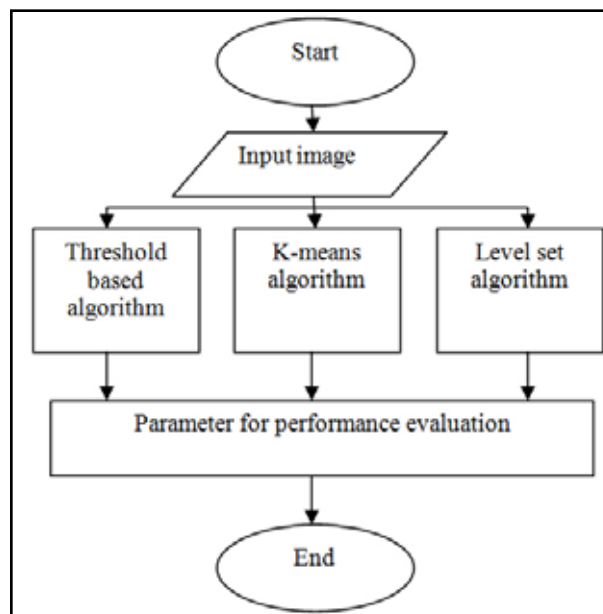


Fig. 5:

As shown in the flow chart, images were applied to different algorithms and then performance parameters were evaluated for the segmented images.

V. Experimental Results

Two standard images of Lena and cameraman were segmented by three above mentioned algorithms and white pixel ratio was calculated for each of the segmented image and the original images. Apart from this, the processing time taken by each algorithm to segment the images was also calculated. Processing time and WPR are shown in the tables below.

Table 1: Processing Time and WPR for Lena Image

lena.jpg	Parameters	Segmented Image
Without Algorithm	WPR	.1667
Thresholding based	Time(sec)	1
	WPR	.0434
K-mean	Time(sec)	1
	WPR	.3750
Level-set	Time(sec)	3
	WPR	.1536

The Table 1 shows the time taken by three different algorithms to segment the Lena image. WPR in the table1 represents White Pixel Ratio which is the ratio of number of white pixels to the total number of pixel in the image.

Table 2: Processing Time and WPR for Cameraman Image

cameraman.bmp	Parameters	Segmented Image
Without Algorithm	WPR	0
Thresholding based	Time(sec)	1
	WPR	.0007
K-means	Time(sec)	1
	WPR	0
Level-set	Time(sec)	2
	WPR	.0012

The Table 2 shows the time taken by three different algorithms to segment standard cameraman image. Time shown in both the tables is in seconds. Second row in each table represents only white pixel ratio for the original images.

VI. Conclusion

Three different types of segmentation algorithms have been taken for the segmentation of Lena and cameraman images. From the table it is clear that level set algorithm takes more time than K-means and thresholding based algorithms while the time taken by K-means and Thresholding based algorithms is same for the segmentation of images of Lena and cameraman. In terms of white pixel ratio, WPR increases for Lena image after segmentation from K-means and Thresholding based algorithm while for Level set algorithm its value decreases from that of original image. WPR for original cameraman image is zero i.e. there is no white pixel present in the original image. When cameraman image is segmented by Level set algorithm, white pixels appear in the image which is indicated by a small value of WPR for the image segmented by Level set algorithm. Similar tendency is shown by Thresholding based algorithm for the cameraman image.

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